Short Communication
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Patterns of seasonal population dynamics of soil macrofauna in meadow phytocenoses in the volga-kama reserve

Abstract

The aim of our study was to reveal patterns of soil macrofauna abundance variation during vegetation season. The studies were carried out in Russia, Volga-Kama reserve. The latter is divided into two part – Raifa (55.900330, 48.723119) and Saraly (55.308186, 49.239262). We sampled macrofauna their in 4 biotopes. Additionally buffer zone was investigated: 2 biotopes under anthropogenic impact. In each biotope, the spring and autumn abundance was estimated for three years. In the Saralinskii section of the reserve, in most cases, it differed insignificantly. In the Raifa section earthworms abundance declined toward autumn slightly. In buffer zone, there was a tendency to decrease in abundance by autumn, which, apparently, is associated with anthropogenic influence.

Keywords: seasonal dynamics, patterns of number variation, reserves, soil macrofauna, earthworms

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Introduction

Soil animals are essential elements of all terrestrial ecosystems.[1,2] They affect ecosystem functions by decomposition and nutrient cycling, and indirectly through the engineering activities.[3] The presence of soil animals can enhance aboveground plant productivity, or facilitate litter decomposition.[2] These effects largely emerge from trophic and other biological interactions among key functional groups of soil animals, microbes, and plants. Local variations in animal communities may have large effects on ecosystem processes at local, landscape, and global scales. There were several calls to include soil animal effects in global biogeochemical or soil erosion models, but the required large-scale comprehensive community data to validate these animal-based models are lacking.

The essential members of soil communities are earthworms. They are divided into three main ecological categories depending on behavioral and morphological adaptations to their environment.[4] Epigeic species live in the litter layers and the upper centimeters of the soil and feed predominantly on fresh surface litter; endogeic species live deeper and feed on soil organic matter; anecic species built vertical permanent burrows from the surface into the soil profile and drag down the fresh surface and feed on both OM sources.[5] Therefore, the earthworms' degree of belonging to ecological categories could influence the regulation of microbial substrate access by modifying the quantity and quality of ingested OM.[4]

Earthworms are of primary importance for ecosystem functioning as they modify the availability of resources for other organisms through physical and chemical changes in their surrounding soil environment.[3] Earthworm ecological preferences and impact on the environment have been largely documented,[6] as well as their burrowing behaviour.[7]

Materials and methods

Here we present earthworms abundance in open habitats of Volga-Kama Reserve. The main aim of investigation was to reveal patterns of earthworms density on certain parts of the reserve. In other words compared earthworms number in spring and autumn samples in certain plot.

The studies were carried out on the territory of two sites of the Volga-Kama Reserve, Raifsky and Saralinsky, in the spring and autumn periods of 2019-2022. Animals were sampled by the standard soil-zoological method: soil samples on plots of 0.0625m^2 to a depth of 0-15cm. Three meadows were surveyed in the Sarali site in plot 32 at different levels: one grassy-forb meadow of the middle level (meadow of the upper level plot 32 Saraly), the other reed-butterbur-forb meadow in a small depression (meadow of the middle level plot 32 Saraly), also in plot 30, a medium-level grass-forb meadow (meadow of an average level plot 30 Saraly). Those meadows were surrounded by forests. Also in the buffer zone, two medium-level grass-forb meadows were studied, one of them in the floodplain of a field lake (floodplain meadow-protection zone-Saraly), the other in 100 m from it (meadow of medium level protective zone-Saraly). The meadows of the buffer zone were located in the agrocenosis (perennial grasses).

Meadows in the Raifa section of the reserve were adjacent to the lake of the same name on one side, and on the other side to the forest (plots 33 and 38). The last of them has being flooded partially by spring waters, which remain on the surface until mid-summer.

The Saralin site was located in the broad-leaved landscape subzone; Raifsky – in the subtaiga landscape subzone.[8]

The significance of fluctuations in the number of pedobionts in the season series was assessed by the mean error (m), if in a pair of comparisons of spring and autumn the values of the mean statistical error and its error did not overlap, then we could speak of significant seasonal differences. We put "+" when the abundance of pedobionts in spring was significantly lower compared to autumn and "-" if vice versa. When the number fluctuated within the error, it was evaluated as "0". So, the method of "counting votes" was used.

Results and discussion

An analysis of trends in the seasonal dynamics of the abundance of earthworms in meadow phytocenoses in the Saralinskii section of the reserve showed that in most cases (60%) the fluctuations in abundance occurred within the error (i.e., there were no significant changes) (Table 1) (Figure 1). In 1/3 of all cases, a decrease in the number of

Lumbricidae was observed in the seasonal aspect (33.3%). And only in one case, an increase in abundance was noted (6.7%).

Table 1 Tendencies of changes in the number of earthworms by season in the Saralinsky section of the reserve

Research points	Seasonal changes in earthworm abundance	Seasonal changes in the abundance of macrofauna
Floodplain meadow-protection zone-Saraly	0 - -	0 - -
Meadow of medium level protective zone-Saraly	0 - -	+ - -
Meadow of the upper level plot 32 Saraly	0 0 0	0 0 -
Meadow of the middle level plot 32 Saraly	- 0 +	- 0 0
meadow of the middle level plot 30 Saraly	0 0 0	- 0 0
Total	0 – 9 (60,0%), - – 5 (33,3%), + – 1 (6,7 %)	0 – 7 (46,7%), - – 7 (46,7%), + – 1 (6,7%)

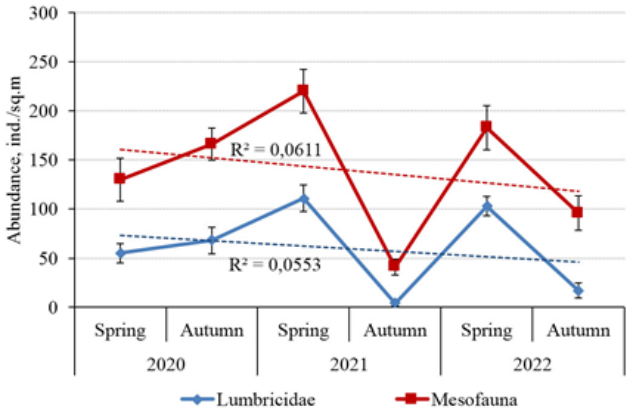

Figure 1 Seasonal dynamics of the abundance of soil macrofauna in the buffer zone of the Saralinsky section of the reserve.

A somewhat different picture was observed in general with the entire macrofauna. The same proportion of cases was noted without changes in the number and with its decrease (by 46.7%) by autumn, in one case a positive trend in the increase in the number.

Meadows in the buffer zone tended to decrease in the abundance of macrofauna and earthworms by autumn, in contrast to the natural meadows of the reserve, where fluctuations occurred within the error (Table 2). It is possible that the decrease in the number of pedobionts is associated with grazing of cattle and hayfields in the buffer zone.

In the meadows of the Raifa section of the reserve, a statistically significant decrease in the number of earthworms in the seasonal aspect was observed in 50% of cases (Table 2), slightly less (33%) of positive trends. Especially a decrease in the abundance of worms was noted in area 38 (Figure 2), which was partially flooded by spring waters due to the lowering of the relief and the proximity of groundwater. In general, the entire macrofauna had equal shares of different directions in the population dynamics.

Table 2 Seasonal trends in the number of earthworms in the Raifa section of the reserve

Research points	Seasonal changes in earthworm abundance	Seasonal changes in the abundance of macrofauna
Plot 33	+ 0 -	+ 0 -
Plot 38	- + -	0 + -
Total	- – 3 (50%), + – 2 (33,3%) 0 – 1 (16,7%)	- – 2 (33,3%), + – 2 (33,3%), 0 – 2 (33,3%)

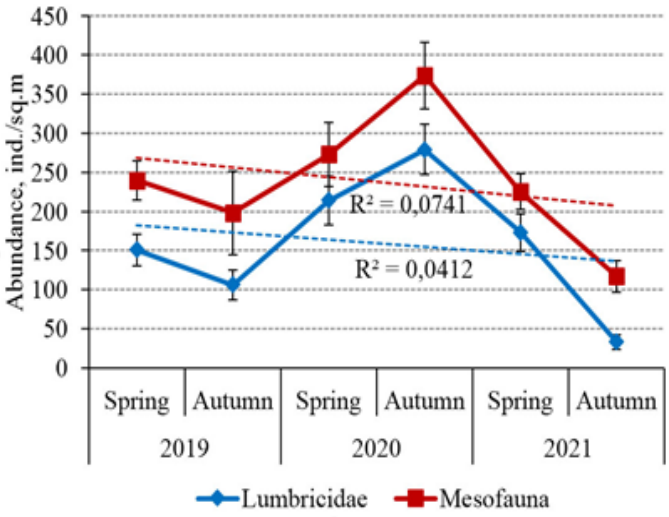

Figure 2 Seasonal dynamics of the abundance of soil macrofauna in area 38 of the Raifa section of the reserve.

Thus, fluctuations in seasonal abundance over the years could be multidirectional in one biotope, their fluctuations can either differ significantly or be within the error. In most cases, the seasonal dynamics in the Saralinsk area is weakly expressed, except for the buffer zone of the reserve, where cattle are grazing and haymaking is carried out. In the Raifa site, fluctuations in the abundance of pedobionts are somewhat better expressed. Previously, we noticed in the forest park zone of Kazan that with an increase in anthropogenic impact, the amplitude of fluctuations in the number of trophic groups of pedobionts increases over the years.[9]

According to the literature data, in high latitude habitats, seasonal fluctuations in species richness, diversity, and uniformity of distribution weaken with increasing soil temperature, while the biomass of invertebrates changes more.[10] Temperature plays a key role in structuring terrestrial communities, especially in high latitude ecosystems with strong seasonal weather dynamics and a short growing season. Since in our case the study area is located in the middle lane, therefore, there are no permanent seasonal differences, which is consistent with the conclusions of the authors.

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Conflicts of interest

The authors declared that there is no conflict of interest.

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