Comparative investigations of biomass composition in differently managed grasslands of the Balaton Uplands National Park, Hungary

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SUMMARY

Phytosociological and biomass samples were collected in two territories of the Balaton Uplands National Park (Hungary) dominated by grassland habitats. Samples in the Tihany Peninsula had been taken in a pasture of Hungarian Grey Cattle. Studies were broadened to four areas of the Tapolcai Basin, Badacsonytördemic (undergrazed and overgrazed pastures, hayfield, control area). The areas were suitable for following up the changes of vegetation and production in every grazing season of a year. We evaluated the changes of species composition and ground cover, the measure of possible regeneration or degradation, and the changes of these factors from the viewpoint of feeding value.

Covering rates of the grassland associations have doubled and species composition has improved in the Tihany Peninsula, however, forage value has not increased, due to the change in land use in favour of the natural area that is converting into grazing field. In case of the Taplocai Basin, low number of species (20 to 30) was detected in the undergrazed pasture and the control area. About one month per year grazing time in the undergrazed area was not enough to achieve a better state for species diversity, and the amount of forage remained high. The overgrazed pasture carries a low forage value and contains a high number of weed species, despite the spectacularly high total number of plant species (38 to 39), consequently, grazing pressure has to be decreased. Although the number of species is lower in the hayfield (26 to 28), species composition and ability for forage supply is much better, showing that the proper management of the area is taken here.

***Keywords**: grazing, pasture, hayfield, species composition, feeding value*

ÖSSZEFOGLALÁS

A Balaton-felvidéki Nemzeti Park gyepgazdálkodási célokra hasznosított két mintaterületén készítettünk cönológiai felvételeket és végeztünk biomassza vizsgálatokat. A mintavételt a Tihanyi-félszigeten egy szürkemarha legelőn, illetve a Tapolcai-medencében Badacsonytördemic térségében négy területen (alullegelt és túllegelt legelők, kaszáló és kontroll terület) végeztük. A területek alkalmasak voltak a legeltetési időszak alatt a növényzetben és a biomassza produkcióban bekövetkező változások évek közötti nyomon követésére. A vizsgálat során tanulmányoztuk a fajkompozíció, valamint a fajok borításának változását, a degradáció vagy regenerácó mértékét, illetve értékeltük ezen tényezők alakulását a gyepek takarmányértékének szempontjából.

A tájhasználatban bekövetkező változásoknak köszönhetően (legeltetés megkezdése) a Tihanyi-félszigeten lévő mintaterület növényzetének borítása a vizsgálat ideje alatt megduplázódott, illetve a fajszám is növekvő tendenciát mutatott, azonban a takarmányozási érték nem változott. A Tapolcai-medencében található mintaterületek esetében az alullegelt legelőn és a kontroll területen alacsony (20-30 közötti) fajszám volt kimutatható. Az alullegelt területen az évi egy hónapos legeltetési időszak nem volt elegendő ahhoz, hogy a diverzitás növekedjen, azonban a takarmányozási érték magas maradt. A túllegelt terület a magas fajszám (38-39) ellenére alacsony takarmányértékkel és a gyomfajok magas számával volt jellemezhető, következésképpen a kedvezőbb cönológiai állapot eléréséhez a legeltetési nyomás csökkentésére van szükség. Habár a kaszált területen a fajok száma alacsonyabb (26-28), a fajkompozíció és a takarmányérték magasabb volt, amely mutatja, hogy a területen a gazdálkodás megfelelő.

***Kulcsszavak**: legeltetés, legelő, kaszáló, fajkompozíció, takarmányérték*

INTRODUCTION

Separate animal breeds were bred to be best adapt to the climatic conditions of the Pannon region. The domestic Hungarian Grey Cattle had originally been grazing on wet grasslands (Török et al., 2014), but it has almost been extinct. Similar to other EU countries, agricultural intensification was typical in Hungary between 1960 and 1980 and it ended in the same way as everywhere (Gregory et al., 2005). After changing the regime, productivity has significantly fallen (Báldi and Faragó, 2007), which, in parallel with shifting from pastures towards stables (that is, intensification in milking parloms), resulted in the decline of extensively managed (particularly grazed) areas and their biodiversity (Tilman et al., 2002; Valkó et al., 2012). Excess use of herbicides and chemical fertilizers and the homogenization of the landscape were also characteristic phenomena on some grasslands (Benton et al., 2003; Robinson and Sutherland, 2002; Tscharntke et al., 2005). In the EU countries, agro-environmental programs were launched in order to stop or even reverse the decline of biodiversity (Kleijn and Sutherland, 2003). In Hungary, this effort was supported by the National Agro-environmental Program (NAKP) and the 2253/1999 (X.7.) government decree.

Hungarian Grey Cattle has come into the focus as a result of incentives for the sustainable use of grasslands, and has become the main preserver of grasslands under nature protection (Török et al., 2016; Tóth et al., 2016). Though this breed is kept extensively, livestock management methods are the same as in case of other cattle breeds. Contrary to the traditional grazing methods, Hungarian Grey Cattle can be kept on the pasture for a longer period (from April till November, through 200 to 240 days). The labour demand is low and the rotational grazing system proved to be the most effective. Besides the usefulness of this breed in nature conservation works, it has got a beef yield similar to other cattle breeds (Kovácsné Koncz et al., 2015). The beef productivity per area unit depends not only on the performance of the animal, but on the head of cattle per area unit and the effectiveness of the use of pasture as well. There is negative correlation between the effectiveness of pasture use and the production per animal, but positive between the amount of ingestion and grass supply, if animals have the chance to select (Penning et al., 1986; Tasi, 2006). Food availability depends on the quality, popularity, savouriness, nutritional value, energy concentration and digestibility of the grass, in one word the forage value of the pasture (Bajnok et al., 2009, 2010; Tasi et al., 2013; Török et al., 2013). Due to certain feeding surveys, the energy content of average grasslands is the highest in foliose status, while flowering grasslands provide only 66% in live-maintenance and 49% in body growth (Schmidt, 2003; Tasi, 2006).

Management takes place on the Hungarian natural grasslands as well. This usually means extensive activities such as mowing or grazing (Halász et al., 2016; Tälle et al., 2016). The total cover of grasslands exceeds 1 million hectares, that is 11% of the total area of Hungary, about 0.4 million hectares of this being under nature protection (Tasi et al., 2014). This is why harmonizing aims and tasks of agriculture and nature conservation is highly important on these areas (Ángyán, 2000). Observations on vegetation of pastures and its changes have got a high importance, especially in case of grass species (*Poaceae*), since it is mainly these species that ensure the most valuable forage for grazing animals (Vinczeffy, 1993, 1998; Barcsák and Kertész, 1986; Szemán, 1994/95, 2003). Organic matter content plays an important role as nutrient, and shallow soils have extreme water regime.

Natural grasslands were observed during the researches on botany and grassland management, and laying emphasize on the maintenance of nature conservation values as well. The current contribution presents a common view on extensively cultivated Transdanubian grasslands and detailed results in the Tihany Peninsula and the Taplocai Basin, where changes in vegetation, management type and nature conservation values are all important.

MATERIAL AND METHODS

Coenological studies were prepared on grazed and non-grazed steppe grasslands near the Inner Lake (Tihany Peninsula) in 1994, 2002, 2006, 2008 and 2015, and wet meadows near Badacsonytördemic (Taplocai Basin) in 2007, 2008 and 2015, all belonging to the Balaton Uplands National Park (Hungary).

Studied area in the Tihany Peninsula is a pasture of Hungarian Grey Cattle (ancient traditional breed) near the Inner Lake, where 5 phytosociological samples were taken both in the upper and in the lower third of the slope (Braun-Blanquet, 1964). A 10 hectares grassland lying along the southern coast of the Inner Lake had been a mown meadow before, and it has been converted into pasture for Hungarian Grey Cattle in 2002 (Penksza et al., 2003). This grassland is grazed by 5 cattles, 1 bull and their calves.

Four areas were studied in the Taplocai Basin (undergrazed and overgrazed pastures, hayfield, control area) near Badacsonytördemic. In parallel with coenological studies, production studies were also made 5 times per year. Vegetation was cut in certain designated points of the pasture and the hayfield, on a 1×1 m plot, at a height of 7 cm above the surface. Cutting and measuring phytomass was also prepared on the control area in favour of determining potential accession. Cut phytomass was separated into the groups of *Poaceae* species important for grassland management; *Fabaceae* species important for grassland management; other *Poaceae*, *Carex* and monocotyledonous species neutral for grassland management; dicotyledonous species neutral for grassland management; dead phytomass. The separated cut phytomass was dried in a dryer machine at 70 °C and weight was given in grams.

During grassland management studies, ratio and quantity of medicinal herbs, forage value and grassland management categories were analyzed. Forage values of significant species occurring in the grassland were determined according to the 10-stage scale of Klapp et al. (1953), which gives value 8 for species with high forage value, 0 for those with the least value or not grazed by animals and -1 for poisonous species.

Values and notations of grassland management categories were used following Tasi (2007):

1. *Poaceae* species important for grassland management
2. *Fabaceae* species important for grassland management
3. other *Poaceae*, *Carex* and monocotyledonous species neutral for grassland management
4. dicotyledonous species neutral for grassland management
5. poisonous plants
6. stinger plants
7. litter
8. medicinal herbs

Groups 1 and 2 contain plants that are the most important for grassland management. Species of groups 3 and 4 do not influence grassland management below a total cover of 20-30%. Species belonging to groups 5 and 6 are harmful regarding grassland management. Species carrying medicinal effect were recorded separately as well.

For evaluation, plant cover (D) and species number (n) were chosen from the analytical parameters and distribution of nature conservation value categories (TVK) (Simon, 2000) from the synthetic parameters. Nomenclature is following the plant determination book of Király (2009).

RESULTS

Tihany Peninsula (Inner Lake area)

Both species number and total coverage showed a significant growth in the grassland near the Inner Lake. Rate of medicinal herbs has grown constantly as well, resulting in 24 (in 2006), 25 (in 2008) and 26 (in 2015) species with medicinal effects in the association. Number of poisonous species has grown as well, but, these species had small covering rate. Amount of stinger plants, however, was high (*Table 1*).

Table 1

Characetristic data of the grassland in the Inner Lake (Tihany Peninsula)

	1994	2002	2006	2008	2015
Species number	37	53	57	62	64
Total plant cover %	66.00	94.80	118.00	138.00	98.00
Protected species number	0	1	1	1	2
Strictly protected species number	0	0	0	0	0
Medicinal herbs number	20	22	24	25	26
Poisonous species number	1	3	4	4	5
Forage value	2.50	2.93	4.10	3.20	3.60

1. táblázat: A Tihanyi Belső-tónál található mintaterület összesített adatainak táblázata

Among grassland management categories, rate of monocotyledonous species neutral for grassland management was the highest, showing a constant growth in coverage. Decrease in rate of grass species useful for grazing and growth in rate of narrow-leaved *Festuca* species are natural, but not disadvantageous processes in case of management by Hungarian Grey Cattle, since this breed was evolved in grasslands with similar species (*Table 2*).

Among forage value categories, number 3 exceeded greater coverage. Rates of the two most important categories have decreased. The reason for this process can be the proliferation of narrow-leaved *Festuca* species. Although, based on species composition, forage value of the grassland has decreased during the study years, this was compensated by the massive growth of total cover, and therefore, the value of the grassland has grown from forage value point of view as well (*Table 3*).

Table 2

Composition of the grassland near the Inner Lake (Tihany Peninsula) based on % distribution of main components of grassland from the perspective of management

Value categories, %	1994	2002	2006	2008	2015
1. Poaceae species	56.3	35.4	39.4	40.7	41.2
2. *Fabaceae* species	5.7	14.4	11.2	9.4	10.2
3. other *Poaceae*, *Carex* species	2.1	3.3	3.7	4.1	3.9
4. dicotyledonous species	23.2	35.3	33.3	31.2	31.4
5. poisonous plants	0.3	3.4	1.2	2.3	1.9
6. stinger plants	12.4	8.2	11.1	12.3	11.4

2. táblázat: A Tihanyi Belső-tónál lévő mintaterület növényzetének összetétele a fő gyepalkotók százalékos megoszlása alapján

Table 3

Distribution of forage value categories in the grassland near the Inner Lake (Tihany Peninsula) between 1994 and 2015

Value categories, %	1994	2002	2006	2008	2015
-1	0.60	7.80	3.50	2.30	3.10
0	5.10	8.00	11.50	13.80	11.40
1	10.50	10.50	5.10	3.60	4.70
2	18.70	14.20	13.80	8.80	117.90
3	29.20	34.50	44.70	32.40	34.30
4	0.00	2.00	0.00	4.30	3.10
5	5.10	7.20	7.50	20.90	14.90
6	6.30	5.80	4.70	6.50	6.30
7	15.10	6.20	5.40	3.30	5.10
8	9.30	3.80	3.70	4.20	3.10
Absolute cover	66.00	102.00	138.00	96.00	98.00
Forage value	**2.50**	**2.93**	**4.10**	**3.20**	**3.60**

3. táblázat: A takarmányozási értékkategóriák megoszlása 1994-2015 között a Tihanyi Belső-tónál lévő mintaterületen

Based on data of nature conservation value categories, the rate of association composing species (E) was about 30% and the rate of weeds (GY) about 10% in every sample. Increasing nature conservation value of the grassland is showed by increasing rate of accompanying species (K) and decreasing rate of natural disturbance-tolerant species (TZ).

Tapolca Basin (areas near Badacsonytördemic)

Both species number and total coverage was the highest in the case of overgrazed site because of higher amount of weed species. Protected species were not turned up in theese sites. There was not significant difference in the number of medicinal herbs between the different samples, however in the case of overgrazed pasture the quantity of poisonous species was twice as much than in the hayfield. From the aspect of forage values the sites were not different from each other (*Table 4*).

Table 4

Characetristic data of the sites in Tapolcai Basin

	Overgrazed pasture	Undergrazed pasture	Mowed hayfield
Species number	39.0	30.0	28.0
Total plant cover %	100.0	76.4	98.0
Protected species number	0	0	0
Strictly protected species number	0	0	0
Medicinal herbs number	2.0	2.0	1.0
Poisonous species number	5.0	4.0	2.0
Forage value	3.0	4.0	3.5

4. táblázat: A Tapolcai-medencében található területek összesített adatainak táblázata

Phytomass left by grazing animals was measured on the pastures near Badacsonytördemic, except for the data of April (*Figure 1*), when production before grazing is presented. These data of April are almost the same in the pastures and in the hayfield. The greatest amount was measured in the overgrazed area, as an effect of manuring in the previous year. Amounts are 5 to 10% less on the control area.

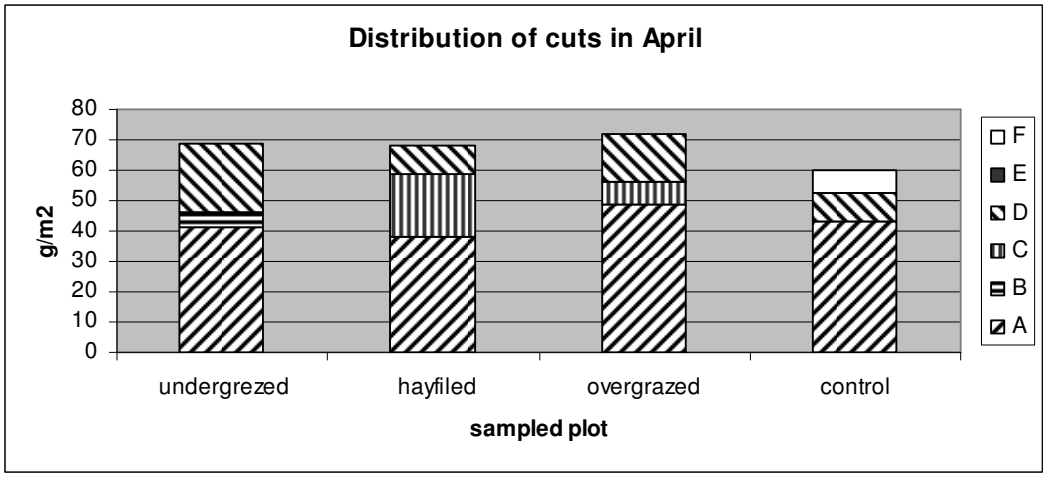
Phytomass production was greater in May than in April at every sample area (*Figure 2*). Almost 100 grams were produced on the hayfield and on the control area. About 300 grams were measured on the undergrazed area, resulting from the composition of the grassland, with a significant weight of *Festuca arundinacea*, giving the greatest part of the *Poaceae* mass (200 grams), growing intensively in this period. Only 65 grams of dry mass were measured on the overgrazed area.

Due to climatic conditions, greatest phytomass was measured in June (*Figure 3*). 155 grams DM was produced on the hayfield and 125 grams on the control area. Over 300 grams were measured on the undergrazed area, showing no significant growth compared to May. The composition of the phytomass has shifted, as the amount of sedges (*Carex* spp.) has increased at the expense of grass species (*Poaceae*) at every sample area.

Phytomass weights have significantly changed by August (*Figure 4*). Cattles were herded onto the undergrazed area, thus, there was a mass decrease in the phytomass of that area. An outstanding weight was measured on the overgrazed area, being also a result of manuring since April. The amount of dead phytomass has increased at every sample area due to summer dryness.

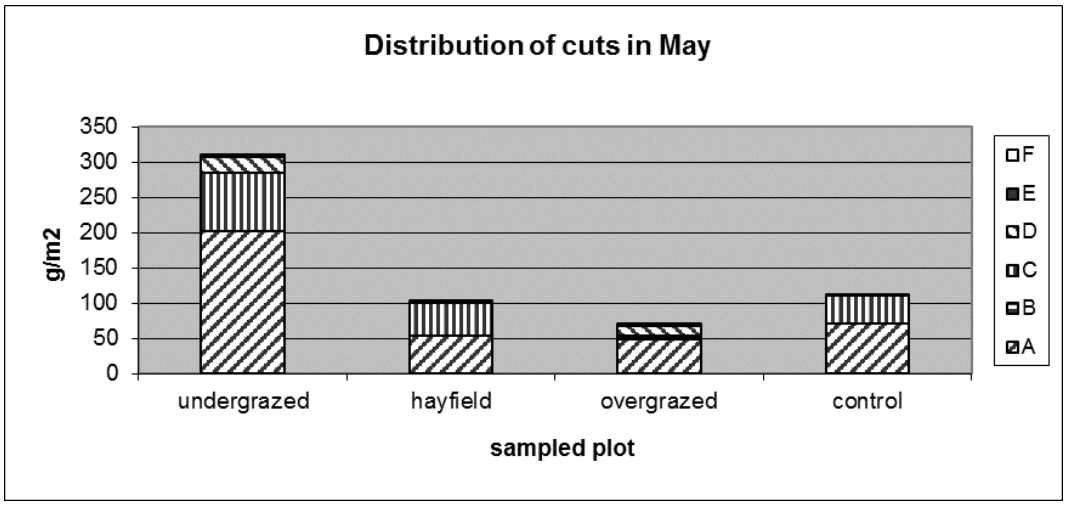
As a result of rainfalls, phytomass weights have significantly increased by September at every sample area (*Figure 5*). Cattles were herded back to the previous (overgrazed) pasture and have grazed almost all the feeding plants. Phytomass values increased in the other 3 areas. The amount of dead phytomass has increased at every sample area due to the autumn period, especially on the undergrazed area.

Figure 1: **Amount of dry matter (DM) and vegetation profile in the areas near Badacsonytördemic in April**
(A: Poaceae species important for grassland management, B: Fabaceae species important for grassland management, C: other Poaceae, Carex and monocotyledonous species neutral for grassland management, D: dicotyledonous species neutral for grassland management, E: medicinal herbs, F: thatch)



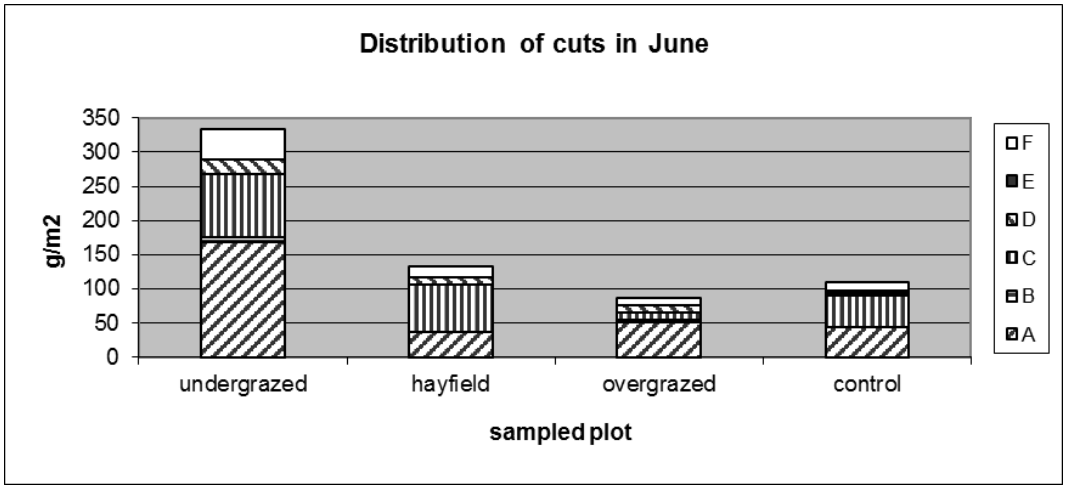
1. ábra: A Badacsonytördemici mintaterületek áprilisi szárított biomassza tömege (DM) a fő gyepalkotók szerinti megoszlásban
(A: Gyepgazdálkodási szempontból jelentős Poaceae fajok, B: Gyepgazdálkodási szempontból jelentős Fabaceae fajok, C: Egyéb, gyepgazdálkodási szemponból nem jelentős Poaceae, Carex és egyszikű fajok, D: Gyepgazdálkodási szemponból nem jelentős kétszikű fajok, E: Gyógynövények, F: avar/elszáradt biomassza)

Figure 2: **Amount of dry matter (DM) and vegetation profile in the areas near Badacsonytördemic in May**



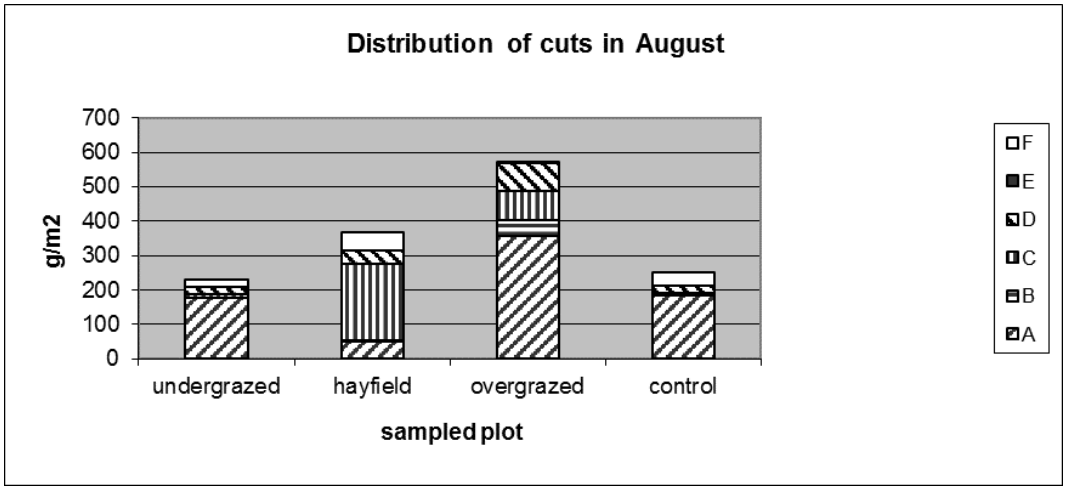
2. ábra: A Badacsonytördemici mintaterületek májusi szárított biomassza tömege (DM) a fő gyepalkotók szerinti megoszlásban

Figure 3: **Amount of dry matter (DM) and vegetation profile in the areas near Badacsonytördemic in June**



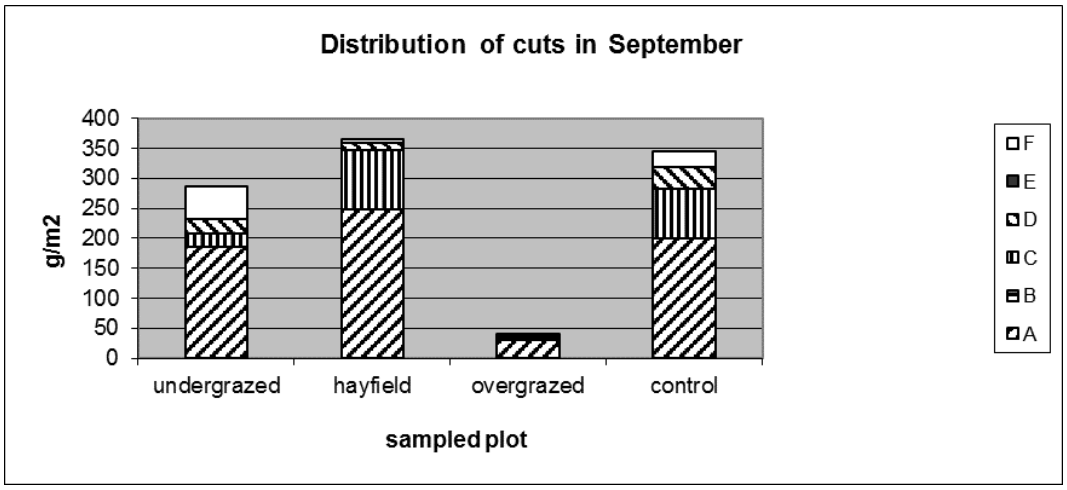
3. ábra: A Badacsonytördemici mintaterületek júniusi szárított biomassza tömege (DM) a fő gyepalkotók szerinti megoszlásban

Figure 4: **Amount of dry matter (DM) and vegetation profile in the areas near Badacsonytördemic in August**



4. ábra: A Badacsonytördemici mintaterületek augusztusi szárított biomassza tömege (DM) a fő gyepalkotók szerinti megoszlásban

Figure 5: **Amount of dry matter (DM) and vegetation profile in the areas near Badacsonytördemic in September**



5. ábra: A Badacsonytördemici mintaterületek szeptemberi szárított biomassza tömege (DM) a fő gyepalkotók szerinti megoszlásban

Total dry phytomass weight per square meter of the 5 cut samples of the year was 1228 g in the undergrazed area, 1035 g in the hayfield, 843 g in the overgrazed area and 879 g in the control (ungrazed) area. This means 12.28 t / 10.35 t / 8.43 t / 8.79 t of hay per hectare.

Based on nature conservation value categories, the undergrazed area was dominated by natural disturbance-tolerant species and association-composing species. Rate of natural disturbance-tolerant species was above 50% in the overgrazed area every time, referring to overgrazing. Association-composing species have disappeared from the grassland by the end of the year. Almost 50% of the surface of sample plots on the hayfield was covered by association-composing species. High rate of weeds was composed mainly by *Carex hirta*.

DISCUSSION

Based on our results it can be stated that the grassland is more sensitive against excess intensive grazing. Ratio of characteristic species has been decreased, giving floor for degradation-tolerant species and poisonous or sticky plants not favoured by animals. From a nature conservation point of view, a positive change has happened on the once mowed area converted into pasture of Hungarian Grey Cattle breed near the Inner Lake on the Tihany Peninsula. During the 14 years of studies, Tihany Peninsula has showed a constant improvement from a nature conservation point of view, however, forage value of the grassland has not increased. The cause for these positive changes has been the change in land use in favour of the natural area, that is converting into grazing field. Covering rates of the grassland associations have doubled in the research period and the species composition has increased and improved, in parallel with the high rate of natural disturbance-tolerant species.

Grassland management and forage value categories show the increase of species that are neutral for grazing, composed mainly by short, narrow-leaved *Festuca* species (belonging to the *Festuca rupicola* group), however, this is not disadvantageous for a well selected animal, in this case the Hungarian Grey Cattle. This breed was evolved in grasslands with similar species in the Hungarian Great Plain. Contrary to former studies reporting species decreasing effects of grazing (Tóth et al., 2003; Orr, 1980; Pettit et al., 1995; Renzhong and Ripley, 1997; Dwayne and Mertens, 1995), in our study, grazing activity did not cause a decrease in the number of species on the sample area of the Tihany Peninsula. Besides well selected grazing animal breed, a possible cause for this is the proper grazing pressure on the area. The amount of annual plants has not increased in the grassland, being a consequence of grazing (Sala, 1988; Sala et al., 1996). The 7 to 9 cattles ensure a balance on the 10 hectares, completed by a clearing mowing once a year. This management ensures the balance of the grassland (Nagy, 1993; Tasi, 2006).

Considering forage value, categories, number 3 exceeded greater coverage and rates of the three most important categories have decreased. The reason for this process can also be the proliferation of narrow-leafed *Festuca* species. Although, based on species composition, forage value of the grassland has decreased during the observed years, this is compensated by the massive growth of total cover, and therefore, the value of the grassland has grown from forage value point of view as well.

In case of the sample areas lying near Badacsonytördemic in the Tapolca Basin, changes in the vegetation were different, and they did not serve either nature conservation or economic profit in every case. Changes in vegetation of the pastures were significantly determined by grazing and there is a strict connection with the improvement of habitats (Milchunas et al., 1988). The model of Milchunas et al. (1988) deals with the co-evolution of grazing and vegetation, and confirms the importance of

environmental effects (Milchunas and Lauenroth, 1993).

It is a characteristic feature that the vegetation of wet areas can change more easily than that of dry habitats (Lukács et al., 2015). Many authors state that, as an indicator of grazing, the amount of annual species also increases (Sala, 1988; Sala et al., 1996). A low number of species (20 to 30) was detected in the undergrazed pasture and the control area. About one month per year grazing time in the undergrazed area was not enough to achieve a better state for species diversity, and the amount of forage remained high. Thus, we cannot strengthen those literature results that state that undergrazed areas hosted the most species (Sala, 1988; Sala et al., 1996). However, if we compare this management method with changes on the abandoned areas, then species decrease and impoverishment of the vegetation support the cited data (Luoto et al., 2003; Sala, 1988; Sala et al., 1996; Mitchley and Xofis, 2005; Peco et al., 2006). In favour of avoiding further decrease in species number and generating more diverse forage, either a thorough mowing is needed once a year or grazing has to be taken at least through 2 grazing seasons (34 days 2 times) on the undergrazed area.

The overgrazed pasture carries a low forage value and contains a high number of weed species, despite the spectacularly high total number of plant species (38 to 39), consequently, grazing pressure has to be decreased here. Although the number of species is lower in the hayfield (26 to 28), species composition and ability for forage supply is much better, showing that the proper management of the area is taken here.

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