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Coenological, grassland management and nature conservation assessments and evaluations of different utilized grasslands of Great Plain

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Background and objectives

Pastroalism has a long tradition and results in retrospect in Hungary. Extensive livestock farming accompanied our history, since even before conquest time this lifestyle was typical among Hungarians. Animal husbandry is an integral part of the ancient peasant farming. In domestically lands mostly wooded grasslands have been formed as combined effect of natural factors, which are the extreme climate, diverse soil conditions and mainly the human converter activity. These collectively resulted formation of new grassland areas. Legislation of pastoalism has already begun in the 17th century. In the 19th century grassland improvement and domiciliate respecting regulations have already appeared, reflecting the fact that Hungarian cattle was a desired product in the markets of Western Europe (Herman 1909; Dorner 1928).

Decline of importance of grasslands have already started in the early 19th century – and still in progress nowadays. Several factors strengthen this condition such as arable field demand of agricultural product manufacturing industry, regulations which affecting pastors and even the fact that old pastors – whose were effective and well they understood effects of animals and grasslands – were removed and new pastors were in lack of appropriate skills (Vinczeffy 1993, 1996, 2005; Viszló 2007). However significant parts of grasslands were rescued for future generations by grazing and mowing (Rakonczay 2001a).

The principal criterion of extensive livestock was to preserve quality of grasslands in long term as well as most economical utilization of animals and pastures. Nowadays the main purpose to incorporate these nature protection aspects – mainly into natural or semi natural grasslands – into grassland management systems (Béri et al. 2004; Bodó 1997; Barcsák and Kertész 1986). Nevertheless, it can not be ignored that the pasture, such as living space contributes to the maintenance of genetic diversity (Bodó et al. 2006). Our grasslands have such peculiarities which are very important in biodiversity protection aspects. These are the follows: higher proportion of natural vegetation, larger habitat diversity, specimen richment in case of flora and fauna, for these traditional farming methods contribute positively (Figeczky 2004, Szemán 2001, 2003, 2005a, 2005b, 2006).

To answer how grazing intensity effect vegetation change, we give data from coenological surveys and their interpretation. With this we would like to point out how may comply the needs of nature protection and management, thereby revealing the delicate balance between two – often opposite – interest. Plant species which can be found on grasslands provide important information in nutrition aspects. Grazing grass – or its product the hay – nutritional value is highly depend on botanical composition thereby affects relative proportion of useful or less useful grass species (Haraszti 1973; Barcsák and Kertész 1986).

General aims:

Studies mainly directed whether there are any changes in vegetation during the period under review. Another question was – if changes can be observed – original vegetation, composition of associations alters in which direction and how these affect dominance relations and presence of dominant species.

Answers were seeking for the follows:

- To what extent can be detected the change in spatial and temporal context of grazed areas?

- Does species composition and dominance relation react similarly to grazing of dry and fresh orientation areas or not? Does grazing homogenise grazing areas and mask the differences? How grazing intensity contribute to preservation of diversity?
- Are there (if so, where and what kind of load and grazing intensity) field sections where grazing – as treatment – meets nature conservation needs?
- How does change the amount and composition of biomass?

Materials and methods

Sampling areas

Sampling area can be found in Pannon biogeographic region between Duna and Tisza rivers (Marosi and Somogyi 1992). Field at Bugac is a dry-, while field at Tatárszentgyörgy is wet lying grassland. For comparison, these two types were analyzed in details. Further investigation was taken in case of a field near to Kunbaracs, which forms transition between dry and wet grassland. All three sampling areas located at the area of Kiskunság National Park. First area is a dry grassland pasture formed on sand, situated south-west from Bugac. Second area is wetter grassland, which situated south-west from Tatárszentgyörgy. The third area include characteristic of the previous two areas and located west from Kunbaracs.

Sandy grassland of Bugac (*Potentillo arenariae-Festucetum pseudovinae* Soó 1938, 1940), can be found at higher spatial. Grazing carried out continuously since 1990. Free grazing was applied on its area until 2000, and then sectioning were performed. Cows and sheep are kept on this area. Loading of the grassland is 0.4 livestock/ha.

Sampling area of Tatárszentgyörgy is a lower lying, which can be classified into *Deschampsenion caespitosae* association group (Borhidi 2003) with marsh (*Agrostio-Deschampsenion caespitosae* Ujvárosi 1947) association. Salinisation can be observed occasionally in the sample areas and drying out bog vegetation fragments (*Molinio-Salicetum rosmarinifoliae* Magyar ex Soó 1933) appeared as well. Area grazed only with cattle, however loading of the grassland identical with the previous one: 0.4 livestock/ha.

Grassland at Kunbaracs – similarly to the area at Bugac – located on a sand ridge. Horses and sheep are kept on this area. Loading of the area is lower than in the two previous cases: 0.5 livestock/ha.

Coenological survey

Recordings from Bugac were taken in June of 1997, 2005 and 2010. Coenological recordings were taken in June of 2007, 2008, 2009 and 2010 in case of Tatárszentgyörgy and Kunbarancs. For recordings Braun-Blanquet (1964) methods were applied –2×2 m quadrates were performed – coverage values specified in percentages for each species. However, each level of coverage values was taken separately. Names of species follow Simon (2000) nomenclature.

In order to monitoring the changes, grazing pressure and intensity of grassland usage, plants were divided into three sections, zones:

- „A” zone: 0–50 m, the greatest degree of disturbance and trampling can be observed here,
- „B” zone: 50–150 m, moderate disturbance prevail,
- „C” zone: 150 m–, disturbance is negligible.

Biomass examinations.

In case of Tatárszentgyörgy and Kunbaracs areas biomass investigation were taken by guidance of Tasi (ex verbis). Paralel with coenological recordings, from north corner of the 3th coenological record, a 2×2 m^2 grassland part were cut by trimmer leaving 7cm high stubble in order to model effect of grey cattle. Sampling was taken from the middle 1×1 m^2 part. Trimming waste was sorted according to important groups of grazing. Coverage values of each grass forming was calculated from total coverage percentage per mass ration of each grass forming. At this point I have received ratio of average coverage values and mass ratio of mowing samples. For grassland qualification Klapp-type (Kalpp et al. 1954) classification system performed.

Processing of data

Processing of coenological data, during specifying species number and calculation of diversity whole set of species were applied. Species, that coverage values were below 1%, were omitted during classification and ordination. Evaluation of data based on bioindicator values, such as relative water demand (WB), relative nitrogen demand (NB) and relative temperature requirements (TB) (Borhidi 1995). Evaluation of social behavior based on Borhidi (1995), while distribution of natural protection categories based on Simon (2000). Life forms completed according Simon (2000), however categories of Pignatti (2005) were added.

During statistical evaluation normal distribution models established, in which species number and number of individuals appeared as dependent variable (coverage values in case of plants). As description variable SHDI value and transect-position values – which indicate inner or marginal position of transects – were applied. Farmer and area effects were taken into model as random factors.

Typical total coverage average, average species number and Shannon-diversity were calculated for each area (Pielou 1975). These were compared pairwise by multiple analyses of variance (ANOVA) in order to measure the effect of grazing intensity. As post hoc test Tukey HSD was applied, which give us adjusted *p*-values, thus Bonferroni-correction performance not necessary.

After calculation of Shannon-diversity of each recording, averages were taken from each area and these were compared beside the increasing disturbance in case of both areas. Beyond calculation of average diversity values, draw the diversity profile represents additional information. For this Rényi-diversity were performed (Tóthmérész 1995).

Results and Discussion

Species composition, vegetation analysis and species diversity

According to zone and area partition of Bugac and Tatárszentgyörgy, distribution of treatment type showed that among species of recordings from „A” zone 3 was weed and these occurred only here. Among species which in general occurred in „A”, „B” or „C” zones, only one race was common *Achillea asplenifolia* – according Simon (2000) it is a characteristic race for natural vegetation, while according Borhidi (1995) it is disturbance tolerance race. Regardless zones and locations ten weeds found among species. Other species, which represent 47%, was disturbance tolerant.

Regarding to species belonging ratio reversed in case of species which occurred only in Bugac and Tatárszentgyörgy. Amount of weeds decreased, in case of Tatárszentgyörgy were not present. In case of Bugac, only *Carduus nutans* occurred as weed. Among disturbance tolerant species, only 2 were recorded in Bugac, in case of Tatárszentgyörgy species from this category were not present. Pioneer species from Bugac occurred in the recordings (e.g. *Bromus squarrosus*, *Anthemis ruthenica*).

Species which occurred in examined location were presented in significant ratio (20-25%). This occurrence was less than occurrence of characteristic species of each area. This group involved species of natural grasslands and taxons of more disturbed area. Among common species components of natural grasslands (K, E, C, and G) showed larger coverage values in Tatárszentgyörgy sampling area.

Data is more evident if dry area compared than wet. Coenological recordings are well separated in stable near areas of „A" zones (territorial tracks (területi sávok)). Recordings from Tatárszentgyörgy form homogenous groups as well. From these recordings of „C" zone of Tatárszentgyörgy (2007) separated and enclosed into „A" territorial tracks as integrated group. Recordings among Bugac, „B" tracks (1997) positioned between „A" zone quadrates. Results of two-way Anova analysis, which was applied in case Bugac area show coenological recordings of „A" involved into „B" zone which enclosed as a single group in 1997. Sample quadrates of „B" and „C" zones mixed as well.

Analysis, made by two-way Anova resulted definite separation of coenological recordings from „A" zone. Recordings of „B" territorial band appeared in one block. Coenological recordings of quadrates which belong to „C" group formed units divided. „A" recordings from 2007 enclosed into element of „B" block as integrated group.

Results of classification confirm results of PCA analysis. Recordings of „A" zones from dataset stretched out protractedly that separated from quadrates of „B" and „C" territorial zones. In case of recordings of Bugac, quadrates of „B" zone were the closest to quadrates of „A" zone. Large part of recordings of „C" zones arranged roughly into two groups. Records were found uniformly and completely separately only in case of recordings which were taken from 2007. Recordings of „B" and „C" zones separated from each other in case of Tatárszentgyörgy and Bugac.

Development of species number in case of Bugac and Tatárszentgyörgy: the largest number of species observed in „B" zone of Bugac, even „C" zone had larger number of species than „C" zone of Tatárszentgyörgy. According to annual statistic – in the aspect of number of species – continuous decline was observed in „B" zone, while increment was observed in „C" zone. However development of average species number showed different tendency per quadrate. Equalization of number of species can be seen in case of „C" zone. Despite of largest total number of species were observed in „B" zone, according to smaller average number of species smaller values were characteristic, however these shown increase.

According to Shannon-diversity diversity was smaller in „A" zone of Bugac than in territory which located farther in each year. It was higher in „B" and „C" zones. It can be observed that diversity showed the smallest results in 1997 and both 2005 and 2010 had higher values in all territorial blocks.

Diversity in „A" zone of Tatárszentgyörgy was high in the first two years (2007 and 2008), however it suddenly decreased in 2009 and 2010. In case of middle „B" zones diversity was constantly permanent during the four years, while the farther located „C" zones showed medium, then high (for three years) results.

In case of Kunbaracs diversity of „A" zone quadrates was fluctuated. Its measure was smaller in „B" zone and only the last year results were outstanding, while it has decreasing tendency in „C" zone.

Diversity not changed significantly in „A" zone of Bugac, its values were 2.15, 2.41 and 2.30 in each year. Father from the stable these measures increased both in „B" zone (50-150m) quadrates – 2.48, 2.97 and 3.18 – and „C" zone – 2.89 2.92 and 3.25.

Similar deduction was taken from number of species formation. Smallest values were observed in disturbance exposed „A" zone, while in „B" and „C" zones these values were higher and increased with time.

Considering average diversity of examined years in case of Tatárszentgyörgy recordings, „A" zone was the smallest (1.62), than the farther located „B" and „C" zone which had higher values (2.93 and 2.80):

Profiles of Rényi diversity

In Bugac three distinct disturbance types separate well with the help of Rényi-diversity profil. The most disturbed „A" zone curve showed the smallest diversity values, while curves of „B" and „C" zones went together at the beginning – their diversity was the same – than it separated at the larger alpha values and diversity of „C" zone –the less disturbed area– became the largest. In this investigation each years were merged and only differences of places and territories were evaluated.

Occurring determinate grasses were *Cynodon dactylon, Festuca pseudovina* and *Poa angustifolia* in coenological recordings of Bugac dry grassland. *Cynodon dactylon* was found throughout, but it's achieved its maximum in „A" overgrazed zone. This race had high coverage in 2nd and 3rd recordings in 1997 „B" zones, nearly reached 20%. *Festuca pseudovina* found everywhere at the territory, however it had large coverage values in „B" zone recordings. Significant occurrence of *Poa angustifolia* observed in „C" zone quadrates in 1997, however it decreased to 10% by 2005.

Analysis according ecological and environmental factors

Borhidi's relative scores based on the followings: away from stable average of nitrogen demand indicator NB value decreased. In case of stable near area – well tramped and fertilized – nitrogen-disposed species multiplied. According to species list of 5 quadrates the average nitrogen demand away from stable decreased in tendency (4.66, 4.00 and 3.91).

„B" zones resulted to be the wettest in case of both sampling areas according to relative water demand indicator means. Clearly outlined, that values from stable near area were identical, however father from stable occurrence of species indicated dry area in case of Bugac, while wet area in case of Tatárszentgyörgy. Average values of water demand indicate clearly drier Bugac areas.

<u>Distribution of species according to value category of nature protection.</u> Disturbance tolerant species (TZ) were present in larger amount in 0-50 m area category. Proportion of weeds was around 40%, which indicates reduction. Species referring natural status was present in minimal amount close to stable. In case of all examined area natural disturbance tolerant species of middle zone were present in the largest amount. In both „B" and „C" zones accompanying (K) and association forming (E) species can be observed in larger amount.

<u>Development of social behaviour forms.</u> Natural disturbance tolerant (DT) and ruderal competitors (RC) presence was determinate in „A" zone. Proportion of former decreased while the latter increased during years. „B" zone of second field category the presence of DT species remained high, however RC species was replaced by other stress tolerant species such as generalist (G) and specialist (S). From ruderal species presence of competitors (C) was determined.

Recordings of „C” zone developed similarly to recordings to „B” zone in the aspect of social behaviour belonging quantitative relationship of species.

Results of biomass examination

Application of data from 2007 and 2008 Klapp-like grassland classification were taken in case of Tatárszentgyörgy and Kunbaracsi areas. According to the results proportion of prime grasses increase further from stable, while amount of tercier grasses decrease. Amount of legumes was not significant. Neutral monocotyledons – mainly *Carex* species– occurred in significant amount further from stable. In case of recordings from 2008, their amount was stronger due to the more humid year. Species composition of grassland in aspect of nutrition was weak near to stable. Proportion of less valuable species was significant according to species composition based on nutritional aspect.

Species composition of Kunbaracs grassland was valuable in the aspect of nutritional view (Figure 41-42) due to large coverage of *Elymus repens* and *Festuca arundinacea.* Extremely high coverage values measured in 2008 near to the stable due to animals were not carried out so the grassland was able to regenerate. Proportion of less valuable species was significant in the aspect of species composition of nutritional consideration. Distribution according to grassland forming the fore mentioned grasses had high coverage values and for this reason proportion of prime grasses was outstanding near to the stable. Away from stable secondary grasses appeared. Third rate grasses were present in all recording zones and their largest proportion observed in „B” zone of 2007. Prime grasses were absent in „A” zone, however they appeared in large proportion in „B” and „C” zones which refers to overgrazing.

New Scientific Results

1. Floristic results

1.1. Species list of examined area prepared. Besides protected plants characteristic weed and appearing invasive species recorded. Found protected species were *Blackstonia acuminate* and *Koeleria javorkae* in Kunbaracs.

1.2. A species group were determined which can be apply as indicator. Due to strong trampling, dominant disturbance-tolerate species appeared consistently *Cynodon dactylon, Lolium perenne, Poa humilis* and *Polygonum aviculare*.

2. Results of vegetation study

2.1. I have clearly demonstrated – in case of three grasslands, both wet and dry lying field – that grazing have different long-term effects on vegetation composition and species richness. Due to the influence of intense trampling pressure, specimen richness of grasslands reduced. Wet and dry lying areas showed different tendency in case of species richness. Dry area was richer in number of species, even in the typically poor precipitated years when each grassland declined in species variety.

2.2. I have determined that coverage values of disturbance tolerant dominate species were stable due to effect of trampling, grazing and climatic effect. Coverage values of dominant and accompanying specie, however, react sensitively to the increase of trampling, grazing and even for the typical weather conditions of the year – including distribution of precipitation as well.

2.3. Long-term study of grazing pressure in Bugac demonstrated that natural status in case of cattle stable and area which is close to stable continuously to deteriorate since. Aggressive alien species appeared in vegetation. Further from stable associations continuously switch into natural vegetation. Degradation increment can be observed in the examined periods, although in lesser degree. Specimen composition changed as well, since coverage values of disturbance tolerant species increased, while number of natural state indicator species decreased.

2.4. I have applied Pignatti-like life forms at first in case of analysis and investigation of grasslands in Hungary. I have successfully showed that it is a good indicator value to analyze grazing. In case of „A” zone, there are groups on the intense trampled and grazed fields, that are indicators since quantity of annual (T scap) and crawling annual (H rept) species accumulate.

3. Results of grassland management

1.1. According to nutrional values of grasslands I concluded that on wet areas with the decrease of trampling intensity the amount of prime grasses – more valuable in aspect of nutrition – increase, while presence of tercier grasses decrease inversely. In more humid years proportion of neutral – in grassland management point if view – graminae increased significantly. Prime legumes were absent near to stable, however appeared in great amount further from stable, which could refer to the overgrazing of further areas. With loading reduction of dry areas proportion of valuable – in nutrition aspect– species increased.

1.2. Effect of grazing type change revealed from vegetation, which has natural protection aspect as well. Total area became more valuable in the aspect of grassland management and natural protection as well.

New scientific results

1. Examined areas can suffice economical and natural protection needs using obtained results and with the reduction of grazing intensity.

2. In case of some sample areas between Duna and Tisza rivers, wet grasslands are more vulnerable for grazing pressure and climatic effect. Dry grasslands are less vulnerable and can tolerate stronger grazing pressure. In case of reserve grassland management and nature protection values both type of territory (dry and wet lying areas) maintenance – in this present case grazing – necessary.

Conclusions and Suggestions

For the preliminary hypothesis that whether territorial status degraded due to continuous grazing the answer is: „A” zone was rich in weeds, as consequence of strong grazing and excessive trampling similarly to the results made by Wilson and MacLoad (1991). This was mostly true for Bugac and Tatárszentgyörgy where no upward road can be found and driving out happened across this field. From grasses, *Poa humilis* can be found only here – on overgrazed and trampled area. This race – similarly to other overgrazed Pannon areas (Szentes et al. 2007, 2009a, 2009b; Penksza et al. 2009a, 2009b) – can be considered as indicator of overgrazing but it is typical at ruderal areas as well (Penksza and Böcker 1999/2000). This test series confirmed its indicator nature. Beside *Poa humilis* the following species occurred: *Cynodon dactylon, Lolium perenne, Polygonum avicular*. These species are trampling and intensive grazing indicators.

Grazing transformed significantly the species composition of the area. There was a decline in number of species and increase in amount of weeds since occurred species in coenological recordings was mainly weeds and disturbance tolerant – approximately quarter part of diagnostic species – in „A zone (Simon 1988). Natural vegetation was typical in case of „B” and „C” zones of dry lying Bugac grasslands, sandy grasslands and wet lying areas of Tatárszentgyörgy. These species not only present here but exceptionally in number of species and coverage values. Beyond generally occurring species, proportion of weeds and species of disturbed areas were small. Grazing did not transform significantly species composition of the areas opposite to preliminary hypothesis. Vegetation composition was determined and did not changed irreversibly only in case of stable close areas. This study confirmed parallel with previous studies (Catorci et al. 2009, 2012; Tóth et al. 2003; Noy-Meir et al. 1989, Fernández-Alès et al. 1993, Hadar et al. 1999) that grazing has its favourable effects on species composition and number of species.

Diversity values in Bugac and Kunbaracs areas increased farther from stable. This was typical for „B” and „C” zones as well in the examined time period. Regeneration processes can be observed in the farthest zone – where animals stayed rarely due to pastored grazing – of Kunbaracs. Moderation of disturbance natural regeneration processes came forward and complexity of associations increased during succession (Tóthmérész 1995; Virágh and Bartha 1996; Pykälä et al. 2005). Similar conclusion was reached with the examination of species number. In case of extensive disturbance („A” zone) stochastic processes came into view since organization was (Tóthmérész 1995; Luoto et al. 2003; Házi et al. 2011). Number of species show positive correlation with time period in the two farther zones. This increased monotonously according to our exceptations. Although number of species is not completely reliable criterion of an association but comparing observed diversity data with two metric numbers complements each others and their reliability increase (Virágh and Bartha 1996; Pykälä et al. 2005, Luoto et al. 2003, Házi et al. 2011).

Diversity profile of Rényi-type showed similar tendency in both areas, herewith confirmed grazing effects wet and dry Pannon grasslands similarly. Values in case of drier area were higher which confirm that dry areas preserve species richness despite of intensive grazing. Therefore they are more suitable for grazing.

Literature confirms that low grazing pressure increase diversity in „A” zone (Bakker 1989, Tóthmérész 1995; Nösberger et al. 1998; Kampmann et al. 2007). According to relative ecology values occurring species had high nitrogen demand in „A” zone because of trampling and fertilization of animals Penksza et al. 2009a and 2009b). In case of „B” and „C” zones lower grazing intensity resulted appearance of smaller nitrogen demand species. According to relative water demand (WB) „B” zone of both sample area occurred to be the wettest. In case of „B” zone of Tatárszentgyörgy, species from wet areas dominated due to presence of large water demand *Carex* species (Borhidi 1995; Simon 2000). According to relative heat demand (TB) clearly determined that Bugac area has dry grassland vegetation and its fauna consist of warmer climate specific species. The largest difference can be observed in „B" zone of Tatárszentgyörgy – wetter area – which contains species of colder area (e.g. *Carex* ssp., *Mentha aquatica* and *Molinia coerulea*).

Distribution according to life habitats significant differences were observed between quadrates of field categories. Besides annual species (T scap) amount of creeping perennial species (H rept) were significant in coverage percentage and in number of species. These species multiplied due to intensive grazing and trampling similarly to the results of Gatti *et al.* (2007) and Catorci *et al. (*2012). In intensively trampled „A" zone as a result of loading, annual had not significantly larger coverage. These results are conflicting with previous experiments (Kahmen and Poschlod 2008, Catorci et al. 2012). Amount of perennial grass species (H caesp) similarly to other experiments (Gatti et al. 2007; Sebastià et al. 2008) grow in areas away from stable which are less exposed of trampling and grazing. Amount of H rept species significant in „B" zone of Tatárszentgyörgy which indicate the effects of intensive grazing (Gatti et al. 2007; Sebastià et al. 2008). The high proportion is due to animals cut open creeping grasses during trampling and thereby contributes to their multiplication.

For the question that are there areas (if yes, where and what kind of load) where treatment and grazing meets with conservation needs, the present study give answer. Stronger grazing in drier grassland (Bugac) leaded to development of more valuable vegetation of „B" zone. Diversity and conservation values of „C" zone increased during examined period, however it is still behind „B" zone in the aspect of natural protection evaluation. Its main reason the change of husbanding. Discontinuous grazing was replaced by free grazing and with this grazing pressure became more consistent in „B" and „C" zones. Development of grass composition which preserve national conservation in case of wet lying grassland of Tatárszentgyörgy realized besides smaller grazing loading in „C" zone.

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