GREEK MINISTRY OF ENVIRONMENT, ENERGY AND CLIMATE CHANGE
SPECIAL SECRETARIAT FOR FORESTS
&
HELLENIC RANGE AND PASTURE SOCIETY

Dry Grasslands of Europe: Grazing and Ecosystem Services

Proceedings of 9th European Dry Grassland Meeting (EDGM)
Prespa, Greece, 19-23 May 2012

Co-organized by
European Dry Grassland Group (EDGG, www.edgg.org) &
Hellenic Range and Pasture Society (HERPAS, www.elet.gr)

Edited by
Vrahnakis M., A.P. Kyriazopoulos, D. Chouvardas and G. Fotiadis

ISBN 978-960-86416-5-5

THESSALONIKI, GREECE 2013

Litter and green biomass in a traditionally managed alkali landscape in Hungary (Hortobágy)

Kelemen A.[1], *Török P.[1], Valkó O.[1], Deák B.[2], Miglécz T.[1], Kapocsi I.[2], Tóthmérész B.[1]

[1]University of Debrecen, Department of Ecology, H-4010 Debrecen, P.O. Box 71., Hungary
[2]Hortobágy National Park Directorate, Sumen út 2, H-4024 Debrecen, Hungary
*corresponding author: molinia@gmail.com

Abstract.

The study of biomass and its effect on species richness in grasslands and wetlands improves our understanding on vegetation dynamics. We provided detailed analysis of the aboveground biomass (total biomass, green biomass and litter) in an alkali landscape along a long productivity gradient. In the lowland area of Hungary (Hortobágy Puszta) we selected alkali (i-v) and loess grasslands (vi-viii) and wetlands (ix-xiii) for our study. The studied association types were the following: (i) *Puccinellia* open alkali grasslands, (ii) *Artemisia* and (iii) *Achillea* short alkali grasslands, (iv) *Juncus* short alkali grasslands, (v) *Alopecurus* alkali meadows, (vi) *Festuca* loess grasslands, (vii) *Bromus* loess grasslands, (vii) *Stipa* loess grasslands, (ix) *Bolboschoenus* alkali marshes, (x) *Typha latifolia* marshes, (xi) *Carex vesicaria* marshes, (xii) *Typha angustifolia* marshes and (xiii) Reeds (*Phragmites australis*). In grasslands, the lowest total biomass (sampled at the peak of biomass production) scores were found in open alkali grasslands (a mean of 113 g/m^2), while the highest ones in *Alopecurus* alkali meadows (a mean of 2,316 g/m^2). In wetlands higher scores were typical, ranging from a mean of 990 g/m^2 (detected in *Bolboschoenus* alkali marshes) to 3,052 g/m^2 (detected in Reeds). In grasslands, the highest amount of litter was detected in *Alopecurus* alkali meadows (as much as 1,856 g/m^2) while in wetlands the highest amount of litter was found in Reeds (as much as 1,268 g/m^2). Species richness was the highest at medium total biomass scores both in grasslands and wetlands. Our results suggest that litter is one of the major factors controlling species richness in highly productive grasslands and wetlands.

Key words: biodiversity, humped-back, grassland, phytomass, steppe

Introduction

Diversity of grasslands has decreased dramatically worldwide during the last century (Bakker & Berendse 1999). Several factors affect species richness via changing the amount of biomass; thus, studies of the major biomass components are important for effective biodiversity conservation. At the landscape scale, the humped-back relationship is most commonly observed between species richness and biomass in studies representing a long productivity gradient (Mittelbach et al. 2001). The ascending part of the humped-back curve is generally explained by decreasing stress, and increasing heterogeneity of nutrients, increasing amounts of litter and water availability (Rajaniemi 2003). The descending part of the curve is likely shaped by the increasing rate of competition, decreasing patchiness and microsite availability and by the accumulation of a thick litter layer (Mittelbach et al. 2001, Xiong & Nilsson 1999). We provided a detailed analysis of the major biomass components (total aboveground biomass, green biomass and litter) in eight types of alkali and loess grasslands and five types of wetlands in an alkali landscape in Hortobágy, Hungary. We studied a broad spectrum of grasslands and wetlands which occur in a large area in a certain landscape providing a broad productivity gradient. No such studies have been published from continental alkali communities so far, even though they occur in large areas in Central and Eastern Europe and are habitats of community interest in the Natura 2000 network.

Materials and methods

We studied five types of alkali grasslands: (i) *Puccinellia* open alkali grasslands; (ii) *Artemisia* and (iii) *Achillea* short alkali grasslands; (iv) *Juncus* short alkali grasslands and (v) *Alopecurus* alkali meadows; and three types of loess grasslands: (vi) *Festuca*, (vii) *Bromus* and (viii) *Stipa* loess grasslands. The studied wetlands were (ix) *Bolboschoenus* alkali marshes, (x) *Typha latifolia* marshes, (xi) *Carex vesicaria* marshes, (xii) *Typha angustifolia* marshes and (xiii) Reeds (*Phragmites australis*). The study area is located in Hortobágy, East Hungary near the towns of Karcag, Nádudvar, Egyek, Tiszafüred, Hortobágy and Balmazújváros. The region is characterised by alkali and loess grasslands traditionally managed by mowing or grazing (by cattle and/or sheep). These grasslands generally form a heterogeneous landscape-mosaic in accordance with the uneven pattern of soil salt and water contents. Grasslands with the lowest productivity are *Puccinellia* open alkali grasslands characterised by high soil salt content and high seasonal differences in groundwater table. These grasslands are generally adjacent to higher-laying dry grassland types characterised by the high cover of *Festuca pseudovina*, *Achillea* and *Artemisia* short alkali grasslands. At lower elevations, near to *Puccinellia* open alkali grasslands, *Juncus* short alkali grasslands are situated. These grasslands are characterised by lower salt content and higher soil moisture level than the *Puccinellia* open alkali grasslands. At the high-elevated loess plateaux adjacent to short alkali grasslands, loess grasslands were historically typical. Nowadays, only small fragments of these types of grasslands remain in near natural state. In our study three types of loess grasslands were sampled: *Festuca, Bromus* and *Stipa* loess grasslands. In low-laying and moderately wet areas with low alkali salt content the high-productivity *Alopecurus* alkali meadows are situated. At the lowest elevations there are several types of marshes. The *Bolboschoenus* alkali marshes are characterised by high salt content, while the other wetland types (*Typha latifolia* marshes, *Carex vesicaria* marshes, *Typha angustifolia* marshes and reeds) are characterised by lower salt content. We studied three independent stands of each (i-viii) grassland type. Within each stand 10 aboveground biomass samples (green biomass and litter; harvested at the soil surface in 20×20-cm-sized plots) were collected in June 2009. We studied three stands of each (ix-xiii) wetland types, and we collected three, 50×50-cm-sized aboveground biomass samples within each stand in June 2011. Both grassland and wetland samples were collected randomly at the peak of biomass production. They were dried (65°C, 48 hours), then sorted to vascular plant species and litter. The species lists in every biomass sample were recorded. Dry weights were measured with 0.01 g accuracy. To obtain relationships between various biomass and species richness data, the Spearman rank correlation and Gaussian-fitting were applied.

Results

In grasslands we found the lowest total biomass and litter scores in *Puccinellia* open alkali grasslands, while the highest ones in *Alopecurus* alkali meadows. In grasslands the relationship between total biomass and species richness showed a humped-back curve (R^2= 0.79). The highest species richness was detected at 750 g/m^2 total biomass score (Table 1). In the studied grasslands, where the amount of litter was relatively low (up to 400 g/m^2) we detected a strong positive correlation between litter and species richness (Spearman, R= 0.84, P < 0.001). In grasslands, where the amount of litter was higher, litter was negatively correlated with species richness (Spearman, R= - 0.95, P < 0.001). The correlation between green biomass and species richness was positive for the whole gradient (Spearman, R= 0.47, P < 0.05). In wetlands, the lowest total biomass scores were found in *Bolboschoenus* alkali marshes, while the highest ones in Reeds. Litter scores were lowest in *Typha latifolia* marshes and highest in Reeds (Table 1). In wetlands the relationship between total biomass and species richness also showed a humped-back curve; however, there were no significant relationships neither between total biomass scores and species richness nor between the amount of litter and species richness. For total biomass and litter scores see Table 1.

Table 1. Biomass and litter scores of the studied grasslands and marshes (mean ± SE).

Association type	Total biomass (g/m^2)	Litter (g/m^2)
Puccinellia open alkali grasslands	112.5±30.2	39.7±14.6
Achillea short alkali grasslands	155.9±19.1	76.2±14.4
Artemisia short alkali grasslands	197.0±6.4	82.6±6.5
Juncus short alkali grasslands	352.1±42.0	208.6±38.5
Alopecurus alkali meadows	2,315.7±18.8	1,856.4±108.1
Festuca loess grasslands	378.2±7.3	210.5±8.6
Bromus loess grasslands	832.0±74.2	160.8±56.4
Stipa loess grasslands	1,117.8±52.3	516.0±77.1
Bolboschoenus alkali marshes	989.7±156.7	386.1±92.2
Typha latifolia marshes	1,568.8±222.0	344.5±80.0
Carex vesicaria marshes	1,851.8±250.9	844.5±168.0
Typha angustifolia marshes	2,442.4±353.6	1,254.1±313.9
Reeds	3,051.5±272.0	1,268.0±190.6

Discussion and conclusions

The range of total aboveground biomass detected in this study is in line with other reports studying a long biomass gradient in grasslands and in wetlands (see Waide et al. 1999). In our study, the peak of the humped-back curve was at 31% of the studied biomass maximum (at 750 g/m^2) in grasslands and at 40% of the studied biomass maximum (at 2,000 g/m^2) in wetlands. In former studies the peak was detected within the range of 25.7% and 60.7% of the studied biomass maximum (Cornwell & Grubb 2003). Several factors might be jointly responsible for the differences in the location of peaks, like climatic factors (Hawkins et al. 2003), disturbance regime (Biswas & Mallik 2011), vegetation type and some landscape properties like landscape-level heterogeneity and rate of fragmentation (Dolt et al. 2005). The biomass scores and biomass-species richness relationship in plant communities are important both from the agricultural and nature conservation point of view. A slight increase or decrease of total biomass production can result in a decrease of species richness in those communities which are situated at the peak of the total biomass-species richness humped-back curve. In the studied case the loess grasslands are at the peak of the humped-back curve. Thus, it is necessary to consider this relationship in the planning of the appropriate grazing and mowing management.

Acknowledgements

We thank B. Lukács, Sz. Radócz, T. Ölvedi, E. Vida and K. Tóth for their help in field and laboratory works. The corresponding author (P. Török) was supported by the Bolyai János Research Scholarship of the Hungarian Academy of Sciences and Hungarian Scientific Research Fund (OTKA, PD 100192). The study was supported by the TÁMOP 4.2.1./B-09/1/KONV-2010-0007, and TÁMOP-4.2.2/B-10/1-2010-0024 projects.

References

Bakker J.P. and F. Berendse. 1999. Constraints in the restoration of ecological diversity in grassland and heathland communities. *Trends in Ecology and Evolution*, 14:63–68.

Biswas S.R. and A.U. Mallik. 2011. Species diversity and functional diversity relationship varies with disturbance intensity. *Ecosphere*, 2(4): art52.

Cornwell W.K. and P.J. Grubb. 2003. Regional and local patterns in plant species richness with respect to resource availability. *Oikos*, 100:417–428.

Dolt C., M. Goverde and B. Baur. 2005. Effects of experimental small-scale habitat fragmentation on above and below-ground plant biomass in calcareous grasslands. *Acta Oecologica*, 27:49–56.

Hawkins B.A., R. Field, H.V. Cornell, D.J. Currie, J-F. Guégan, D.M. Kaufman, J.T. Kerr, G.G. Mittelbach, T. Oberdorff, E.M. O'Brien, E.E. Porter and J.R.G. Turner. 2003. Energy, water, and broad-scale geographic patterns of species richness. *Ecology*, 84:3105–3117.

Mittelbach G.G., C.F. Steiner, S.M. Scheiner, K.L. Gross, H.L. Reynolds, R.B. Waide, M.R. Willig, S.I. Dodson and L. Gough. 2001. What is the observed relationship between species richness and productivity? *Ecology*, 82: 2381–2396.

Rajaniemi T.K. 2003. Explaining productivity-diversity relationships in plants. *Oikos*, 101: 449-457.

Waide R.B., M.R. Willig, C.F. Steiner, G.G. Mittelbach, L. Gough, S.I. Dodson, G.P. Juday and R. Parmenter. 1999. The relationship between productivity and species richness. *Annual Review of Ecology Systematics*, 30: 257-300.

Xiong S. and C. Nilsson. 1999. The effects of plant litter on vegetation: a meta-analysis. *Journal of Ecology*, 87:984–994.