Theses of Doctoral (PhD) Dissertation

HABITAT MANAGEMENT OF LOW-LYING HORTOBÁGY GRASSLANDS BY GRAZING DIFFERENT CATTLE GENOTYPES

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1. INTRODUCTION AND GOALS OF THE THESIS

Among the extensive agricultural farming systems in Hungary, grassland farming systems are the most important from both an economic and a nature conservation point of view, as about a third of the protected plant and animal species are linked to them (Török et al., 2013). More than 250,000 ha of grassland areas are under nature conservation protection (Ángyán et al., 2003; Kárpáti, 2007), therefore, in order to protect or restore these areas, it is necessary to develop a nature conservation grassland management method where the coordination of agriculture and nature conservation is of paramount importance. This is especially true in those sensitive natural areas, where the maintenance of agricultural cultivation is a basic condition for the preservation of biodiversity. Grassland maintenance is for the purpose of nature conservation, when the production goal is not the production of fodder, but the provision of habitat for protected organisms using grassland management methods (Szemán, 2006).

Grazing with farm animals is one of the options for managing grasslands valuable from a nature conservation point of view, which can be a solution for preserving the species richness of grasslands. Traditional grazing plays an important role worldwide in nature conservation management programs aimed at preserving grasslands (Török et al., 2014). The successful application of grazing in order to achieve environmental protection and biodiversity goals requires thorough planning and must be adapted to local conditions (Tóth et al., 2018). That is why comprehensive extensive grazing programs are needed, supplemented by ecological, botanical, agronomic, animal husbandry research results.

From the point of view of nature conservation, in addition to the general effects of grazing, the species and breed of the animal are determinative. Different species of animals have different grazing habits, but in this regard, large differences can often be observed even within species (Pauler et al. 2019). As a result, each species or variety has a different effect on grasslands. The different dietary choices and grazing methods of individual species and breeds determine the species composition and structure of the lawn (e.g. the less time a species spends grazing, the less trampling damage).

Native breeds play an important role in grazing protected areas. The native Hungarian gray cattle spread mainly on the saline grasslands of the Great Plain. These varieties are the best adapted to the local characteristics, they are resistant and do not require special care, and their importance for tourism is also increasing (Gencsi, 2005; Kárpáti et al., 2004). Thanks to the "gentler" grazing of the Hungarian gray, it can create favourable habitat conditions for several plant species, which can lead to the creation of species-rich pastures (Szentes et al., 2009a).

The demand for food produced under natural conditions is increasing more and more, which entails an increase in the economic importance of Hungarian gray cattle. It is less suitable for fattening and as slaughter cattle, because its growth rate is medium and it shows less good meat forms. It is not competitive with the production indicators of world breeds, but its real significance today is that it represents a gene reserve, its meat is used to make special products, Hungaricum products, and it is also an important animal for national parks, nature conservation, and rural development programs.

Among the intensive breeds, the charolais is one of the best beef breeds in the world due to its meat quality and ability to grow. Due to their large body weight, they already have a greater demand for grass, and they are also more demanding on the quality of the feed. They play a minor role in turf management for the purpose of nature conservation, despite the fact that they have many properties (excellent grazing ability, feed utilization and adaptation to extreme conditions) that favor sustainable grazing. They are primarily suitable for grazing dry areas. Since they are large breeds, their trampling on the soil and vegetation is significant, especially in wet areas, which can cause problems. Even under extensive and intensive conditions, the types of the breed mostly contain the quality characteristics that make the breed a world breed - they have excellent fattening and cutting properties and favorable meat forms (Herd Book Charolais, 2004).

In recent decades, several attempts have been made to restore the previous traditional farming, but only a few studies are available that compare the effect of extensive and intensive varieties on the composition of the vegetation (Rook and Tallowin, 2003; Pauler et al., 2019). In the course of several years of work, several researchers have come to the conclusion that the less selective grazing of Hungarian gray cattle than the intensive breeds probably creates more "leaks" in the lawn, where other, mainly dicotyledonous species can settle (Szabó et al., 2011). On the other hand, the animals that require intensive husbandry technology graze more homogeneously, the above species settlement is limited, this is shown in the smaller number of species and the lower value of the number of species combinations.

My research is a topic related to nature conservation and agriculture, which is closely related to the work carried out in the framework of a LIFE+ project entitled "Habitat management of pasture lakes in Hortobágy". During the program, the artificial channels and dams that threaten the catchment areas of the pasture lakes were removed, and the number of grazing animals in the project area was significantly increased and a nature conservation grazing system was introduced. With our research, we joined the LIFE+ program at this point.

During the restoration of the pasture lakes, the main goal is the local suppression of competing plant species, the creation of habitats for other species, and the conversion of reeded saline marsh habitats into open saline bodies of water by grazing. In the project areas, grazing for the purpose of nature conservation was solved with extensive and intensive beef cattle, buffalo, and sheep, so I had the opportunity to examine the effects of the smaller-bodied extensive and the larger-bodied intensive beef cattle breeds on the vegetation and soil of the pasture.

Objectives

The main goal of my research is to determine whether grazing for conservation purposes can also be achieved with beef cattle breeds that are more profitable, economically favorable than the Hungarian gray cattle breed, with low and medium intensity grazing on different habitat types (saline meadow, saline marsh) and similar environmental conditions.

Aim of the research:

• Determination of the differences between the vegetation characteristics of the two habitat types (alkaline wet pasture and alkaline marshes) when grazing with beef cattle of different genotypes.

• Demonstration of the effect of grazing with a low and medium number of animals on the composition, diversity, coverage values, nutrient content and biomass of the pasture's vegetation (hereinafter: vegetation characteristics).

• Determination of the difference between the grazing of beef cattle of different genotypes (Hungarian gray and intensive beef cattle of a mixed genotype) on the vegetation of the habitats.

• Comparison of the soil of different habitats based on their physical and chemical properties.

2. MATERIALS AND METHODS

2.1. Characterization of the examined pastures, associations, and presentation of cattle types

Pap - ere

One of the deepest points of Hortobágy. The Pap - ere that broke out of the Hortobágy stream (mainly due to floods) and other smaller veins that broke out from it brought the flood water into the depressions every year (Ecsedi et al., 2020). Following an ancient riverbed, Pap-ere is located to the east of Hosszú-fenék, a slightly southerly sloped area with salt marshes. In its southwestern areas, the damaging effects of the former rice fields is still visible in some places. The natural movement of water was hindered by the existence of the Tonnás - canal, the draining canal of the Kungyörgy fish pond, which cut the area in two from west to east. The Tonnás canal, which caused the greatest natural damage, was closed in 2019. This made it possible to connect the catchment areas of the natural deep lying areas, as well as bare surface and underground water movements.

Zám-puszta

Zám-puszta is one of the most important representatives of the southern Hortobágy, which were previously flooded by rainwater carried by the Sáros-ér and the Árkus river. The excess water flowed back into the veins through the steps, and only remained more permanently in the deepest lying areas (Ecsedi et al., 2020). In the past, only a few places on Zám were heavily grazed and trampled, and the accumulation of rotting reeds and mats was more typical. The reed - cattail stands were species-poor.

Alkaline marsh

Alkaline marshes (*Bolboschoenetum maritimi*) occur in deeper areas, so they are under water for longer than saline meadows, which is why their vegetation is fresher (Deák et al., 2014c). Characteristic species are *Bolboschoenus maritimus*, *Eleocharis palustris and E. uniglumis*, *Agrostis stolonifera*, *Carex melanostachya*, and *Potentilla reptans.*

Alkaline wet pasture

Alkaline wet grasslands (*Beckmannion eruciformis*) occur in areas that are also fresh, but at a slightly higher elevation. In summer, they dry out completely, and the soil surface cracks polygonally. After heavy summer rains, they can become waterlogged again for a few weeks. Some of the stands of the saline grasslands are secondary, because they were formed in the place of the former marshes after the water management. As the amount of water decreased, the zones were located lower, which may be partly the reason for their frequent species poverty. Their characteristic species are *Alopecurus pratensis, Agrostis stolonifera, Beckmannia eruciformis,* in the drier areas are *Carex praecox and C. stenophylla* and *Festuca pseudovina* (Deák et al., 2014b).

Hungarian Gray cattle

Our sample area of 1,200 ha, grazed with Hungarian grays, is located in the Pap-ere of Máta-puszta, in the northern part of Hortobágy. This area was grazed by a Hungarian gray herd of 540 cows and their offspring (480 calves). The average live weight of cows is 550-600 kilograms.

Crossbred beef cattle

Our area grazed with mixed genotype intensive beef cattle is located in the southern part of Hortobágy, at the border of Faluvéghalma village, in Zám. This 1100 ha area was grazed by an intensive crossbred beef herd of 550 cows and their offspring (500 calves). The average live weight of cows is 700-750 kilograms.

The grazing intensity of the selected areas was lower before the study (0.35 AU/ha) than from the first year of treatment, 2015. From this year, the pastures were utilized with a grazing intensity of 0.61 UA/ha in Pap-ere with the traditional breed, and 0.68 UA/ha in Zám-puszta with the intensive beef cattle. The intensity of grazing was determined from the size of the grazed area and the number of animals grazed. The feed for the animals was exclusively pasture grass. The grazing season lasted from early spring to late fall. Both herds grazed from sunrise to sunset, and spent the afternoon and night at their summer accommodation.

2.2. Materials and methods

Coenological and nature conservation studies

We carried out our surveys in May 2015, 2016 and 2017. On Pap-ere and Zám, we designated three 8×8 meter sample areas for each plant association (alkaline marshes: *Bolboschoenetum maritimi* and alkaline wet pastures: *Beckmannion eruciformis*), where we took coenological recordings to monitor the effect of grazing. We used the Balázs quadrat method (Balázs, 1960), during which the 8×8 meter areas were divided into 5 2×2 meter squares (permanently marked), and the plant species found in them and their coverage were recorded. Thus, we analyzed a total of 60 quadrats at the 12 locations (sample areas).

The nomenclature of the species follows the work of Király (2009). The plant species were grouped according to several aspects. For the classification of weeds into conditional and absolute weeds categories, and for the grouping of herbaceous species into grasses and forbs, Barcsák et al. (1978) were used as a basis. We also calculated the cover of sour grasses and legumes, as these groups are important for assessing forage quality.

Social Behavior Type (SBT) system of Borhidi(1995) were used as a basis for expressing the relative naturalness of the vegetation of each area. For each area, the weighted average SBT value was expressed. The system classifies plant species on an ordinal scale, from low (e.g. adventive species are given a score of -3) to high naturalness value (e.g. habitat specialist species are given a score of +6). Among the characteristics of the plant species, the conservation value categories were classified according to Simon (2000). For each quadrat, we calculated the WB (Borhidi's moisture demand) value weighted by the cover of the occurring plant species. We have also prepared a list of alkaline species, which are typical species of the *Festuco-Puccinellietea* and *Bolboschoeno-Phragmitetea* phytosociological classes (Borhidi, 1995).

Biomass sampling

In parallel with the coenology recordings (2015-2017), we also carried out production tests for each plant community in both our areas. Biomass production was determined by measuring the average plant height and trimming the vegetation in the 8 meter × 8 meter squares. The height of the vegetation was recorded randomly at 5 points in each quadrat. During the shearing test, in the buffer zone of our 8-meter × 8-meter sample areas, we mowed in 20 sample squares of 20×20 cm, and then collected the entire above-ground plant biomass and the dead plant parts, the chaff. Thus, we collected a total of 680 samples (240 in 2015, 200 in 2016, and 240 in 2017) during the three years. The plant material was dried in the sun (for two weeks) until the mass was constant. In the samples, the living biomass separated from the litter was sorted by species, and then the mass of the fractions was weighed on a storage scale with an accuracy of 0.01 g.

After the sorting, the plant species were grouped according to several aspects. The total phytomass was divided into two main fractions: living phytomass and litter. The living plant mass was further sorted into monocots and dicots. Monocotyledons: grasses and sour grasses, dicotyledons: leguminous plants, conditional and absolute weeds.

Forage quality tests

We carried out our tests in May 2016 and 2017. The vegetation samples were collected in 3 replicates from the 8×8 meter sample area for each plant community on Pap-ere and Zám-puszta. Thus, we analyzed a total of 12 samples from the sample areas. We formed 1-1 average samples per square, which were cut from 10 randomly selected places (point sample), leaving 6-7 cm stubble. Weende analysis of the cutting samples was carried out in the laboratory of the MÉK Agricultural Instrument Center of the University of Debrecen. The original dry matter content, crude protein, crude fat, ash and crude fiber content is MSZ-6830. according to standard and Harris et al. (1972) was determined.

Soil tests

The soil resistance was measured with an electronic soil testing pressure probe combined with a PENETRONIK brand moisture meter (2017). The device is a manually operated device that can be used to register the mechanical resistance of the soil and the moisture content of the top layer. Depending on the heterogeneity of the soil, the penetration resistance of the soil was measured at a depth of 0-50 cm in 6 repetitions per square.

The samples for the soil chemistry analysis were also collected in the third (2017) sampling year. We collected three pooled samples per square from the "A" level (0-20 cm) with a manual soil sampler. A pooled sample consisted of 4 point samples. We collected a total of 36 soil samples from our two areas (Zám-puszta and Pap-ere). We measured soil permeability, Arany binding, water-soluble total salt content, calcium carbonate content, organic C%, organic nitrogen, nitrate-nitrogen content, Lakanen-Erviö soluble phosphorus and potassium concentration. The soil samples were analyzed in the laboratory of the MÉK Agricultural Equipment Center of the University of Debrecen.

2.3. Statistical evaluation of the results

In the coenological and nature conservation studies, we analyzed the effects of cattle breed (extensive / intensive breeds, fixed factor), habitat type (marsh / moist saline meadow, fixed factor) and years (2015, 2016 or 2017, fixed factor) on the vegetation characteristics (dependent variables) using general linear models (Zuur et al. 2009). The GLM (general linear models) analysis was performed with the Statistica 7.0 program package. The dependent variables were the following: variables related to the nature conservation value of grasslands (Shannon diversity, species richness, total cover, height, cover of perennial species, annual species, short grasses, tall grasses, and alkali species, SBT and WB values), as well as those related to forage quality variables (sour grasses, legumes, unconditional weed and conditional weed cover). Sampling areas were included as a random factor. We used detrended correspondence analysis (DCA; CANOCO 5.0; Ter Braak and Šmilauer, 2012) to show the differences in the vegetation composition of the two investigated habitats grazed by the cattle breeds in the three investigated years. We used the average percentage cover values of the species occurring in the same sample area (5 quadrats).

In the grassland management studies, we compared the characteristics of the vegetation with different types of cattle (extensive or intensive beef cattle, fixed factor), type of habitat (saline meadow or saline marsh, fixed factor) and treatment (low grazing pressure, increased grazing pressure, fixed factor) with general linear models (GLM). The GLM analysis was performed with the Statistica 7.0 program package.

In the statistical analysis of the forage quality, an independent sample t-test was used to compare two groups, and in the case of more than two groups, a univariate analysis of variance was used, followed by the Tukey-Kramer post-hoc test. We compared the characteristics of the vegetation with different cattle breeds (extensive or intensive beef cattle, fixed factor), type of habiutat (wet or dry grassland, fixed factor) and treatment (low grazing pressure, increased grazing pressure or control, fixed factor) using the SPSS 22 program package. We calculated a significance level of 5%.

The statistical analysis and evaluation of the soil tests was carried out with the SPSS 22 program package.

3. RESULTS

3.1. The effect of pasture use on the coverage of the lawn and the composition of the vegetation

The data from 2015 (year 1) still show the results of areas grazed with low intensity (0.35 unit/ha). The number of animals in the pastures (0.61 unit/ha and 0.68 unit/ha) was increased from this year, so the data for 2016 (year 2) and 2017 (year 3) show the effect of increased grazing intensity.

Table 1.

The effect of habitat types on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	Habitat type		p
	Alkaline marsh	Alkaline wet pasture	
Shannon diversity	**1.45**	**1.68**	**<0.001**
Species richness (pcs)	**13.13**	**15.06**	**<0.001**
Total cover (%)	**83.42**	**89.67**	**<0.001**
SBT (%)	**4.06**	**3.04**	**<0.001**
WB (%)	**6.54**	**4.26**	**<0.001**
Short grass cover (%)	20.28	21.48	0.298
Tall grass cover (%)	**41.47**	**31.57**	**<0.001**
Sour grass cover (%)	**12.63**	**22.92**	**<0.001**
Leguminous plant cover (%)	1.26	6.59	0.152
Absolute weed cover (%)	**3.63**	**1.63**	**<0.001**
Conditional weed cover (%)	**8.49**	**31.78**	**<0.001**
Specialist species cover (%)	**5.00**	**21.98**	**<0.001**

Table 1 illustrates the effects of habitat types. It can be observed that we recorded more species and higher Shannon diversity in the alkaline wet pasture than in the alkaline marsh. The same tendency was observed in the case of the total cover, the cover of sour grasses, conditional weeds and specialist species. At the same time, higher naturalness and moisture index values (SBT and WB) and higher absolute weed cover were recorded in the marshes than in the alkaline wet pasture.

Table 2.

Effect of grazing intensity on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	**Intensity**			**p**
	Low (Year 1)	**Medium (Year 2)**	**Medium (Year 3)**	
Shannon diversity	**1.43**	**1.55**	**1.71**	**<0.001**
Species richness (pcs)	**13.87**	**12.98**	**15.43**	**0.002**
Total cover (%)	**86.82**	**88.12**	**84.70**	**0.038**
SBT (%)	**3.78**	**3.84**	**3.02**	**<0.001**
WB (%)	**5.33**	**5.57**	**5.30**	**0.045**
Short grass cover (%)	**15.92**	**24.60**	**22.11**	**0.021**
Tall grass cover (%)	**37.01**	**39.96**	**32.60**	**0.019**
Sour grass cover (%)	**25.59**	**16.15**	**11.59**	**0.006**
Leguminous plant cover (%)	2.32	3.42	6.04	0.359
Absolute weed cover (%)	1.80	3.04	3.06	0.080
Conditional weed cover (%)	23.60	19.99	16.81	0.842
Specialist species cover (%)	10.60	17.33	12.55	0.432

Based on Table 2, it can be concluded that with increasing grazing intensity, the species richness of the vegetation changed significantly: it first decreased, then increased, and the Shannon diversity showed a continuously increasing trend. The coverage of amount of grasses also showed a significant increase. At the same time, the total vegetation cover, the SBT value, the cover of sedges and sour grasses decreased with the increasing number of animals. The highest WB value was obtained in the second year, and the lowest in the third year.

Table 3.

The effect of grazing cattle breeds of different genotypes on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	**Cattle breed**		**p**
	Hungarian Grey	**Crossbred beef cattle**	
Shannon diversity	1.72	1.40	0.055
Species richness (pcs)	16.48	11.71	0.055
Total cover (%)	86.81	86.28	0.842
SBT (%)	3.37	3.72	0.275
WB (%)	5.36	5.44	0.546
Short grass cover (%)	19.13	22.63	0.685
Tall grass cover (%)	35.07	37.97	0.890
Sour grass cover (%)	18.92	16.63	0.530
Leguminous plant cover (%)	5.70	2.15	0.223
Absolute weed cover (%)	**3.28**	**1.98**	**0.037**
Conditional weed cover (%)	24.79	15.48	0.233
Specialist species cover (%)	7.40	19.59	0.874

The results of Table 3 were obtained from the average of the data of the three years and the two habitat types. In the areas grazed by traditional beef cattle, the cover of absolute weeds was higher than in the areas grazed by intensive beef cattle.

Table 4.

Evaluation of interactions between grazing cattle breeds of different genotypes and habitat types on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	Alkaline wet pasture		Alkaline marsh		*p*
	Hungarian Grey	Crossbred beef cattle	Hungarian Grey	Crossbred beef cattle	
Shannon diversity	**1.78**	**1.58**	**1.66**	**1.23**	**0.002**
Species richness (pcs)	**17.02**	**13.09**	**15.93**	**10.33**	**0.040**
Total cover (%)	**91.47**	**87.87**	**82.16**	**84.69**	**0.004**
SBT (%)	2.76	3.31	3.98	4.14	0.068
WB (%)	4.25	4.27	6.48	6.60	0.706
Short grass cover (%)	19.95	23.00	18.30	22.26	0.507
Tall grass cover (%)	**32.72**	**30.42**	**37.42**	**45.52**	**0.032**
Sour grass cover (%)	23.98	21.85	13.86	11.41	0.097
Leguminous plant cover (%)	9.38	3.80	2.03	0.50	0.517
Absolute weed cover (%)	2.04	1.22	4.52	2.74	0.303
Conditional weed cover (%)	39.72	23.83	9.86	7.13	0.431
Specialist species cover (%)	**9.69**	**34.28**	**5.10**	**4.90**	**0.013**

Based on *Table 4*, we detected a significant interaction between cattle breeds and habitat types for six dependent variables. Extensive beef cattle grazing maintained higher species numbers and Shannon diversity in both habitat types than intensive beef cattle grazing. The highest number of species was found in the grassland grazed by extensive cattle, and the lowest in the marsh grazed by intensive cattle. The total coverage of vegetation was the largest in the wet grassland grazed by extensive beef cattle, and the lowest also in the extensive cattle, but in the marsh. In the marsh, we found greater sedges cover in both breeds of beef cattle. The highest value was recorded in the marsh grazed with intensive beef cattle, and the lowest also with intensive beef cattle, but in the grassland. In the case of both breeds of beef cattle, the coverage of the specialist species was greater in the grassland. The highest value was found in the grassland grazed by intensive beef cattle, and the lowest also in the intensive beef cattle, but in the marsh.

Table 5.

Evaluation of interactions between cattle breeds of different genotypes and grazing intensity of on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	**Crossbred beef cattle**			**Hungarian Grey**			***p***
	Low intensity (Year 1)	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**	**Low intensity (Year 1)**	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**	
Shannon diversity	1.25	1.46	1.51	1.61	1.64	1.91	0.117
Species richness (pcs)	10.93	11.07	13.13	16.80	14.90	17.73	0.340
Total cover (%)	86.07	87.07	85.70	87.57	89.17	83.70	0.260
SBT (%)	3.88	4.14	3.15	3.67	3.55	2.89	0.455
WB (%)	**5.50**	**5.54**	**5.27**	**5.16**	**5.60**	**5.34**	**0.036**
Short grass cover (%)	18.82	25.96	23.12	13.03	23.25	21.10	0.463
Tall grass cover (%)	**41.14**	**36.09**	**36.68**	**32.88**	**43.83**	**28.52**	**0.017**
Sour grass cover (%)	**21.50**	**14.34**	**14.05**	**29.68**	**17.95**	**9.12**	**0.001**
Leguminous plant cover (%)	**1.26**	**3.18**	**2.01**	**3.38**	**3.66**	**10.07**	**<0.001**
Absolute weed cover (%)	0.70	2.46	2.78	2.90	3.62	3.33	0.206
Conditional weed cover (%)	**17.21**	**12.88**	**16.35**	**30.00**	**27.11**	**17.27**	**0.007**
Specialist species cover (%)	13.74	25.31	19.72	7.45	9.35	5.39	0.332

Table 5. shows that the interaction between beef cattle types and grazing intensity had a significant effect on most vegetation characteristics. The cover of leguminous plants increased continuously from the first to the third year of the study. The highest coverage was recorded in the area grazed with extensive beef cattle in the 3rd year of treatment, the lowest in the area grazed with intensive beef cattle with a low animal population. Sour grass, tall grass and conditional weed cover decreased both in the extensive and in the area grazed with intensive beef cattle as the number of animals increased, especially in the case of the extensive beef cattle. The value of the moisture indicator (WB value) decreased somewhat with the increase in the number of animals in the area grazed with intensive beef cattle, and increased somewhat in the case of extensive beef cattle.

Table 6.

Evaluation of interactions between habitat types and grazing intensity on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	**Alkaline marsh**			**Alkaline wet pasture**			***p***
	Low intensity (Year 1)	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**	**Low intensity (Year 1)**	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**	
Shannon diversity	1.32	1.47	1.55	1,53	1,63	1,87	0.393
Species richness (pcs)	13.37	11.87	14.17	14,37	14,10	16,70	0.563
Total cover (%)	84.40	83.27	82.60	89,23	92,97	86,80	0.090
SBT (%)	4.16	4.53	3.48	3,39	3,16	2,56	0.244
WB (%)	6.51	6.77	6.34	4,15	4,37	4,26	0.458
Short grass cover (%)	**19.72**	**20.37**	**20.74**	**12,13**	**28,83**	**23,47**	**0.002**
Tall grass cover (%)	**44.47**	**38.39**	**41.55**	**29,55**	**41,52**	**23,65**	**<0.001**
Sour grass cover (%)	**14.79**	**15.22**	**7.89**	**36,39**	**17,07**	**15,29**	**0.004**
Leguminous plant cover (%)	0.43	0.96	2.41	4,22	5,88	9,68	0.582
Absolute weed cover (%)	2.49	5.07	3.34	1,11	1,01	2,77	0.061
Conditional weed cover (%)	8.61	8.99	7.88	38,60	30,99	25,74	0.949
Specialist species cover (%)	3.38	6.97	4.66	17,81	27,69	20,45	0.998

Based on *Table 6.*, as the number of animals increased, the cover of amount of short grasses increased in both habitat types. The highest coverage was measured in the second year on the alkaline wet pasture, and the lowest also on the alkaline wet pasture, but at low intensity. As the intensity increased, the coverage of the tall grasses initially increased in the alkaline wet pasture, then significantly decreased, and we also experienced a decrease in the marsh. The highest value was in the alkaline marsh in the first year, and the lowest in the alkaline wet pasture in the third year of treatment. In the case of sour grasses, the decrease was significant with increasing intensity in both habitat types.

Table 7.

The effect of grazing intensity and grazing of cattle breeds of different genotypes on vegetation characteristics in an alkaline marsh (Hortobágy, 2015-2017)

Vegetation characteristics	**Hungarian Grey**			**Crossbred beef cattle**		
	Low intensity (Year 1)	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**	**Low intensity (Year 1)**	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**
Shannon diversity	1.60±0.24	1.62± 0.28	1.77±0.19	1.04±0.32	1.31±0.37	1.34±0.42
Species richness (pcs)	16.93±1.67	13.81± 2.76	17.07±2.84	9.81±3.03	9.93±2.84	11.27±5.04
Total cover (%)	84.41±7.36	83.07± 8.24	79.01±6.01	84.41±6.11	83.47±8.91	86.21±7.97
SBT (%)	**3.95±0.42**	**4.27± 0.42**	**3.71±1.07**	**4.38±0.91**	**4.78±0.16**	**3.26±1.45**
WB (%)	6.18±0.80	6.81± 0.63	6.44±3.43	6.83±0.49	6.73±0.37	6.25±0.65
Short grass cover (%)	19.21±20.23	16.54± 17.66	19.15±15.59	20.23±22.21	24.21±17.51	22.33±22.83
Tall grass cover (%)	41.76±15.98	36.44± 14.31	34.07±10.42	47.19±20.09	40.33±15.93	49.03±29.43
Sour grass cover (%)	**14.05±13.39**	**19.43± 15.18**	**8.09±7.65**	**15.53±12.15**	**11.01±4.62**	**7.68±14.72**
Leguminous plant cover (%)	**0.65±1.12**	**1.63± 1.63**	**3.79±4.01**	**0.21±0.33**	**0.28±0.57**	**1.02±1.31**
Absolute weed cover (%)	4.22±2.99	5.64± 1.88	3.71±2.19	0.75±1.13	4.51±5.09	2.97±3.18
Conditional weed cover (%)	11.28±14.58	10.95± 14.39	7.35±6.75	5.94±10.42	7.04±8.31	8.41±14.91
Specialist species cover (%)	5.08±6.56	6.08± 2.76	4.15±4.05	1.67±1.55	7.87±5.79	5.17±3.92

Table 8.

The effect of grazing intensity and grazing of cattle breeds of different genotypes on vegetation characteristics in an alkaline wet pasture (Hortobágy, 2015-2017)

Vegetation characteristics	**Hungarian Grey**			**Crossbred beef cattle**		
	Low intensity (Year 1)	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**	**Low intensity (Year 1)**	**Medium intensity (Year 2)**	**Medium intensity (Year 3)**
Shannon diversity	1.61±0.37	1.66±0.26	2.05±0.32	1.45±0.43	1.61±0.35	1.68±0.33
Species richness (pcs)	16.67±2.79	16.01±3.25	18.41±2.21	12.07±0.65	12.21±2.96	15.01±4.81
Total cover (%)	90.73±10.01	95.27±2.91	88.41±3.92	87.73±10.54	90.67±4.98	85.21±5.03
SBT (%)	**3.39±0.61**	**2.82±0.65**	**2.07±0.46**	**3.38±1.26**	**3.49±1.21**	**3.05±1.21**
WB (%)	4.13±0.63	4.38±0.44	4.23±0.35	4.17±0.62	4.35±0.58	4.29±0.86
Short grass cover (%)	6.85±6.93	29.95±24.42	23.05±12.57	17.41±15.52	27.71±22.46	23.91±17.21
Tall grass cover (%)	23.99±9.45	51.21±26.86	22.97±13.21	35.11±18.61	31.84±21.06	24.33±17.76
Sour grass cover (%)	**45.31±14.30**	**16.47±11.43**	**10.15±8.95**	**27.47±23.07**	**17.67±22.14**	**20.43±22.28**
Leguminous plant cover (%)	**6.11±4.34**	**5.69±3.91**	**16.35±13.07**	**2.33±3.42**	**6.08±8.31**	**3.01±1.89**
Absolute weed cover (%)	1.57±1.43	1.59±2.12	2.97±1.89	0.65±0.93	0.43±1.07	2.58±5.28
Conditional weed cover (%)	48.71±18.86	43.27±33.46	27.19±20.04	28.48±22.63	18.71±21.81	24.29±20.81
Specialist species cover (%)	9.82±15.44	12.63±11.24	6.63±6.07	25.81±24.75	42.75±33.97	34.27±36.82

The combined effect of all variables is shown in *tables 7-8*. presented in tables. With the increase in the number of animals, both the grazing of the two types of beef cattle and the two habitat types significantly reduced the cover of sour grasses (p=0.014). The greatest decrease was observed in the alkaline wet pasture grazed with Hungarian gray. With increasing grazing intensity, the cover of legumes increased significantly in the alkaline wet pasture grazed by extensive beef cattle, in the case of intensive beef cattle, no changes were found over the years (p=0.005). The value of SBT decreased slightly with increasing pasture intensity for both habitat and cattle types (p=0.018).

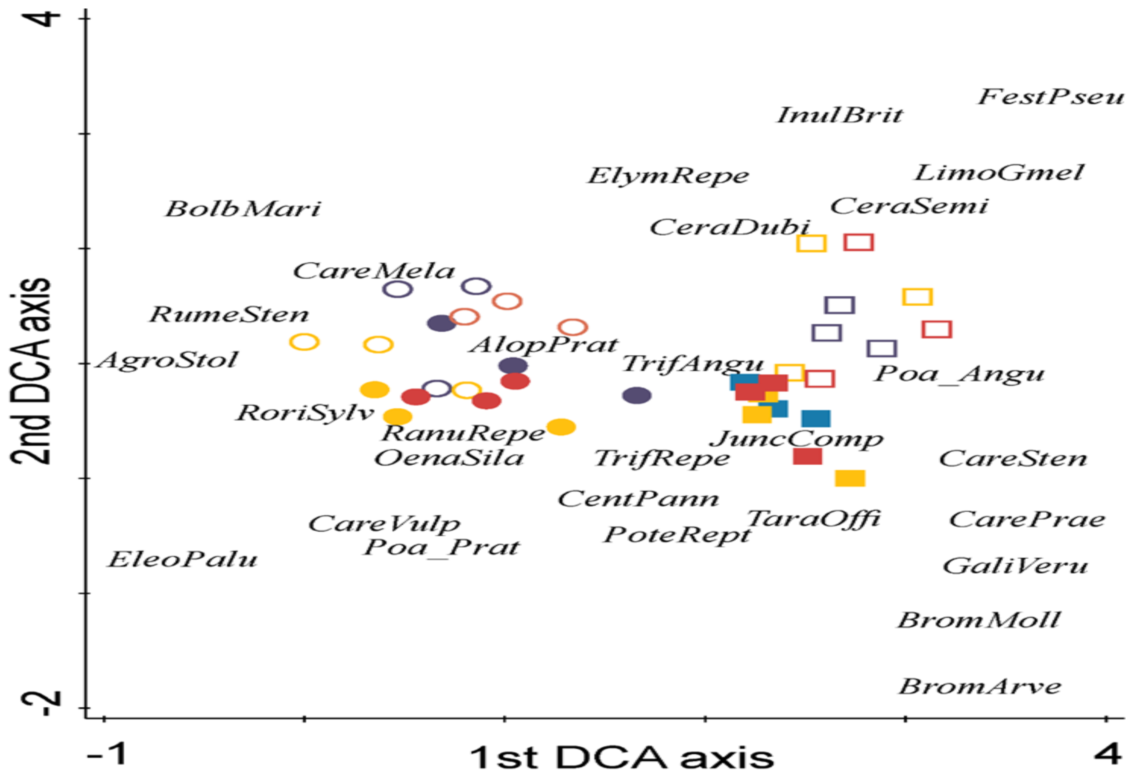

Figure 1: **DCA ordination of the plant species composition of the studied plots**

Notations: circles – alkaline marshes, squares: alkaline wet pasture; full symbols – areas grazed by traditional cattle breed, empty symbols – areas grazed by crossbred beef cattle; blue symbols: data from 2015, yellow symbols: data from 2016, red symbols: data from 2017. Species names are abbreviated using the first four letters of their genus and species names. (edited by Balázs Deák)

Figure 1. shows that the DCA ordination showed a clear separation in the species composition according to the habitat type and the grazed animal. The vegetation composition of marshes was much more similar in areas grazed by different cattle species than in wet grasslands.

3.2. The effect of pasture use on the amount of biomass fractions and the height of vegetation

During the sorting of the biomass by species, we found a total of 109 vascular plant species in the grazed areas. We counted 86 species in 2015, 78 species in 2016 and 77 species in 2017. In the areas grazed with extensive cattle, there are 96 species (72 in 2015, 65 in 2016, and 62 in 2017), and in the areas grazed with intensive cattle, 71 species (50 in 2015, 36 in 2016). and 56 in 2017). Our research was carried out at the beginning of June in all three years (2015-2017), so the plant material that accounts for the significant part of the annual yield of the lawn/pasture was collected from our area.

Table 9.

The effect of habitat types on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	Habitat types		p
	Alkaline marsh	Alkaline wet pasture	
Litter (g/m^2)	**217.66**	**125.83**	**<0.001**
Living matter (g/m^2)	**375.04**	**182.59**	**<0.001**
Height (cm)	**53.04**	**26.04**	**<0.001**
Monocots (g/m^2)	**311.14**	**131.03**	**<0.001**
Dicots (g/m^2)	62.00	50.25	0.063
Grasses (g/m^2)	**263.18**	**104.89**	**<0.001**
Short grasses (%)	**86.38**	**51.89**	**<0.001**
Tall grasses (%)	**176.80**	**53.00**	**<0.001**
Sour grasses (%)	**46.98**	**26.13**	**<0.001**
Leguminous plants (%)	**5.53**	**12.75**	**<0.001**
Absolute weeds (%)	11.67	7.96	0.077
Conditional weeds (%)	54.11	42.38	0.096
Moss (g/m^2)	**0.73**	**1.30**	**0.048**

Based on *Table 9*, it can be concluded that in the wetter alkaline marshes we recorded a higher amount of living matter and litter matter, as well as higher vegetation, than in the saline grassland. The same trend was observed in the amount of biomass of monocots, grasses (short and tall grasses), sour grasses and mosses. We also found a difference in the biomass of legumines, we measured three times the amount in the saline grassland than in the marsh.

Table 10.

Effect of grazing intensity on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	Intensity (Years)			p
	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)	
Litter (g/m^2)	230.91	104.40	179.91	<0.001
Living matter (g/m^2)	170.67	392.60	273.18	<0.001
Height (cm)	21.82	55.50	41.30	<0.001
Monocots (g/m^2)	136.41	309.30	217.53	<0.001
Dicots (g/m^2)	33.49	81.87	53.02	<0.001
Grasses (g/m^2)	111.65	259.48	180.98	<0.001
Short grasses (%)	46.04	92.73	68.63	<0.001
Tall grasses (%)	65.61	166.74	112.34	<0.001
Sour grasses (%)	24.75	48.36	36.56	<0.001
Leguminous plants (%)	4.87	6.95	15.60	<0.001
Absolute weeds (%)	3.94	13.83	11.67	<0.001
Conditional weeds (%)	28.63	73.33	42.78	<0.001
Moss (g/m^2)	0.31	1.42	1.30	0.002

In *Table 10*, we compared the impact on vegetation of grazing with lower intensity (year 2015, initial state) and increased number of animals (years 2016 and 2017). (In this case, we averaged the biomass values of both cattle breeds and both grass types). Grazing intensity had an effect on all investigated vegetation characteristics. Grazing with an increased number of animals had an opposite effect on the two main fractions of the total biomass, litter and living matter. While the amount of litter decreased, the biomass of living matter increased. With increasing grazing intensity, the height of the vegetation increased significantly. In the case of monocots, the amount of short grasses, tall grasses, and sour grasses also showed a significant increase. The largest amount of biomass was measured in the second year, the smallest in the first year. Among the short grasses, *Agrostis stolonifera*, *Festuca pseudovina* and *Poa angustifolia*, among the sour grasses *Carex praecox* and *Eleocharis palustris*, and among the tall grasses *Elymus repens*, *Alopecurus pratensis* and *Bromus arvensis* increased. We also experienced a significant increase in dicotyledons. The amount of biomass of leguminous plants showed a continuously increasing trend with increasing grazing intensity. The biomass of conditional and absolute weeds was the highest in the second year and the lowest in the first year. Among dicotyledons, the growth was caused by the biomass of *Limonium gmelinii*, *Potentilla reptans*, *Rumex stenophyllus* and *Trifolium repens*.

Table 11.

The effect of grazing cattle breeds of different genotypes on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	Cattle genotype		p
	Hungarian Grey	Crossbred beef cattle	
Litter (g/m^2)	162.65	180.84	0.070
Living matter (g/m^2)	282.16	275.48	0.590
Height (cm)	38.92	40.17	0.810
Monocots (g/m^2)	214.30	227.86	0.200
Dicots (g/m^2)	**66.22**	**46.03**	**<0.001**
Grasses (g/m^2)	174.26	193.81	0.050
Short grasses (%)	**60.67**	**77.59**	**0.010**
Tall grasses (%)	113.58	116.22	0.800
Sour grasses (%)	39.75	33.36	0.160
Leguminous plants (%)	**17.14**	**1.14**	**<0.001**
Absolute weeds (%)	**13.22**	**6.41**	**<0.001**
Conditional weeds (%)	50.31	46.17	0.550
Moss (g/m^2)	0.75	1.27	0.070

The results of *Table 11* were obtained from the average of the data of the three years and the two habitat types. The biomass of dicotyledons, leguminous plants, and absolute weeds were much higher in areas grazed with extensive beef cattle. This big difference was caused by the higher biomass of *Trifolium species* (*T. angulatum, T. fragiferum, T. repens, T. striatum*) and *Oenanthe silaifolia* and *Ranunculus repens*. In the case of grasses, the higher biomass was measured in the area grazed with intensive beef cattle.

Table 12.

Effects of interactions between cattle breeds of different genotypes and grazing intensity on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	Hungarian Grey			Crossbred beef cattle			p
	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)	
Litter (g/m^2)	222.56	85.44	179.95	239.27	123.37	179.88	0.360
Living matter (g/m^2)	**178.22**	**447.96**	**220.29**	**163.12**	**337.25**	**326.06**	**<0.001**
Height (cm)	**21.47**	**58.16**	**37.13**	**22.18**	**52.85**	**45.47**	**0.009**
Monocots (g/m^2)	**135.53**	**353.83**	**153.55**	**137.30**	**264.78**	**281.51**	**<0.001**
Dicots (g/m^2)	42.42	92.86	63.38	24.56	70.88	42.65	0.960
Grasses (g/m^2)	**107.66**	**281.94**	**133.18**	**115.65**	**237.01**	**228.78**	**<0.001**
Short grasses (%)	**34.80**	**99.98**	**47.25**	**57.29**	**85.48**	**90.01**	**0.003**
Tall grasses (%)	**72.86**	**181.96**	**85.93**	**58.36**	**151.53**	**138.76**	**0.003**
Sour grasses (%)	**27.85**	**71.03**	**20.38**	**21.65**	**25.69**	**52.74**	**<0.001**
Leguminous plants (%)	**8.75**	**12.91**	**29.75**	**1.00**	**0.98**	**1.45**	**<0.001**
Absolute weeds (%)	6.24	19.37	14.04	1.63	8.29	9.30	0.377
Conditional weeds (%)	**34.05**	**85.82**	**31.06**	**23.20**	**60.83**	54.49	**0.015**
Moss (g/m^2)	0.28	1.26	0.73	0.34	1.59	1.88	0.243

Based on *Table 12*, it can be concluded that the amount of living matter increased with the increase of the intensity for both breeds of beef cattle, the significant increase in biomass was measured in the second year of the treatment. For both types of beef cattle, the height of the vegetation increased significantly with increasing intensity. The biomass of short grasses initially increased in the case of extensive beef cattle, then decreased, while a continuous increase was measured in the case of intensive beef cattle. The quantity of tall grasses changed similarly for both beef cattle, the largest quantity was measured in the second year and the smallest in the first year at low pasture pressure. The biomass of sour grasses initially increased with the Hungarian Gray, then decreased significantly with the increase in the number of animals, but we measured a continuous increase with the intensive cattle. The biomass of leguminous plants in both beef cattle increased from the first year to the third year of the study.

The biomass of the conditional weeds changed oppositely to the increase in intensity for the two beef cattle, it decreased for the extensive cattle and increased for the intensive cattle.

Table 13.

Evaluation of interactions between habitat types and grazing intensity on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	Alkaline marsh			Alkaline wet pasture			p
	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)	
Litter (g/m^2)	**277.45**	**118.52**	**257.02**	**184.38**	**90.29**	**102.81**	**<0.001**
Living matter (g/m^2)	**201.56**	**582.66**	**340.91**	**139.77**	**202.54**	**205.45**	**<0.001**
Height (cm)	**28.47**	**70.22**	**60.44**	**15.17**	**40.79**	**22.16**	**0.001**
Monocots (g/m^2)	**170.12**	**470.94**	**292.35**	**102.70**	**147.66**	**142.71**	**<0.001**
Dicots (g/m^2)	**30.27**	**110.39**	**45.34**	**36.71**	**53.36**	**60.69**	**<0.001**
Grasses (g/m^2)	**138.47**	**402.51**	**248.57**	**84.84**	**116.44**	**113.39**	**<0.001**
Short grasses (%)	**57.23**	**132.70**	**69.21**	**34.85**	**52.76**	**68.05**	**<0.001**
Tall grasses (%)	**81.24**	**269.81**	**179.35**	**49.99**	**63.68**	**45.34**	**<0.001**
Sour grasses (%)	31.66	65.49	43.79	17.85	31.22	29.33	0.132
Leguminous plants (%)	**2.21**	**5.57**	**8.81**	**7.54**	**8.32**	**22.39**	**0.018**
Absolute weeds (%)	**4.20**	**20.15**	**10.65**	**3.68**	**7.51**	**12.69**	**0.012**
Conditional weeds (%)	**28.58**	**95.23**	**38.53**	**28.68**	**51.43**	**47.03**	**0.007**
Moss (g/m^2)	0.26	1.33	0.59	0.36	1.52	2.01	0.107

Based on *Table 13*, the interaction between grazing intensity and habitat type had a significant effect on all vegetation characteristics, except for sour grasses and moss. As the number of animals increased, the amount of litter matter decreased in both habitat types, especially in the second year of the study. On the other hand, the biomass of living matter increased over the years, the highest amount was measured in the marsh in the second year. With the increase in the number of animals, the height of the vegetation increased significantly in both habitat types, especially in the second year of the study. The highest vegetation was measured in the marsh in the second year of treatment, and the lowest in the first year in the wet pasture. The biomass of short grasses also increased with the increase in the number of animals in both habitat types. Growth was continuous in the alkaline wet pasture, but in the marsh the highest value was measured in the second year. The biomass of the tall grasses decreased somewhat in the alkaline wet pasture, but increased significantly in the marsh, similarly to the grasses, the highest value was measured in the second year. The amount of leguminous plants increased continuously with increasing intensity in both habitat types. The biomass of the absolute weeds in the marsh initially increased, then decreased somewhat, but in the alkaline wet pasture it shows a continuous increase. The amount of conditional weeds also increased over the years, for both habitat types the highest value was measured in the second year and the lowest in the first year.

Table 14.

Evaluation of interactions between grazing cattle breeds of different genotypes and habitat types on vegetation characteristics (Hortobágy, 2015-2017)

Vegetation characteristics	**Alkaline marsh**		**Alkaline wet pasture**		**p**
	Hungarian Grey	**Crossbred beef cattle**	**Hungarian Grey**	**Crossbred beef cattle**	
Litter (g/m^2)	**218.50**	**216.82**	**167.69**	**144.85**	**0.033**
Living matter (g/m^2)	371.11	378.98	384.83	171.97	0.213
Height (cm)	54.27	51.82	23.57	28.51	0.124
Monocots (g/m^2)	**287.53**	**334.75**	**319.20**	**120.97**	**0.002**
Dicots (g/m^2)	**81.05**	**42.95**	**64.72**	**49.11**	**0.004**
Grasses (g/m^2)	**233.87**	**292.49**	**280.86**	**95.13**	**<0.001**
Short grasses (%)	**66.83**	**105.93**	**99.04**	**49.26**	**0.001**
Tall grasses (%)	167.05	186.55	181.82	45.88	0.107
Sour grasses (%)	53.08	40.88	36.96	25.84	0.202
Leguminous plants (%)	**10.08**	**0.98**	**15.35**	**1.31**	**<0.001**
Absolute weeds (%)	16.49	6.84	12.39	5.98	0.176
Conditional weeds (%)	**47.00**	**61.22**	**65.14**	**31.13**	**0.009**
Moss (g/m^2)	**0.79**	**0.66**	**0.89**	**1.88**	**0.028**

On the basis of *Table 14,* it can be concluded that a larger amount of litter matter was measured in both habitat types grazed with extensive beef cattle than in habitats grazed with intensive beef cattle. In the case of monocots, the intensive beef cattle keep a larger amount on the saline marsh, and the Hungarian Gray cattle on the alkaline wet pasture. In the case of dicotyledons, we measured a higher biomass amount in the area grazed with Hungarian gray in both habitat types. The biomass of short grasses was higher in the area grazed with intensive beef cattle in the marsh, and in the area grazed with extensive beef cattle in the alkaline wet pasture. In the case of leguminous plants, we measured a larger amount of biomass in the area grazed with Hungarian gray in both habitat types. The grazing of the two cattle breeds had the opposite effect on the amount of conditional weeds in the two habitat types. The highest values were measured in the areas grazed by intensive beef cattle in the saline marsh, and in the areas grazed by extensive beef cattle in the alkaline wet pasture. We experienced just the opposite in the case of moss biomass.

Table 15.

The combined effect of grazing intensity and grazing of cattle breeds of different genotypes on vegetation characteristics in an alkaline marsh (Hortobágy, 2015-2017)

Vegetation characteristics	Hungarian Grey			Crossbred beef cattle		
	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)
Litter (g/m^2)	**302.96**	**97.16**	**255.37**	**251.93**	**139.87**	**258.67**
Living matter (g/m^2)	**233.03**	**627.33**	**252.96**	**170.10**	**538.00**	**428.85**
Height (cm)	**29.11**	**74.74**	**58.95**	**27.84**	**65.69**	**61.93**
Monocots (g/m^2)	**179.41**	**490.25**	**192.93**	**160.83**	**451.64**	**391.77**
Dicots (g/m^2)	**53.55**	**135.11**	**54.48**	**6.98**	**85.68**	**36.20**
Grasses (g/m^2)	**145.39**	**386.53**	**169.70**	**131.54**	**418.49**	**327.43**
Short grasses (%)	38.16	123.41	38.90	76.30	141.98	99.53
Tall grasses (%)	**107.23**	**263.12**	**130.80**	**55.25**	**276.51**	**227.90**
Sour grasses (%)	**34.03**	**101.99**	**23.23**	**29.29**	**28.99**	**64.35**
Leguminous plants (%)	**4.25**	**9.78**	**16.23**	**0.17**	**1.37**	**1.40**
Absolute weeds (%)	7.72	**31.00**	**10.75**	**0.67**	**9.31**	**10.55**
Conditional weeds (%)	26.05	95.70	19.25	31.10	94.76	57.80
Moss (g/m^2)	**0.06**	**1.98**	**0.33**	**0.46**	**0.68**	**0.85**

Table 16.

The combined effect of grazing intensity and grazing of cattle breeds of different genotypes on vegetation characteristics in an alkaline wet pasture (Hortobágy, 2015-2017)

Vegetation characteristics	Hungarian Grey			Crossbred beef cattle		
	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)	Low intensity (Year 1)	Medium intensity (Year 2)	Medium intensity (Year 3)
Litter (g/m^2)	**142.16**	**73.73**	**104.53**	**226.60**	**106.86**	**101.09**
Living matter (g/m^2)	**123.42**	**268.58**	**187.63**	**156.13**	**136.50**	**223.27**
Height (cm)	**13.83**	**41.57**	**15.31**	**16.52**	**40.00**	**29.01**
Monocots (g/m^2)	**91.64**	**217.42**	**114.18**	**113.77**	**77.91**	**171.25**
Dicots (g/m^2)	**31.28**	**50.62**	**72.28**	**42.14**	**56.09**	**49.10**
Grasses (g/m^2)	**69.93**	**177.35**	**96.65**	**99.75**	**55.53**	**130.13**
Short grasses (%)	31.43	76.54	55.60	38.28	28.99	80.50
Tall grasses (%)	**38.50**	**100.81**	**41.05**	**61.48**	**26.54**	**49.63**
Sour grasses (%)	**21.68**	**40.07**	**17.53**	**14.01**	**22.38**	**41.13**
Leguminous plants (%)	**13.25**	**16.05**	**43.28**	**1.83**	**0.59**	**1.50**
Absolute weeds (%)	**4.76**	**7.74**	**17.33**	**2.60**	**7.28**	**8.05**
Conditional weeds (%)	42.06	75.95	42.88	15.31	26.91	51.18
Moss (g/m^2)	**0.50**	**0.54**	**1.13**	**0.23**	**2.50**	**2.90**

The *15-16. tables* show that with increasing intensity, while the amount of litter matter decreased in the case of grazing of both types of cattle in the alkaline wet pasture, it decreased in the case of extensive beef cattle in the saline marsh, and slightly increased in the case of intensive beef cattle (p=0.002). We observed an increase in the amount and height of the biomass of living matter over the years (p<0.001) for both cattle breeds and both types of grassland. Among the monocots, the amount of tall grasses in the saline marsh increased for both species, a more significant increase was recorded in intensive beef cattle grazing (p=0.001). The biomass of sour grasses in both habitat types initially increased and then decreased in the areas grazed by extensive beef cattle, but their amount doubled in intensive beef grazing (p=0.004). The amount of biomass of liguminous in the alkaline marsh increased several times when both breeds grazed, in the alkaline wet pasture it also increased significantly in the case of extensive beef cattle, and slightly decreased in the case of intensive beef cattle (p=0.015). Absolute weed biomass increased significantly in both habitats and for both types of cattle, especially in the second year of treatment (p=0.014).

3.3. The effect of pasture use on the nutrient content of vegetation

Tables 17-20 show the effects of different lawn uses on the nutrient content of pasture vegetation.

Table 17.

The effect of different habitats on the nutrient content of grass-forming plants (Hortobágy, 2016-2017)

Examined parameters	Habitat type		p
	Alkaline marsh	Alkaline wet pasture	
Dry matter (m/m%) (m/m%)	32.90	30.95	0.464
Crude protein (m/m%)	11.95	13.55	0.325
Crude fiber (m/m%)	30.35	30.75	0.506
Life-sustaining nett energy (MJ/kg o.m.)	5.03	5.08	0.561

Based on the data in *Table 17*, it can be seen that, in the case of the different habitat types, we could not demonstrate a significant effect on the examined parameters.

Table 18.

The effect of different years on the nutrient content of lawns (Hortobágy, 2016-2017)

Examined parameters	Treatment		p
	Year 2016	Year 2017	
Dry matter (m/m%) (m/m%)	31.27	31.93	0.930
Crude protein (m/m%)	**10.60**	**12.75**	**0.042**
Crude fiber (m/m%)	29.62	30.55	0.937
Life-sustaining nett energy (MJ/kg o.m.)	**4.55**	**5.05**	**<0.001**

According to *Table 18*, in the case of the crude protein content, the higher value was measured in the 3rd year of the treatment, and the lower value was measured in the year 2016 with a lower dry matter yield. The same trend can be observed for the life-sustaining net energy content. The larger value was obtained in 2017, i.e. in the area grazed with the increased number of animals already two years ago, and the smaller value was obtained in 2016.

Table 19.

The effect of grazing cattle breeds of different genotypes on the nutrient content of grasses (Hortobágy, 2016-2017)

Examined parameters	Cattle genotype		p
	Hungarian Grey	Crossbred beef cattle	
Dry matter (m/m%) (m/m%)	31.60	32.25	0.815
Crude protein (m/m%)	12.12	13.35	0.472
Crude fiber (m/m%)	30.50	30.60	0.665
Life-sustaining nett energy (MJ/kg o.m.)	**4.96**	**5.15**	**0.006**

Based on *Table 19*, the type of cattle only influenced the life-sustaining net energy content. A higher value was measured in the area grazed with intensive beef cattle.

Table 20.

Evaluation of interactions between different genotypes of grazing cattle types and different years on the nutrient content of grass-formers (Hortobágy, 2016-2017)

Examined parameters	Year 2016				Year 2017				p
	Alkaline marsh		Alkaline wet pasture		Alkaline marsh		Alkaline wet pasture		
	Hungarian Grey	Crossbred beef cattle	Hungarian Grey	Crossbred beef cattle	Hungarian Grey	Crossbred beef cattle	Hungarian Grey	Crossbred beef cattle	
Dry matter (m/m%) (m/m%)	27.01	28.35	33.37	36.38	33.60	32.21	29.62	32.30	0.735
Crude protein (m/m%)	10.21	11.63	9.86	10.71	10.60	13.30	13.70	13.40	0.431
Crude fiber (m/m%)	27.92	29.34	31.71	29.51	31.20	29.50	29.80	31.70	0.435
Life-sustaining nett energy (MJ/kg o.m.)	**4.54**	**4.56**	**4.53**	**4.60**	**4.97**	**5.09**	**4.95**	**5.20**	**<0.001**

According to *Table 20*, we could also demonstrate a statistically verifiable effect only in the case of life-sustaining net energy. In both habitat types and both types of cattle, the net life-sustaining energy increased with increasing grazing intensity.

3.4. Comparative analysis of soil parameters

Table 21 shows the effect of different habitat types on soil chemical parameters.

Table 21.

Comparison of soils of habitat types (Hortobágy, 2017)

Examined parameters	Alkaline marsh		Alkaline wet pasture		P
	Hungarian Grey	Crossbred beef cattle	Hungarian Grey	Crossbred beef cattle	
pH (KCl)	5.65	4.98	6.31	5.20	0.130
KA	51.50	54.38	50.22	46.56	0.115
total water-soluble salt content (m/m) %	0.05	0.05	0.05	0.05	0.083
$CaCO_3$ (m/m) %	0.10	0.10	0.10	0.10	0.098
Organic C (m/m) %	3.87	3.85	3.31	2.71	0.149
AL-soluble P_2O_5 (mg/kg)	57.12	43.94	47.88	43.87	0.523
AL-soluble K_2O (mg/kg)	**332.10**	**256.01**	**209.98**	**205.70**	**0.037**
KCl-soluble NO_3- + NO_2- - N (mg/kg)	0.39	0.42	0.49	0.44	0.460

According to *Table 21*, the chemical properties of the soils of the areas mostly did not differ significantly from each other. A statistically confirmed difference was only measured in one case for the Lakanen-Erviö soluble K concentration. We found that the alkaline marsh maintains a much higher concentration of K than the alkaline wet pasture. In the alkaline wet pasture, we measured almost the same values for the two types of cattle, in the alkaline marsh, the soil K concentration was higher in the area grazed with Hungarian gray.

The comparison of the soil of the pastures based on their compaction is shown in 2-4. is described in Fig. The penetration resistance of the soil was influenced by the type of cattle, habitat types and their combined effect.

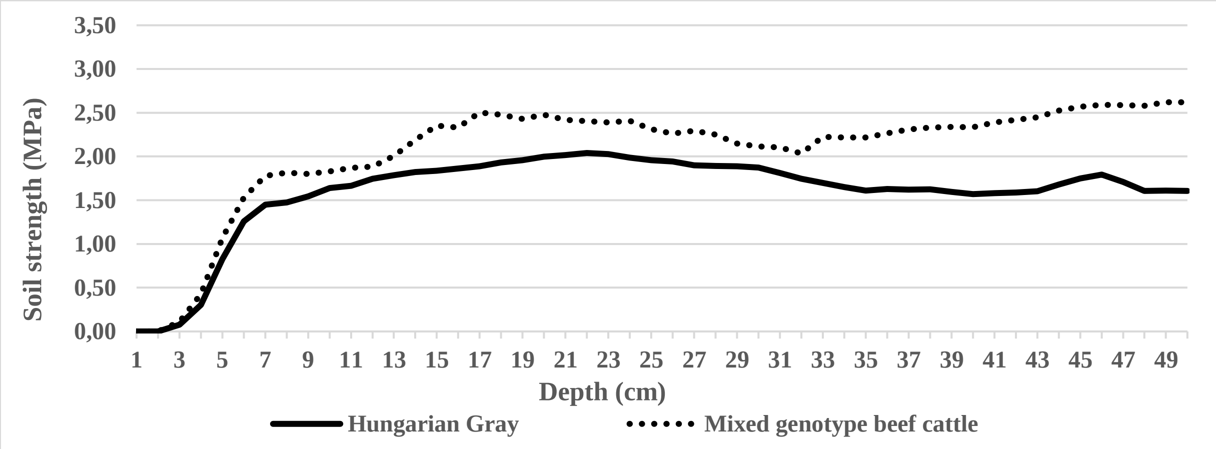

Figure 2: **Penetration resistance of pasture soils (Hortobágy, 2017)**

The significant difference between the Pap-ere pastures grazed with Hungarian Gray and the Zám-puszta pastures grazed with intensive beef cattle first appeared at 18 cm and then at 35 cm. As expected, our area grazed with a larger mass of intensive beef cattle turned out to be more compacted *(Figure 2.)*.

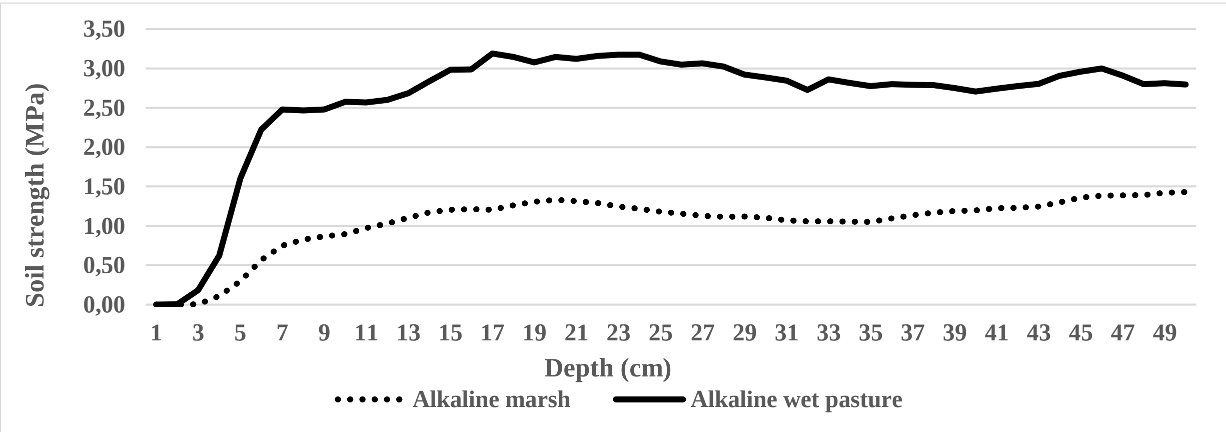

Figure 3: **Penetration resistance of the soil of different habitat types (Hortobágy, 2017)**

When comparing the two habitat types, we found that the soil resistance of the saline grassland was much higher than that of the saline marsh *(Figure 3)*. The significant difference first appeared at a soil depth of 3 cm and lasted continuously up to 50 cm, i.e. in the measured range.

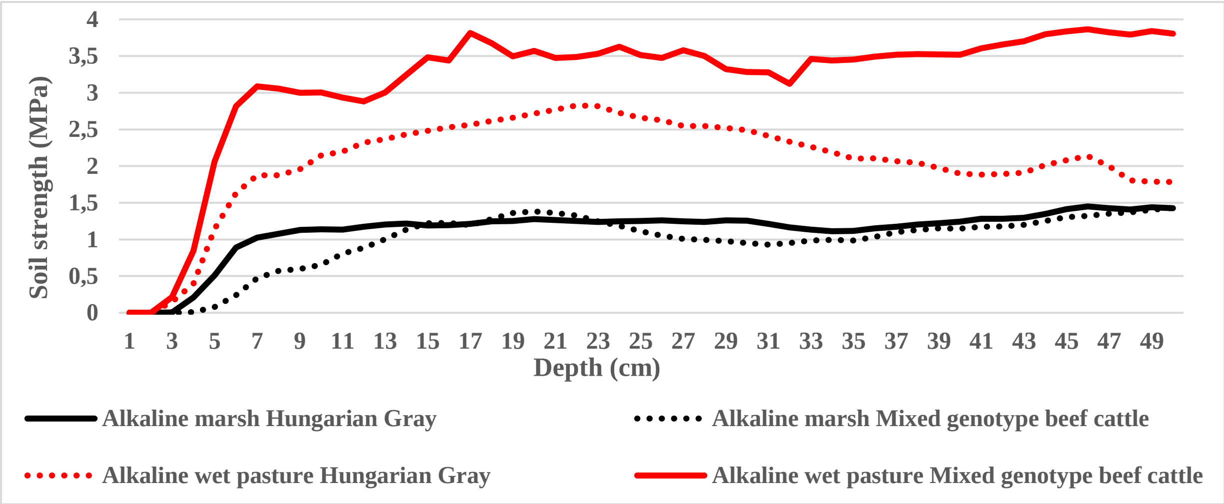

Figure 4: **Penetration resistance of the soil of beef pastures of different genotypes in different habitat types (Hortobágy, 2017)**

In the case of the interactions, based on *Figure 4*, we established that the penetration resistance of the soils of the two pastures (Pap-ere and Zám puszta) differed to a greater extent in the saline grassland, which was intense immediately below the soil surface. A statistically proven difference was measured at 4 cm of foreskin, which lasted up to 17 cm, then continuously from 33 cm to 50 cm. We experienced the highest soil resistance in Zám on the saline grassland utilized by intensive beef cattle. Compaction was low in both pastures in the saline marsh.

4. NEW SCIENTIFIC RESULTS

The following are the new scientific results of my studies establishing the effect of grazing beef cattle of different genotypes on different habitat types:

1. I have found that the effect of grazing is different for each habitat type. The number of species (by 15%), the Shannon diversity (by 16%), and the total cover were higher in the alkaline wet pasture, but the biomass of living matter was less (by 51%) than in the marsh.

2. When comparing the effect of grazing with low (0.35 AU/ha) and medium livestock numbers (0.61-0.68 AU/ha), I found that increasing the number of animals increased species richness (by 11%), Shannon diversity (by 19%), which is consistent with the intermediate disturbance hypothesis. Medium-intensity grazing can effectively suppress the cover of sour grasses (by 55%) and create a mosaic vegetation structure of short and tall grasses. I showed that grazing with an increased number of animals had the opposite effect on the two main components of the total biomass, litter and living matter. While the amount of litter (by 22%) decreased, the biomass of living matter (by 60%) increased significantly.

3. I have found that increasing the number of animals also improves wetlands from an feed value of view: as a result of grazing with a higher animal density, the biomass of the leguminous plants tripled, and the crude protein and life-sustaining net energy content increased.

4. I found that the effect of grazing of different types of cattle on the composition of the vegetation and the quality of forage depend on the type of habitat. The Hungarian Gray maintained a higher number of species (alkaline marsh: by 54%, alkaline wet pasture: by 30%), Shannon diversity (alkaline marsh: by 35%, alkaline wet pasture: by 12,6%), total cover and leguminous biomass in both habitat types (by 90%) than the intensive beef cattle. The richness and diversity of plant species was the highest in the alkaline wet pasture grazed with traditional beef cattle (17,02 pcs/sqm), and the lowest in the alkaline marsh with intensive beef cattle (10,33 pcs/sqm). The biomass of the conditional weeds also developed differently: in the alkaline marsh, the intensive beef cattle (by 30%), in the alkalibe wet pasture, the extensive beef cattle grazed a larger quantity (by 109%).

5. The two breeds of cattle have different forage selectivity, by grazing with Hungarian Gray we can achieve higher quality feed in both habitat types: by grazing with Hungarian gray, the cover of sour grasses biomass decreased more (alkaline marsh by 32%, alkaline wet pasture by12%), while at the same time the proportion of leguminous increased to a greater extent than in intensive beef cattle grazing (alkaline marsh by 282%, alkaline wet pasture by 227%).

6. The amount of absolute weed biomass increased with the increase in the number of animals in the case of both types of cattle and both types of habitat. The largest increase (20 times) was measured in the alkaline marsh grazed with intensive beef cattle, and the smallest increase (1.5 times) was also measured in the alkaline marsh, in the area grazed with Hungarian Gray. There was no difference in the alkaline wet pasture, when grazing both types of beef cattle, the increase in the amount of absolute weed biomass was threefold.

7. On the basis of the research results, it can be stated that with an animal density of less than 1 AU/ha on saline wet pastures and marshes, the ancient Hungarian cattle and the modern beef cattle of mixed genotypes are both suitable for the management of nature conservation areas, and at the same time for the production of high-quality food raw materials. From a nature conservation point of view, the grazing of the Hungarian gray is particularly beneficial in wetlands.

5. PRACTICALLY APPLICABLE RESULTS

1. I showed that the effect of increasing the number of animals on the amount of absolute weed biomass appeared differently for different cattle types and habitat types. The largest increase (20-fold) was measured in the saline marsh grazed with intensive beef cattle, the smallest increase was also in the saline marsh in the area grazed with Hungarian Gray, where the absolute weed biomass increase was only 1.5 times with the increase in the number of animals. There was no difference in the saline grassland, when grazing both types of beef cattle, the increase in the amount of absolute weed biomass was threefold. Based on my results, in terms of agricultural usefulness, the use of traditional varieties is recommended for the management of saline marshes. From a nature conservation point of view, it should also be taken into account that *Ranunculus repens*, which is classified as an absolute weed, is naturally disturbance-tolerant, *Oenanthe silaifolia* and *Cirsium brachycephalum* are companion species, and the latter is our protected, endemic species. In the present quantity, these species do not threaten the fodder value of grasslands (below 6%). The grazing of beef cattle of mixed genotypes and extensive Hungarian Gray can be recommended from both an agricultural and nature conservation point of view on the alkaline wet pasture, in addition to the number of animals used in the study.

2. The naturalness value decreased with increasing grazing intensity for both habitat and cattle types. The largest decrease (40%) occurred in the saline grassland grazed with Hungarian Gray, and the smallest in the saline marsh grazed with Hungarian Gray, which draws attention to the importance of determining and planning appropriate management intensities.

3. The two breeds of cattle have different forage selectivity, by grazing with Hungarian Gray we can achieve higher quality feed in both habitat types: by grazing with Hungarian Gray, the cover of sour grasses and conditional weeds and their biomass decreased more, while at the same time the proportion of leguminous increased to a greater extent than in intensive beef cattle grazing. This result suggests that the Hungarian Gray may be particularly suitable for the suppression of sour grasses and conditional weeds in the investigated habitat types.

4. I found that the effect of grazing different types of cattle on habitat protection values and forage quality may depend on the type of habitat. The Hungarian Gray maintained a higher number of species (alkaline marsh: by 54%, alkaline wet pasture: by 30%) , Shannon diversity

(alkaline marsh: by 35%, alkaline wet pasture: by 12,6%), total cover and leguminous biomass in both habitat types (by 90%) than the intensive beef cattle. The richness and diversity of plant species was the highest in the alkaline wet pasture (17,02 pcs/sqm) grazed with traditional beef cattle, and the lowest in the marsh grazed with intensive beef cattle (10,33 pc/sqm). The biomass of the conditional weeds also developed differently: in the alklaine marsh, the intensive beef cattle (by 30%), in the saline grassland, the extensive beef cattle grazed a larger quantity (109%). These results draw attention to the selection of varieties that best suit the habitat conditions.

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List of publications related to the dissertation

Hungarian scientific articles in Hungarian journals (3)

1. **Kovácsné Koncz, N.**, Tóth, K. Á., Radócz, S., Béri, B.: Extenzív és intenzív húsmarha legeltetés természetvédelmi szempontú összehasonlító vizsgálata hortobágyi mélyfekvésű gyepekben. *Gyepgazdálk. Közl. 15* (1), 39-47, 2017. ISSN: 1785-2498.
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