

Final report of NKFIH KH 130320 project
"Funkcionális növényi jellegek szerepe a gyepterminológiában és a restaurációban."
Project period: 01/12/2018-31/12/2020

Research progress and project results

The work progress followed the work- and timeline of the proposal. In 2019, at the beginning of the proposed research we started collecting the trait data needed to create the trait database (Pannonian Database of Plant Traits - PADAPT). We collected plant seed weight and distribution data for the Hungarian flora. Later we completed the dataset with many ecological indicator values, plant leaf traits and other easily measurable plant traits. During the whole project period, we have been collecting leaf trait and seed weight data with the help of several domestic professionals, supporting the project with field sampling throughout the whole country. In the second reporting period we measured leaf traits and seed weights in the laboratory, following international standardised protocols. In our paper published in *Folia Geobotanica* (IF: 1.242, Vojtkó et al., 2020) we presented new leaf trait data for 491 species. Besides these data published in 2020, we collected data for further 250 species and for more than 400 species in the second project period. In total, we collected plant trait data for nearly 1,200 species. In the spring of 2019, we organised a workshop about creating PADAPT. The workshop, entitled 'Növényi stratégiák és jellegek szerepe az ökológiai kutatásokban', was held on 12 April 2019 in the regional centre of HAS in Debrecen. At this workshop we introduced the recent advances in trait-based ecological research, and together with our collaborators and other domestic professionals we discussed the possibilities and challenges of the construction of a national plant trait database. Based on the discussions of the meeting, we continued the construction of the database. In the second project period we planned a second workshop related to PADAPT, but we had to cancel it due to the COVID-19 pandemic. The process of building an open-access internet database and creating a website has begun. We hope to have a demo version with 15 species ready in the first quarter of 2021, so that the main structure and features of the database and the website can be tested and evaluated by researchers throughout the country. Our future plans include discussing the possibilities of improving the database with other researchers to solve possible difficulties in the usage of the database. PADAPT will be connected with the online version of *Atlas Florae Hungariae*, the implementation is already in progress. There is an ongoing consultation with the authors of the *New Hungarian Herbal – The Vascular Plants of Hungary* (Király 2009) and the *Flóra Database* (Horváth et al. 1995) about including some of their data in PADAPT (for example growth forms, flowering times, ecological indicator values and the flora element classification). This year we plan to introduce our database in a paper published in a Q1 journal, for example *Data in Brief* (2019 CiteScore: 1.5) or *Journal of Vegetation Science* (IF:2.698). The latter is a more promising option, as the reported data could reach a wide community of scientists and gain a popularity and reputation similar to that of the Czech flora and vegetation database (Pladias).

In one work package, we planned to study grassland community resistance and resilience during shrub encroachment. In the publication of Teleki et al. (2020) in *Applied Vegetation Science* we studied the effect of native woody encroachment on grassland plant biodiversity in fragmented loess steppes. We studied the following hypothesis: a) increasing woody encroachment decreases total diversity and the species richness of dry-grassland species; and b) the effect of woody cover on grassland biodiversity differs between ancient and restored grasslands. The selected grassland fragments have been abandoned or some were managed by low-intensity or occasional cattle or sheep grazing. In the study we analysed the effects of woody encroachment and grassland age on diversity, total species richness of the herb layer, and richness of dry-grassland species. Based on our results woody encroachment and grassland age affected the total richness of the herb layer and the species richness of dry-grassland species. The species composition and richness of dry grassland species showed a relatively high resistance to moderate woody encroachment. We conclude that moderately encroached loess grasslands can be easily restored with the suppression of woody species, because many dry grassland specialist species have a high functional resistance and resilience. Woody encroachment was related to changes in the grazing regime. Both abandonment and very high intensity grazing negatively affected loess grassland diversity and resilience. In case of loess grasslands, the effect of moderate woody encroachment is not as detrimental as the effect of an inappropriate grazing regime.

In our paper published in the *Journal of Vegetation Science* (Sonkoly et al. 2020) we tested the germination and seedling growth of 11 herbaceous invasive species in a full-factorial greenhouse experiment. We tested the effects of four levels of seed burial depths and litter cover and their interaction on germination, seedling length and biomass. The changes of seedling number and biomass were analysed across species and at the species level. We found a significant effect of seed burial depth and litter cover on the germination of the studied species but there were considerable differences between species. We showed a general trend that species with bigger seeds were less seriously affected by litter cover and soil burial depth than small seeded species. Based on our results, seed weight is a major driver of species' response to litter cover and to the combined effects of soil burial and litter cover, but there is no general trend regarding the response to soil burial depth. An opposite trend was detected for the small-seeded *Cynodon dactylon*, as its germination was not affected by soil burial. The germination of the relatively large-seeded species *Ambrosia artemisiifolia* was hampered by both factors, despite its high seed weight. Based on these results, seed weight is a very important functional plant trait and a major driver of ecological processes, such as germination and dispersal capacity. We stressed that the response of species to soil burial and litter cover is very important when planning the management and restoration of threatened grassland habitats.

At the end of project period we published a paper in the journal *Preslia* (IF: 4.357, Takács et al. 2020), which provided evidence for the hybridization between *Galatella villosa* and *Galatella linosyris*, and the hybrid *Galatella* × *subvillosa* is reappraised. Specimens morphologically intermediate between the two parent species were recently observed at the westernmost distribution of the steppe species *G. villosa*. Based on the results of the study *G.*

villosa is likely to be the maternal parent in the Hungarian and Ukrainian populations and *G. linosyris* in the Serbian population. The intermediate forms produced sterile seeds. However, based on genetic analyses *Galatella* \times *subvillosa* is not really a hybrid of these two species. The hybrid *G. linosyris* \times *G. villosa* was described in this publication as a new nothospecies *G. \times feketegaborii* A. Takács, Sennikov et Sramkó. The study also demonstrated how readily available molecular phylogenetic tools can be used to prove the hybrid origin of plants.

Two further papers were published in the Hungarian journal *Kitaibelia* (Takács et al. 2020, Bódis et al. 2020) which presented new information on species accidentally distributed by the ornamental plant trade (*Cardamine occulta*, *Eclipta prostrata*, *Euphorbia prostrata*, *E. serpens*, *E. maculata*, *Veronica peregrina*, *Amaranthus emarginatus*); and presented new data about the protected species *Fritillaria meleagris*.

Another publication based on the results of the project is still under review. The manuscript by Balogh et al. is based on functional trait analyses. Biomass removal and defoliation are among the most important effects of grazing on the vegetation, while the sufficient quantity and quality of plant biomass is an important ecosystem service for animal husbandry. In this study we conducted a trait-based analysis of the effect of low and medium intensity cattle grazing on the species-rich meadow steppe vegetation, and of the preference of grazing animals. We wanted to test what kind of plants do Charolais cattle prefer (i.e., graminoids, forbs, litter or moss). Specifically, we asked: What are the direct effects of grazing on the main biomass fractions? Besides, which traits distinguish the preferred and non-preferred plant species? We calculated flowering shoot number and the trait-based analysis extended it to plant species, which were present on control and study area too. We grouped the species based on preference: (i) non-preferred, (ii) moderately preferred and (iii) highly preferred group. Based on our results the reduction of the live biomass of vascular plants was 65% in grazed units compared to the controls and cattle grazing significantly decreased the flowering success of plants. Plant species preferred by cattle were characterized by high specific leaf area and high nitrogen content. We stressed that to ensure the reproduction of most plant species in the long term it is unfavourable to graze an area every year in the same period. We emphasized that, in the long-term, the appropriate management is heterogenic and spatially mosaic cattle grazing. Long-term grazing management can be planned and livestock carrying capacity of an area can be effectively evaluated by measuring biomass fractions and the trait-based analysis of the nutritional value of plants (for example SLA, LA, LDMC, nitrogen content).

Publications related to the project

During the project period, in line with the dissemination plan, four papers were published in international refereed journals with an impact factor. We published a paper in *Applied Vegetation Science* (IF :2.574), one paper was published in *Journal of Vegetation Science* (IF.:2.698), and a database paper closely related to the proposed functional trait database, the Pannonian Database of Plant Traits (PADAPT) was published in *Folia Geobotanica* (IF: 1.242). In the second reporting period one additional paper was published in *Preslia* (IF: 4.357) and two other publications in the Hungarian botanical journal *Kitaibelia*. One additional manuscript is being reviewed for an international journal with an impact factor (Balogh et al., manuscript).

Communicating the results in conferences

In the first study period we presented our results at many international conferences and also at several national conferences and workshops. In the first period we visited two international conferences, the 62nd Annual Symposium of the International Association for Vegetation Science in Bremen, Germany, and the 16th European Grassland Conference in Graz, Austria. Edina Tóth and Judit Sonkoly held oral presentations in the conferences. In 2019, three national conferences and workshops took place in Debrecen, where members of the NKFIH project presented oral presentations. The conferences and workshops were the following: "Növényi stratégiák és jellegek szerepe az ökológiai kutatásokban", "Rising Stars" - Tehetséges Fiatal Ökológusok és Evolúcióbíológusok Bemutakozása", and "90 éves a DE Növénytani Tanszék Botanikai kutatások Debrecenben: növények a környezet és a társadalom szolgálatában". Attila Takács also hold an oral presentation at the Celebration of Science event in Budapest, 2019.

In the second study period we planned to attend three international conferences, the 63rd Annual Symposium of the International Association for Vegetation Science (Vladivostok, Russia), SER Europe 2020 (Alicante, Spain) and the 17th European Grassland Conference (Bilbao, Spain). We have already registered for the 63rd IAVS Conference, but the IAVS Governing Board and the local organizers for the Vladivostok symposium and organising committee of EDGG and SER have also decided they must cancel the symposiums due to the global pandemic of COVID-19. Thus, the dissemination of our research in the form of conference oral presentations was forced to be omitted in 2020. We were able to successfully recover a high portion of the conference costs, and because of the flexibility of the grant provider, we were able to use it to cover further research expenditures.

Scientific importance of results related to the project

The results of the project period are of great national and international interest. All planned publications have been published in Q1 international journals, so the results obtained can be expected to be of great scientific interest, and the resulting database is also of outstanding unique value. The PADAPT database is a very important local plant trait database in the Pannonian region. In the last few decades, a number of international databases have been set up, in which the most important measurable plant properties (= traits) are collected in order to meet the data needs of targeted basic research. An example of such a database is the LEDA (Kleyer et al. 2008) database, which is a collection of vegetative, generative, and propagation traits; the CLO-PLA (Klimešová & de Bello 2009), which is a searchable database of vegetative growth and propagation data, the GLOPNET (Wright et al. 2004) database summarizes the physical, chemical and structural properties of leaves, the SID database (Liu et al. 2008) is a compilation of seed trait data, while the BIOPOP (Poschlod et al. 2003) and BiolFLOR (Anonymous 2004) databases deal with plant life characteristics. The database TRY (Kattge et al. 2020) also compresses a wealth of character databases. These databases provide data on many plant characteristics and properties, but their disadvantage is that in many cases the data come from many sources, several countries, and from under different climatic conditions.

Therefore, the usefulness of the data may be limited, as different climates and different local biotic and abiotic environmental conditions affect individual plant characteristics. This problem led to the creation of a domestic database of plant characteristics of the Pannonian flora. The PADAPT (Pannonian Database of Plant Traits) will be a database of a number of easily measurable plant traits and seeks to summarize as much measured and easily measurable data on native plant species as possible, based on domestic collections, measurements and previous domestic publications. The database will be freely accessible for researchers to provide effective assistance for trait-based ecological studies. The presented publications highlight the importance of functional trait-based analyses in restoration and conservation ecological research.