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Several aspects of the study of Pannonian calcareous sandy grasslands

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Precedents of the work, goals

Identification of *Festuca* taxa is an important question. This survey was conducted primarily in sandy grasslands, but checking potentially occurring *Festuca* spp. and the taxa mentioned in the literature became a task too. *Festuca* spp. are dominant in associations and are key taxa in the coenosystematic system. For this reason, their examination is important.

Members of this genus are important in Hungary, and are determinative species in habitats, where the conditions are too extreme for most plants (Borhidi et al. 2012). Different surveys have shown that habitats of fescues (the so called low productivity grasslands, which occupy 65% of the dry grasslands in Hungary) are of high nature conservation value in most cases, and they provide refuge for many insects, small mammals and reptilians (Tasi et al. 2016, Halász et al. 2016).

Natural and seminatural grasslands are important also in aspect of farming (Tasi 2003, 2011). Food are produced largely on these vegetation types. Their spreading was helped by landscape use, deforestation and grazing.

Many dry grassland patches belong to associations to be protected and to be found only in Hungary. The most valuable endemic and relic species of the country also grow here. Since fescues are the coenosystematic skeleton of the grasslands associations of our climatic zone (Soó 1963, Borhidi 2003, Borhidi et al. 2012), so maintaining the structure and species composition of dry grasslands as natural and seminatural is an important task (Simon 2000).

The main goals of this survey were the following:

The first goal was to analyse sandy calcareous grasslands along the Danube containing *Festuca* taxa in terms of coenology, coenosystematic correction and potential farming uses; to set the relation of every *Festuca* spp. in the vegetation and to identify new taxa.

The survey dealt with three main groups:

1. **Open sandy grasslands.** Analysis of *F. vaginata* and *F. pseudovaginata* grasslands, and vegetations dominated by *F. wagneri* which is an uncertain species in terms of taxonomy. An important question was: how is these large grasslands usable in terms of farming and grassland management? What are the content value of the biomass, especially of *Festuca* taxa? In the central part of the Carpathian Basin, to what extent do the vegetation mirror the original, natural one? Is there any proof that in the past, forest patches were also present in the area? Can the present vegetation give clues about the original forest-steppe habitats? Can be drawn parallels between the present state, species composition and soil data?

2. **Open and closing grasslands.** Do *Festuca wagneri* and *Festuca javorkae* occur in these grasslands, on the Little Hungarian Plain, in Csallóköz? Which vegetation types were the most diverse, and how do their species composition evolve after grassland restoration? The grassland at Gyórszentiván was set up as an example for grassland restoration. How does it resemble the seminatural sample areas in terms of species composition and species number?

3. **Comparing the coenologic structure and biomass.** The analysis was carried out in open and closing grasslands as well. Our question was: For which farming activity (mowing, grazing) will the amount of biomass be suitable?

2. Material and methods

Open sandy grasslands

Coenological records were made in the central part of the Hungarian Great Plain, in four geographic units from northwest to south by southeast. In these four units, the dominant

fescues of the sandy grassland vegetation types were the following: *Festuca vaginata*, *F. pseudovaginata*, *F. wagneri*. Records were sorted by these taxa. The areas were the following:

1. Little Hungarian Plain, Csallóköz,
2. Northern part of the central area of Carpathian Basin (Kiskunság)
3. Southern part of the central area of Carpathian Basin (Kiskunság)
4. Southernmost sandy area of the Carpathian Basin

Open and closing grasslands

During the survey, 6 vegetation units in 3 sample areas (Győrszentiván Military Area, Gönyű Military Area, and grasslands near Čenkov) were examined.

1. *Festucetum vaginatae* natural calcareous open sandy grassland at Gönyű
2. *Festucetum vaginatae* Manually undersown and spontaneously growing seminatural grassland at Győrszentiván
3. *Festucetum vaginatae* natural calcareous open sandy grassland at Čenkov
4. Natural sandy steppe at Győrszentiván dominated by *Festuca rupicola*
6. Sown closing grassland dominated by *Festuca javorkae* at Cenkov.

Biomass samples were made along the Danube in the central part of the Carpathian Basin in the aforementioned four geographical units. Further samples were made in Romania (Balta Verde) and Bulgaria (Vidin). Besides of the geographical units, dominating *Festuca* taxa were the following: *Festuca vaginata*, *F. pseudovaginata*, *F. wagneri*, *F. tomanii*, *F. javorkae* and *F. rupicola*. The last two were combined in the survey. Samples were made from the dominant *Festuca* specimens exclusively and also from the vegetation as a whole, labelling them as “mixed”.

Coenological samples were made using quadrats of 2×2 m size, based on the method of Braun-Blanquet (1964) but giving the cover values. Species nomenclature follows Király (2009). Nature Conservation Values (Simon 2000) and Social Behaviour Types (Borhidi 1995) were also used.

The classification of the coenologica data was conducted based on Podani (1997). Shannon Simpson diversity were also computed. For data analysis and visualization PAST (PAleontological STatistics Version 3.06 – Hammer 1999-2015, Hammer et al. 2001) was used.

For comparing the vegetation, multivariate, hierarchic cluster analysis (UPGMA – Unweighted pair-group average, Saitou and Nei 1987) was used, utilizing euclidian mean distance. Diversity was also analysed using Rényi diversity profiles (Tóthmérész 1995).

4. Results and discussion

The taxonomic place of the *Festuca* specimens with spiky paleas and silvery, rough leaves collected in the Homoktöves Nature Conservation Area was uncertain. It varied from *Festuca pseudovaginata* in leaves and hairiness and size of the palea. This taxon was identified as a new taxon for Hungarian flora: *Festuca tomanii*.

During the coenological survey it was verified that *Festuca vaginata* is to be found all along the Danube from Austria to Romania. Based on its coenological composition, *Festuca vaginata* grasslands differ from sandy steppes (*Astragalo austriaci-Festucetum sulcatae*). *Festuca wagneri* occurs in here. *Festuca javorkae* vegetation falls halfway between open and closed sandy grasslands, and it is the least species-rich and diverse one. It has been found only in Slovakia so far but we could not verify its occurrence also in Hungary. The specimens

identified formerly as *F. javorkae* are in fact *F. rupicola*. Thus the Hungarian occurrences of *Festuca javorkae* need further investigation.

In open grasslands within calcareous sandy vegetation (Borhidi et al. 2012), only *F. vaginata* was considered as dominant species for a long time, which was denied by Pócs (1953) for the first time. He discovered *Festuca wagneri* in Hungary, but treated it as a forest-steppe species. The coenological place of *F. wagneri* remained uncertain, though its taxonomy was cleared by Penksza et Engloner (1999/2000), when they identified it as a separate species. Since some greenish specimens in *Festuca vaginata* grasslands treated as *F. wagneri* lose their epidermal hairs and their sclerenchime becomes circular, they were identified as a new species by Penksza (2003), named *Festuca pseudovaginata*, which can form also an association (Penksza et al. 2000). Sometimes they occur in records simultaneously, and in this case they can be separated well by their color. *Festuca wagneri* forms closed grasslands in the first place.

According to Szabó et al. (2017), the soil of the *F. pseudovaginata* differs greatly in organic matter, Ca and Mg, but they did not make soil profiles. The latter was conducted in this work for the first time, during which the environmental background indicated by *F. pseudovaginata* was verified. It was proved that this taxon has formed on forest soils. The soil profile under *F. pseudovaginata* and *F. wagneri* showed forest soil to 1.5 m, and organic matter values proved to be higher. The relative ecological values of the taxa showed that in these vegetation types, cover of plants with greater water and nitrogen demand is bigger.

According to the results, the conclusion of Borhidi (2012) that *F. vaginata* is the only association forming taxon of open sandy grasslands in Hungary, needs refining. It was found that grasslands dominated by *F. vaginata* and *F. pseudovaginata* varied greatly in species composition. We showed that both types include elements of *Festucion vaginatae*, *Festucetalia vaginatae*, *valesiaca* and *rupicola*. The spread of *Cynodon dactylon* and other ruderal species indicate the anthropogenic disturbance in habitats colonized by *F. pseudovaginata*. Literature about grazing has verified that *Cynodon dactylon* accrues under higher grazing pressure, thus it can be used as an indicator of intensive grazing and treading (Deák et al. 2015, Török et al. 2018).

Biomass values of *F. jurpicola/javorkae* and *F. wagneri* were the highest, where values of dicots and legumes were also significant. Despite of this, these grasslands can be utilized economically only for grazing with small ruminants (Tasi 2011).

5. New scientific results

The occurrence of *Festuca tomanii* was verified for the first time in Hungary. These species was described in the northern valleys of the Upper Rhine and the Elbe, and the calcareous sand dunes of Moravia. It was found in the Homoktövis Nature Conservation area and other places.

On calcareous and acidic areas, *Festuca vaginata* is the only dominant species. However, in the central sandy part of Carpathian Basin, populations of the endemic *Festuca pseudovaginata* also occur.

During the examination of open grasslands it was proved that the habitat type of *Festuca pseudovaginata* is the most diverse, and its natural and degraded populations are both important. Based on the relative ecological indicators of the species, these type is the most diverse. During the coenosystematic survey, *F. pseudovaginata* vegetation also occurred in forest-shrub areas.

During the survey of the open and closing grasslands it was verified that *Festuca wagneri* is a member of closing grasslands and it can be found also in the Little Hungarian Plain and in Csallóköz. Furthermore, *Festuca javorkae* has been also found in the area, but its domestic occurrences are questionable yet.

The open *Festuca vaginata* grassland near Györszentiván formed by restoration, was identical to the seminatural open calcareous grasslands in species composition and in dominance relations as well. Grassland regeneration was successful.

The green mass in the biomass of the open sandy grasslands would be enough only for grazing with small ruminants.

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