ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LXI SECTIO E 2006

Dep. of Grassland Ecosystems and Fodder Crops, Faculty of Agrobiology and Food Resources
Slovak Agricultural University in Nitra, Tr. A. Hlinku 2, 949 76 Nitra
Slovak Republic

JÁN NOVÁK

Correlation between selected factors and quality of seminatural Western Carpathian grasslands

ABSTRACT. The research on the seminatural Western Carpathian grasslands (1992–2005) in Slovak Republic with the altitude from 360 to 1150 m and inclination up to 28º, in the regions of Kysuce, Orava, Liptov, Turiec, Považie, Horehronie, and Spiš presents 900 floristic analyses performed on 60 farms with the area of 9 712 ha. Regression and correlation analyses, namely pair coefficients of correlation and non-linear regression analysis (parabolic function), were used to study the correlation between the evaluation of the grassland quality (E_{GQ}) and the selected factors (floristic group, leguminoses, other herbs and ferns in %, share of empty places in %, diversity of species, altitude and inclination). The progress of the correlation between the selected factors was analysed to set the optimal values E_{GQ}. The diversity of species varied from 8 to 66 species, and the quality of the grassland (E_{GQ}) varied from 8.50 to 85.38. A positive (direct) correlation was found out in case of two factors (% of grasses and leguminoses); while a negative (indirect) correlation was proved in case of the other factors (other herbs, empty places, number of species, altitude, exposition, and inclination).

KEYWORDS: grassland, grasses, legumes, other herbs, mosses and empty places, diversity of species, E_{GQ}

Vegetation with a huge volume of its aboveground phytomass represents the most important sustainable resource for the herbivores in the ecosystem. Within the geographical and ecological conditions of Europe (excluding Ukraine and Russia) there can be found about 90 million (in the world about 3 billion) ha of grassland [Voigtländer, Jacob 1987]. In the Slovak Republic the seminatural grasslands create one third of the agricultural land, in the submountain areas up to 48%

[Valihora 2001]. The grasslands used in agriculture mainly in the mountain and submountain areas form multicomponent grass-herbal communities, composed of the plants in various combinations. Forage quality depends on their composition, i.e. grasses (50–60%), leguminoses (20–30%), and the other herbs (20–30%), Krajčovič et al. [1968]. Buchgraber [2002] declares 50–60% of grasses, 10–30% of leguminoses, and 10-30% of other herbs. The presumption that all the green is suitable for forage is wrong. There can be found the species with various forage values, from highly valuable to worthless species, some of which are remedial for the animals but others are toxic. It is highly important to recognise this natural wealth for its appropriate and reasonable use [Novák, 2000, 2004].

MATERIAL AND METHODS

The research on the seminatural Western Carpathian grasslands was conducted during ten years (1992–2002) at the altitude from 360 to 1150 m and inclination up to 28 °, in the regions of Kysuce, Orava, Liptov, Turiec, Považie, Horehronie, and Spiš. It includes 900 floristic analyses on 60 farms with the area of 9 712 ha. The soils on flysh sediments and weathered crystalline rocks (granite, paragneiss, etc.) were mainly acid, up to strongly acid, alkaline only in case of lime soil substrates primarily on the south slopes, mainly medial heavy to heavy, here and there lighter, mostly clay loam, in some places with gravelly structure. The predominant types of soil were Cambisols, Podzols, Planosols or Gleyosols, Histosols in some sites. The soils mostly contained sufficient amounts of potassium, but insufficient amount of phosphorus.

For the evaluation of grassland quality it is nesesary first to find out the percentage of coverage (D – dominance) for different plant species in floristic group in percentage. The best way is to make floristic analyses on the area of 1 m^2 in four runs, and then on the whole area. If the ground cover is homogenous, floristic analysis corresponding with one type of cover and area approximately up to 25 m^2 was set by the author's own method [Novák, 2004]. Regression and correlation analyses, namely pair coefficients of correlation and non-linear regression analysis (parabolic function), were used to study the correlation between the quality of the grassland E_{GQ} and the selected factors (floristic group, leguminoses, other herbs and ferns in %, share of empty places in %, diversity of species, altitude and inclination). The progress of the correlation between the selected factors was analysed to set the optimal values E_{GQ}. Polynomial functions of the second degree (parabola) by Obtulovič [2002] were considered the most suitable for this purpose (statistic program SAS 9).

RESULTS

The associations of Lolio-Cynosuretum, Festuco-Cynosuretum, smaller incidence of Festucetum pratensis, Trifolio repentis-Lolietum, Festucetum pseudoovino-rupicolae on some places and also Anthoxantho-Agrostietum, Arrhenatheretum elatioris, especially Nardetum strictae predominated on the semi-natural grassland. The mean quality of the studied grassland (E_{GQ}) reached the value of 57.29. However, the main constituents of the grasslands with high forage value – floristic group of grasses (38.37%), and leguminoses (12.94%) did not reach the optimum. The share of the other herbs was 32.27%, and the share of the mosses and empty places was 16.42%. Buchgraber [2002] declares that in case of 50–60% share of short species, 15–20% medium, and 20–30% tall grass species there is 10–30% of leguminoses, 10–30% of other herbs without problematic and weed species. The grasses support the creation and certainty of yields, stability of grassland, turf density; they are well-silageable; the leguminoses are of high quality, and they hold nitrogen, so they are of protein character; and other herbs replenish the grassland with the higher content of minerals, and at the same time they are highly adaptable to the site conditions.

Table 1. Correlation matrix of the analysed factors

	Grasses %	Legumes %	Other herbs %	Mosses and empty places %	Diversity of species	E_{GQ}
Grasses (%)	1	-0,28	-0,69	-0,15	-0,20	0,23
Legumes (%)	-0,28	1	-0,28	-0,38	-0,11	0,68
Other herbs (%)	-0,69	-0,28	1	-0,13	0,28	-0,41
Mosses and empty places (%)	-0,15	-0,38	-0,13	1	-0,01	-0,58
Diversity of species	-0,20	-0,11	0,28	-0,01	1	-0,19
E_{GQ}	0,23	0,68	-0,41	-0,58	-0,19	1

Table 1 gives the calculated pair coefficients of the correlations between the analysed factors and the E_{GQ} value. The positive values of the coefficients mean that there is a direct correlation between the compared variables, i.e. with the increase of one factor the other one increases, too, and in reverse the negative correlation means indirect dependence, when with the increase of one factor the other one decreases. Our attention was focused on the influence of selected factors on the value of E_{GQ} coefficient. The progress of the correlations between the selected factors and E_{GQ} coefficient was studied (Fig. 1–5) with the aim of setting their optimal values by the polynomial functions of the second degree (parabola). A positive (direct) correlation was found in case of two factors (% of grasses, and % of leguminoses), and in reverse a negative (indirect) correlation was found in the other factors (other herbs, empty places, number of species, altitude, exposition, and latitude). Evaluating the statistical significance, or insignificance, we found the significance except for the factor 'exposition'. During the more detailed evaluation (Table 1) of the correlations between the coefficient values there was found the strongest positive correlation (coefficient of correlation = 0.68) in case of the correlation between E_{GQ} coefficient and % of leguminoses, and the strongest negative correlation was found in case of the factor 'empty places' in % (correlation coefficient = - 0.58).

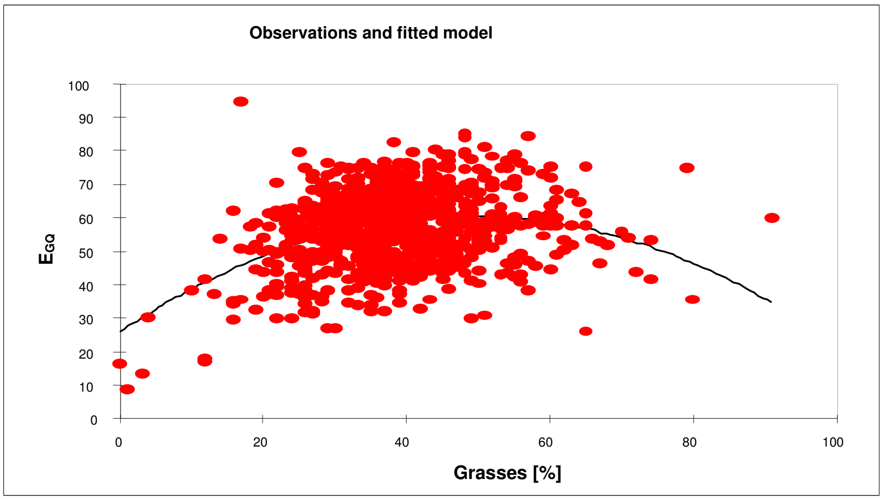

Figure 1. Parabolic correlation between E_{GQ} and grass cover in %

It can be seen from Figure 1 that with the growing density of grass cover in % the value of E_{GQ} coefficient grows too, up to the maximum value of the parabolic function, which equals the value 48.78%. Behind this point the value of E_{GQ} coefficient decreases, means that the values of the percentage of grasses in the cover given by Krajčovič et al. [1968] and Buchgraber [2002] are not valid generally, though they are valid for intensive grasslands. The extreme of this factor shows the optimal value of the density of the grasses in the cover in %, when the value of E_{GQ} coefficient is maximal. The mean value of the analysed areas of grasslands in the Western Carpathian grasslands in the floristic group of grasses reached 38.37 %.

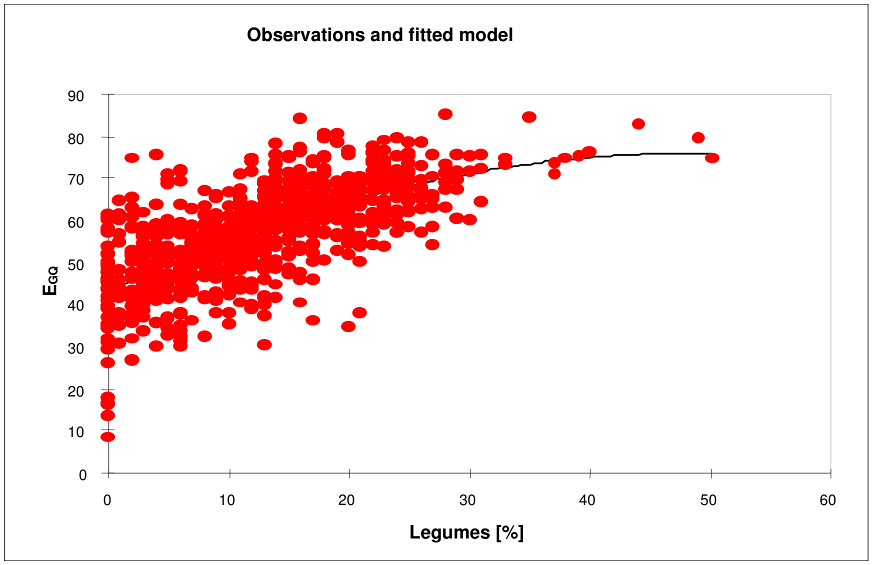

Figure 2 Parabolic correlation between E_{GQ} and leguminose cover in %

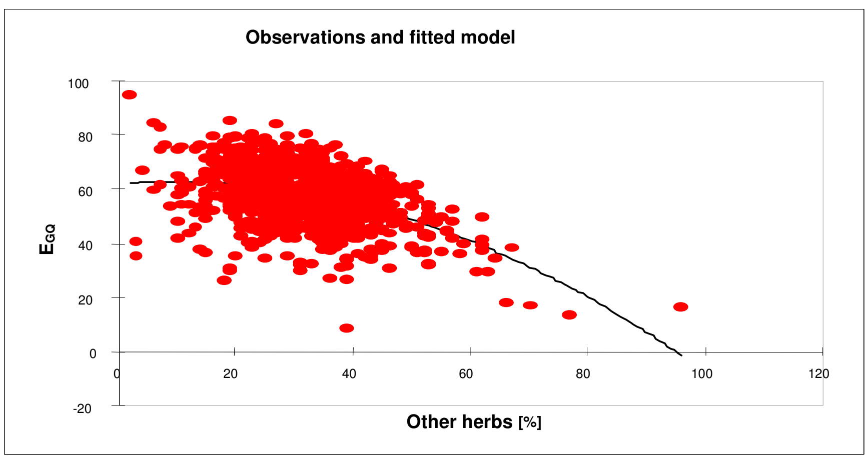

Figure 3. Parabolic correlation between E_{GQ} and other herbs in %

Evaluating the correlation between E_{GQ} coefficient and the density of leguminoses in % (Fig. 2) it can be seen that with increasing percentage of the density the value of E_{GQ} coefficient increases too, up to the value 49.43% behind this point the value of E_{GQ} coefficient decreases. The mean value of the analysed areas in the floristic group of leguminoses was 12.94%, optimal diffusion for leguminoses is up to the value 25, which corresponds to Krajčovič et al. [1968] and Buchgraber [2002]. A higher share of the leguminoses in the grass cover disrupts the optimal ratio for the farm animals; it causes increased content of protein in the fodder and following flatulence, and thus the recommended share is max. 25%.

From the progress of the correlation between E_{GQ} coefficient and the density of other herbs in the grass cover in % (Fig. 3) an optimal value 9.73 of E_{GQ} coefficient was set. E_{GQ} coefficient rises up to the optimal value, and it reaches its maximum; if the value of the density in % exceeds the optimal value, the value of E_{GQ} coefficient falls. Other herbs reach maximum forage value 6, from the 13-point scale [Novák 2004], thus their higher incidence causes the decrease of E_{GQ} coefficient. The most remarkable quality decrease can be seen in case of weed species, particularly toxic herbs that cause toxicoses and seldom death loss of farm animals, as Frantová, Ofukaný [1990], and Míka [2001] assert. The mean value of the analysed areas in the floristic group of other herbs was 32.27%. Krajčovič et al. [1968] and Buchgraber [2002] give the maximum values up to the 30%, which is not valid for the mostly extensive seminatural Western Carpathian grasslands.

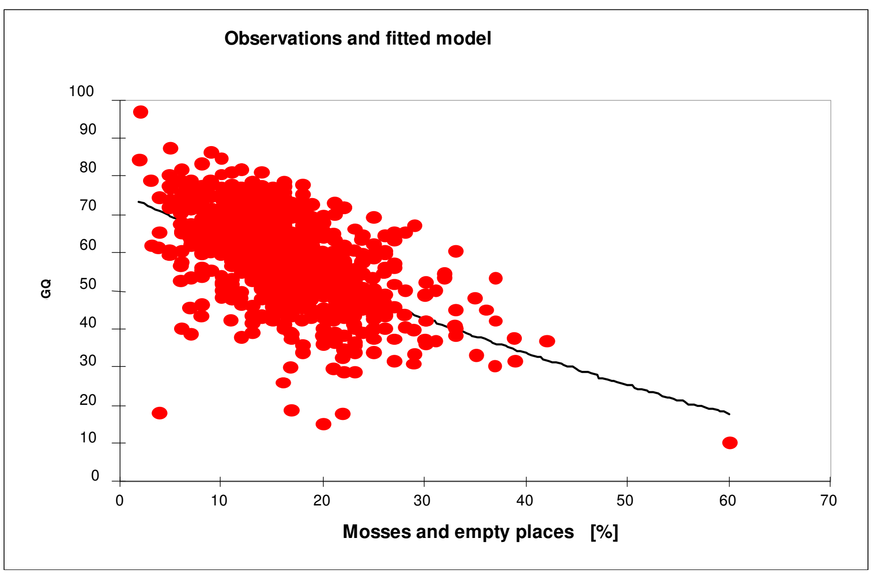

Figure 4. Parabolic correlation between E_{GQ} and mosses and empty places in %

From the evaluation of the curve of the correlation between E_{GQ} coefficient and the factor 'mosses and empty places' in % (Fig. 4) there can be seen an unambiguous tendency of E_{GQ} coefficient value to decrease with the increase of the share of mosses and empty places in %. The grasslands without empty places, or those with their minimum share, are of the highest quality. Grasslands with optimal density are also the best prevention against the weeds. The more empty places there are in the turf, the better are the conditions for penetration and germination of weed seeds, which are more competitive and stronger. In their later growth stage they radically lower the quality of grassland (E_{GQ}). The influence of extensification and global warming caused that the highly valuable and valuable species that were less adapted to these changed conditions declined, the share of empty places increased, and thus the mean value of the empty places on the analysed area was relatively high (16.42%).

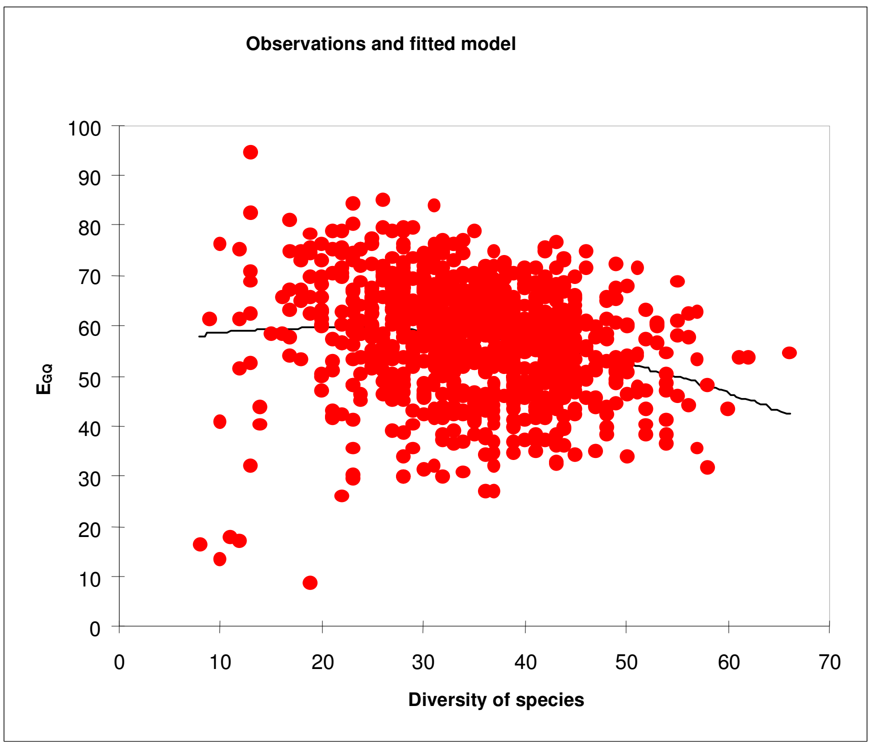

Figure 5. Parabolic correlation between E_{GQ} and diversity of species

The number of species (diversity of species) influences E_{GQ} value: with an increasing number of species up to the extreme value of the parabolic function 21.37 E_{GQ} value is increasing too (Fig. 5). If the number of species exceeds the value 22, E_{GQ} coefficient falls. It means that from the grassland quality point of view the number of species should not exceed the calculated optimal value. The mean number of species on the analysed areas was 34.83. The diversity of species depends on the intensity of use; thus if the grassland is intensive, the diversity of species is lower, and its forage quality is higher, in comparison to the quality of extensive grassland, where its aboveground phytomass is of low – even inferior – quality, and in comparison to the number of species is higher.

Conclusions

In seminatural grasslands of Western Carpathians, which are agriculturally exploited, the quality was represented by the value 57.29 of 100-point scale. The main components of analyzed grasslands were a floristic group of grasses (38.37%), leguminoses (12.94 %) and other herbs (32.27%). Observing the dependence between the selected factors, we determined a positive correlation between the quality of E_{GQ} and the share of grasses and leguminoses in %. The quality of grasses rose up to 48.78%, leguminoses to 49.43% and the quality of other herbs rose up to 9.73%. Above these marginal values, the quality of grassland phytomass decreased in the parabolic curve. Concerning leguminoses, such a big percentage share is not real. In practice, a percentage share up to 25% is recommended to maintain the ratio between carbohydrates and proteins. Other herbs, mainly weeds and toxic species, which have lower feeding value than grasses and legumes, increased the floristic diversity. Moreover, they caused a sharp decrease of the quality of phytomass. The floristic diversity up to 22 species in grassland caused an increase of E_{GQ}. Above this value, the fodder quality declined and the non-production functions became more important.

Acknowledgement. The following Grant Projects supported the research: No. 1/3453/06 of the Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences

References

Buchgraber K. 2002. Grünlandwirtschaft. BAL Gumpenstein, CD.
Frantová E., Ofúkaný L. 1990. Poisonous plants. Vydavateľstvo Obzor, Bratislava. (in Slovak)
Krajčovič V., Belej J., Dančík J., Folkman I., Holúbek R., Kováč A., Labuda J., Lichner S., Pačuta M., Tomka O., Vološin J. 1968. Forage production. SVPL, Bratislava. (in Slovak)
Míka V. 2001. Phenolic substances in meadow plants. VÚRV, Praha. (in Czech)

Novák J. 2000. Ekosystems of fodder plants. SPU, Nitra. (in Slovak)
Novák J. 2004. Evaluation of grassland quality. Ekológia (Bratislava), Vol. 23, No 2, 127–143.
Obtulovič P. 2002. Biostatistics. SPU, Nitra (in Slovak).
Opitz von Boberfeld W. 1994. Grünlandlehre. Biologische und ökologische Grundlagen. Verlag Eugen Ulmer, Stuttgart.
Steen E. 1957. Lutningsriktngens och lutningsgradens inflytande pa växtlighet och mark i ett naturbete. Kungl. Landbrukshögskolan Stat. Landbrucksförsök, Medd. 86, 1–64.
Valihora B. 2003. Differentiated approach to cultivation and use of grasslands. In: Cultivation of Grasslands (collection of lectures), Banská Bystrica, VÚTPHP.
Voigtländer G., Jacob H. 1987. Grünlandwirtschaft und Futterbau. Verlag Eugen Ulmer, Stuttgart.