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DIVERSITY OF SOIL BIOTA ON ESTONIAN FLOODED GRASSLANDS

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Flooded meadows may be defined as seminatural communities that have been transformed by human agricultural activity, in which natural species are dominant and which remain as they are only as long as moderate human impact (mowing, grazing) is exerted. Throughout Europe seminatural communities or traditional rural biotopes have been disappearing at an alarming rate, as a consequence, traditional types of meadows and pastures are being abandoned or transformed into fields. The uniqueness, environmental value and cultural importance of these landscapes have become evident too late: most previously semi-natural communities are today overgrown or cultivated. After the period of intensive agriculture on 1970-80thies more attention has been paid on the extensive agricultural technologies like mowing and grazing, and sustainable land-use on seminatural meadows. Nowadays the importance of seminatural communities on the wiev of point of agricultural production is not so high as the importance of areas with extremily high plant biodiversity. The species diversity of semi-natural meadows is influenced by the continuity of extensive management (mowing, grazing); historical management influences the formation of both plant communities and soil characteristics (reduced fertility). Seminatural communities are evaluated on EU level – they are included in the Natura 2000 ecological network created for the implementation of Europe nature directive. The rapid disappearance of extensively managed agricultural lands has made their preservation and restoration vitally important, mostly including restoration of traditional management of seminatural communities. The aim of our study was to get new knowledge of soil biodiversity on seminatural flooded meadows and to find out the effect of management on soil biota.

Materials and methods

The term “coastal meadow” refers to a meadow directly influenced by sea i.e. flooded at least by storm waves. The soils of West Estonian coastal grasslands are saline littoral soils. Estonian west coast and islands are unique because as the slowly but constantly rising land emerges from the sea, vast expances of shallow coastal areas are formed, allowing light to reach the bottom. This phenomenon creates rich and diverse natural system (Kokovkin 2005). The conditions of West Estonian coast are more brackish then in Western Fennoscandia (Kakkuri & Chen 1992). The distribution of vegetation on the shore may be regarded as a spatial expression of coastal grassland succession; as a result of land uplift, the soils and vegetation of Estonian coastal grasslands undergo a series in their development, in response to changes in the hydrological and chemical properties of the substrate over time (Puurman, Ratas 1998). A key factor for preservation of the biodiversity of seashore grasslands is the continuation of traditional land use practices, especially regular grazing.

The term “floodplain meadows” refers to the flooded grasslands in river valleys (on floodplains). The meadows feature periodic flooding and continuous accumulation of organic and mineral sediments. The volume and extent of the sediments depend on flood duration and water level and on the local surface and soil. The quantity of sediment, its physical and chemical properties as well as flood duration are the main factors that determine the soil and vegetation types on floodplains

(Truus, Tõnisson 1998). The flood duration is one month in spring with shorter periods in autumn and summer. Estonian floodplain grasslands hold considerable environmental worth, supporting plant communities important from an international perspective as well as many plant species that are rare in Estonia and the Baltic region.

Soil biota communities were studied in West-Estonia 1999-2008 on 11 coastal and 4 floodplain meadows. Agricultural practices are similar for all sites; the meadows are mown annually or grazed extensively, two coastal meadows were not managed and covered by reed-bed. Soils were classified according to the system of the World Reference Base for Soil Resources (1998). Moisture content (105oC), pH, organic matter (in muffle furnace at 360^{o}C), nitrogen concentration (Kjeldahl method) and soluble phosphorus concentration (lactate method), K- and Na- concentration (flame photometer) were determined for each composite soil sample to characterize soil conditions.

Microbial community studies. Substrate-induced respiration (SIR) by Isermeyer technique was applied to measure metabolically active microbial biomass carbon. The microbial biomass C was calculated according to Beck et al. (1996). Soil microbial respiration rate (basal respiration) was measured by titration according to Ohrlinger (1996).

Earthworms. At each site five soil blocks (50 x 50 x 40 cm) were examined by the hand sorting or using mustard solution as vermifuge (Meyer 1996; Gunn 1992). Species were identified (Timm, 1999) and individuals were counted. The mean number of individuals per m^2 of soil surface and standard error (SE) were calculated.

Epigeic invertebrate fauna was collected using pitfall traps (plastic cup with diameter 7 cm and height 12 cm) one third filled with 20% NaCl solution and placed for 7 days in the soil in July. All individuals in traps were counted and identified to species (ground beetles, spiders), genus (ground beetles) or family (all other groups) level.

All data were analyzed using non-parametric methods: Kruskall-Wallis' test, Spearman's correlation coefficient.

Result and discussion

Effect of meadow type on diversity and abundance of soil communities

The historical management of different types of meadows influences the formation of both plant communities and soil characteristics (reduced fertility). No relationships between plant and soil invertebrate's diversities was found (Ivask et al 2006). Periodically flooded meadows receive the additional potassium in the course of flooding especially by sea but also by river water which was negatively related to the active microbial biomass. Together with potassium also some unfavorable compounds (salts) for the soil microbes can be carried into the wetland soils during flooding. Stress conditions in these soils are reflected also by smaller microbial biomass and higher mean microbial metabolic quotient (qCO_2) value compared to the values measured for the other natural soils. Microbial community's SIR biomass differs significantly ($p<0.001$) in soil of different types of meadows. The microbial biomass was low in soil of flooded (coastal and floodplain) meadows. The structural diversity of bacterial communities was higher in flooded meadows; respiration activity of microbial community did not differ in different types of meadows (Truu 2008).

Total abundance of earthworms (40±22 individuals per m^{-2}) and number of species are low in flooded grasslands. Common in all habitats in Estonia species *Aporrectodea caliginosa* was normally missing because of high moisture except in years when the meadows were not flooded because of drought and small precipitation (Ivask et al 2007). Anecic species are missing because of high groundwater table. Characteristical for overflooded meadows was high number of semi-aquatic species (*Octolasion lacteum, Eiseniella tetraedra*) and some epigeic species (*Lumbricus rubellus, Dendrobaena octaedra*) but the diversity was low. Salinity of sea water was an additional limiting factor for earthworms on coastal meadows but some individuals of *Lumbricus rubellus* were found in soil closed to coastline. Dominant species is semi-aquatic *Octolasion lacteum*, abundance of semi-aquatic epigeic *Eiseniella tetraedra* is high as well; additionally we found individuals of species *Lumbricus castaneus, Aporrectodea rosea* and *Dendrobaena octaedra.*

The numbers of epigeic invertebrates were the highest on flooded meadows but flooding was not positive factor for diversity. The diversity of species well adapted to conditions after flooding can be extremely high but for the majority of epigeic invertebrate species the conditions are not suitable. Ground beetles community had the most higher diversity on open meadows without or with short-term overflooding. The most abundant species on meadows were *Pterostichus vulgaris, Dyschirius thoracicus* and *Trechus quadristriatus* preferring habitats with higher soil moisture but also grazed meadows.

The diversity of spiders was high on flooded meadows, communities consisted mostly on individuals of families *Linyphiidae* and *Lycosidae*. The most abundant species in traps was *Ozyptila trux* (*Thomisidae),* the most dominant species in sweep-net was *Porrhomma pygmaeum*. The highest number of spiders was found on coastal meadows despite of extreme conditions of habitat. On floodplain meadows the diversity of spiders was high as well.

Effect on management on diversity and abundance of soil communities

Management of meadows had significant effect on soil communities. Diversity and abundance of earthworms were highly dependent on grazing intensity of meadow. The community parameters had the highest values on meadows grazed extensively. On meadows with high intensity of grazing the diversity and abundance of earthworm communities was significantly lower as well as on non-managed meadows. Epigeic invertebrate fauna also was influenced positively by extensive grazing and negatively by intensive grazing. The diversity of epigeic fauna was relatively low on meadows with intensive grazing as well as on non-managed meadows. In pitfall traps the most numerous groups were ants and spiders. The diversity of ground beetles was the highest on extensively grazed meadows and the lowest on intensively grazed meadows. Diversity of ground beetles on mowed and non-managed meadows were similar abd had values between the values of differently grazed meadows. On same type of meadows, the management was a positive factor for spiders diversity.

Conclusions

The abundance and diversity of soil microbial and earthworm communities are depending on type of meadows, soil characteristics and duration of flooding. Salt ions content of sea water is an additional negative factor for microbial and earthworm communities. Diversity of epigeic invertebrate fauna is more depending on duration of flooding and on other environmental factors like openness of landscape and meadow management type.

Extensive management of seminatural flooded meadows is a positive factor for soil invertebrate's diversity. Moderate mowing or grazing increases the number as well as the diversity of invertebrates. Intensive management significantly .decreases diversity of soil biota.

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