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AN INVENTORY OF FLORISTIC COMPOSITION IN PERMANENT GRASSLANDS OF RUCĂR-BRAN CORRIDOR: APPLICATION AND PERSPECTIVES OF MELLIFEROUS POTENTIAL

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Abstract

The paper presents the melliferous and landscaping inventories in the Rucăr-Bran Corridor to assess the corresponding non-pastoral utilization values for complementary valorization of grassland herbaceous canopies. The space occupied by permanent grasslands in the study area is home to 235 species of plants, which shows an increased biodiversity. The inventories showed that 36 species were grasses, 29 species were legumes, 12 species were sedges and bulrushes, and 158 species were from other botanical families. A number of 72 melliferous species was identified, most of them having also forage utilization. GIS analysis showed that the total area occupied by permanent grasslands in Rucăr-Bran Corridor and neighboring landforms based on Corine data is 5007.6 ha. Consequently, the honey production potential was evaluated between 5 and 10 t of honey. Depending on the number of species that form the heterogeneous canopy and their color of flowers, the ordering of dominant colors and tones was as follows: yellow (24.3%), green (21.3%), white (17.3%), red (14%), pink (8.1%), purple (7.2%), blue (6.4%), and brown (1.3%).

Key words*: flower color, melliferous potential, non-pastoral utilization value, floristic composition.*

INTRODUCTION

A basic principle of sustainable agriculture is the exploitation of natural resources to allow their regeneration and to maintain the resilience and stability of natural ecosystems. In agropastoral domain, this goal requires the use of herbaceous canopies for fodder purposes only up to the limit of resilience capacity (Puia et al., 2001). This signifies the knowing of the tolerance of permanent grassland ecosystem to anthropogenic actions, so that it does not suffer significant or irreversible modifications, which excludes the intensive operations and cropping practices, especially for the medium and long-term applications (Motcă et al., 2009). In the Rucăr-Bran Corridor, the economic efficiency of grasslands operations based usually on extensive cropping practices, can be achieved not only by using differentiated prices for ecological animal products, but also by valorizing complementary potentials in the system of grassland multifunctional utilization.

According to the concept of grassland multifunctional utilization (Motcă et al., 2010; Huyghe, 2009; Barrio and Vounouki, 2002) concomitant with the primary use of grasslands as a food source for livestock, either mowed or grazed, the valorization of the secondary potentials of floristic composition needs to be addressed, namely melliferous, medicinal, tourism-related, environmental protection-related, biodiversity conservation, and landscaping potentials.

Among the abovementioned potentials, the paper presents the melliferous and landscaping inventories to assess the corresponding non-pastoral utilization values for complementary valorization of grassland herbaceous canopies in the Rucăr-Bran Corridor. In the first step, biodiversity status was assessed by establishing the total number of species, the floristic composition based on their utilization, on spatial distribution (widely distributed, rare or endemic species), the species protected by law, and the species flower color.

The melliferous utilization potential was determined by identifying the melliferous species in the canopy structure based on the floristic composition, and by estimating the

production of honey. Landscape potential was quantified using the structure and participation of species with colorful flowers and the color range.

Colors of species in a bee visual system, scent and phenology have potential key roles in attracting pollinators, which also have influence on honey production. Arnold et al. (2009) found that a foraging bee will not necessarily remain loyal to a color or species of flower indefinitely, and might shift to other species if the previously visited variety is not available in the immediate vicinity. A flower colors' classification of the species occurring in the studied grasslands was performed to support future studies related to the melliferous utilization potential.

MATERIALS AND METHODS

The objectives of the study were carried out by performing inventories on the established itineraries in the central and northern districts of the Rucăr-Bran Corridor. During field surveys, floristic compositions were performed recording fodder, honey and medicinal utilization of species, stationary conditions for each survey, plant phenological stage, color of flowers, canopy height and other descriptive ecological and biological characteristics. The maintenance status of investigated grasslands and improvement operations applied in the year of observations were also investigated. Dry matter determinations and calculations of potential honey production of analyzed grasslands were carried out in the laboratory.

The real potential for honey production of each melliferous species is reduced because of the primary use of vegetation for fodder purposes. Therefore, an appropriate average production to the honey production potential of the less productive species was considered (Motcă, 2010). Quantities of 1-2 kg honey ha^{-1} depending on the equivalent of 0.1 to 0.2 kg ha^{-1} for each canopy coverage percent were adequate for the envisaged area of study.

Vector data from Corine land cover - version 16 (04/2012) was overlapped on the CGIAR SRTM 90 m digital elevation model in ESRI ArcGIS 9.3 to obtain a general map of permanent grassland distribution in Rucăr-Bran Corridor. Figure 1 presents the polygons of the delineated natural grasslands and of woodland shrubs existent in the region.

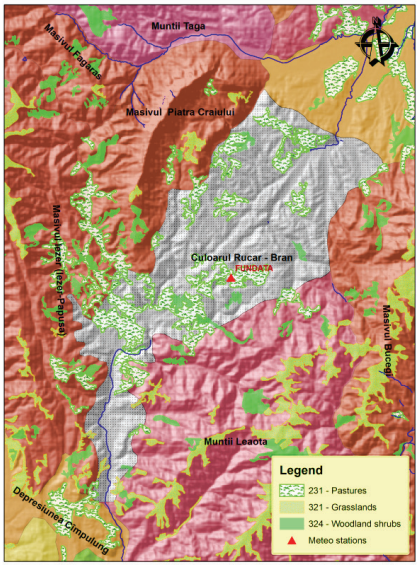

Figure 1. Distribution of grasslands and woodland shrubs in Rucăr-Bran Corridor and neighboring landforms

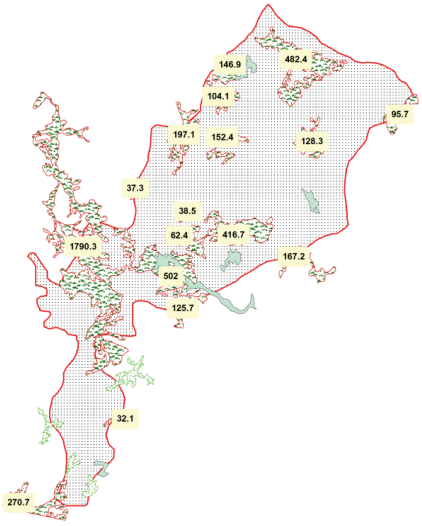

Figure 2. Areas in hectares (ha) occupied by pastures in Rucăr-Bran Corridor and neighboring landforms

RESULTS AND DISCUSSIONS

In the studied area, four groups of zonal grassland types were identified as follows: *Agrostis capillaris* with mesophilic character on flat surfaces, *Agrostis capillaris* with meso-xerophilic on slopes, *Festuca rubra* and *Agrostis capillaris*, and *Festuca rubra* and *Nardus stricta* grasslands.

Figure 2 presents the areas in hectares occupied by pastures in Rucăr-Bran Corridor and neighboring landforms resulted in GIS.
A number of 235 species was found in all the grasslands of these groups (Table 1), from which: 36 species of grasses (15.3%), 29 species of legumes (12.3%), 12 species of sedges and bulrushes (5.1%), and 158 species from other botanical families (67.3%).

Table 1. Floristic composition based on the potential utilization of grassland vegetation (number of species)

Utilization	Grasses	Legumes	Sedges	Other families	Total species	Percentage %
Fodder (F)	36	22	-	21	69	29
Medicinal (M)	-	3	-	41	44	19
Melliferous (MF)	-	22	-	50	72	31
Total, from which	36	47	-	112	185	79
F+M	-		-	7	7	15
F+MF	-	17	-	5	22	47
F+M+MF	-	1	-	3	4	8
M+MF	-	2	-	12	14	30
Multifuncțional use - Total	-	20	-	27	47	20
Landscaping	36	29	12	158	235	100
Total of species in the canopy	36	29	12	158	235	100

The floristic composition surveys performed in the Rucăr-Bran Corridor based on species potential utilization and importance, have identified 69 forage species (29%), 72 melliferous species (31%), 44 medicinal species (19%), 47 multifunctional utilization species (20%), and 2 natural monuments species (1%) i.e. *Lilium martagon* (Turk's cap lily) and *Trollius europaeus* (globe-flower).
A number of 72 melliferous species was identified on the permanent grasslands, most of them having forage utilization. Because of their main use as fodder, the honey production potential of these species is diminishing accordingly. On the average, data for all the grasslands area in Romania showed that the melliferous potential is between 2.0 and 6.0 kg honey ha^{-1}. Other influencing factors are the altitude and the canopy cover percentage. We have found that the permanent grasslands in Rucăr-Bran Corridor have a potential of 1-2 kg ha^{-1} corresponding to 10-20% canopy cover.
GIS analysis showed that the total area occupied by permanent grasslands in Rucăr-Bran Corridor and neighboring landforms based on Corine data is 5007.6 ha. The spatial analysis was performed considering the polygons from 231 and 321 categories that are contained entirely or some portions within the Rucăr-Bran Corridor. Consequently, the honey production potential was evaluated between 5 and 10 t of honey.
The chromatic diversity of grasslands in various stages of flowering was observed because this trait is related to the landscape aspect, but also because flower colors attract pollinators, which also have influence on honey production.
Through their bright colors, the flowers of species located in the grasslands of Rucăr-Bran Corridor (central and northern districts) range within the whole spectrum of colors in visible, which favors an attractive landscape of inner natural grasslands (Table 2).
Due to the high degree of grass species participation in the canopy (50-80%), whose flowers have greenish color, this color is dominant in the areas of studied permanent grasslands. Therefore, the dominance of colors depends on the number of species with the same color in the heterogeneous canopy and the phenophase of development. Spatial and temporal repartition of foliage biomass and caulinar biomass is influencing the evolution of canopy architecture, which is a summing junction of the individual component forms pertaining to various species that form the heterogeneous canopy (Dunea and Moise, 2008).
Numerically, the predominant colors in the 6-7 months of growth season are shown in Table 2. Depending on the number of species that form the heterogeneous canopy and their color of flowers (Table 3), the ordering of dominant colors and corresponding tones was as following: yellow (24.3%), green (21.3%), white (17.3%), red (14%), pink (8.1%), purple (7.2%), blue (6.4%), and brown (1.3%).

Table 2. Floristic composition based on the color of the flowers in the permanent grasslands of Rucăr-Bran Corridor

Pollinator-perceived color	Human-perceived color	Color Tone	Number of species	Participation (%)
Blue; UV-Blue	Blue	-	8	3.4
		Purplish	7	3.0
		Total	15	6.4
Blue-green	White	-	37	15.7
		Yellowish	2	0.8
		Greenish	2	0.9
		Total	41	17.4
Ultraviolet (UV)	Brown	Total	3	1.3
Green; UV-Green	Yellow	-	55	23.4
		Greenish	2	0.9
		Total	57	24.3
Ultraviolet (UV)	Red	-	21	8.9
		Orange	1	0.4
		Purplish	11	4.7
		Total	33	14.0
Blue; UV-Blue	Pink	-	14	6.0
		Reddish	2	0.9
		Purplish	3	1.2
		Total	19	8.1
Green	Green	Greenish	49	20.9
		Greenish-purplish	1	0.4
		Total	50	21.3
Blue; UV-Blue; UV-Green	Purple	-	8	3.4
		Blueish	2	0.9
		Purplish	5	2.1
		Purplish-reddish	1	0.4
		Pinkish	1	0.4
		Total	17	7.2
Main Color Total			235	100.0
Color Tone Total			92	39.1

Table 3. Identified species and corresponding human-perceived flower color in the permanent grasslands of Rucăr-Bran Corridor

Grasses	Human-perceived color	Other families	Human-perceived color	Other families	Human-perceived color
Agrostis capillaris	greenish	*Achillea distans*	white	*Knautia arvensis*	lilac-pink
Agrostis rupestris	greenish	*Achillea lingulata*	white	*Knautia longifolia*	red-lilac
Agrostis stolonifera	greenish	*Achillea millefolium*	white	*Leontodon autumnalis*	yellow
Alopecurus pratensis	greenish	*Achillea setacea*	white	*Leucanthemum vulgare*	white
Anthoxanthum odoratum	greenish	*Achillea stricta*	white	*Leucanthemum waldsteineii*	white
Apera spica venti	greenish	*Agrimonia eupatoria*	yellow	*Ligusticum mutellina*	pink
Arrhenatherum elatius	greenish	*Alchemilla flabellata*	yellow-greenish	*Lilium martagon*	pink-purple
Avenula versicolor	greenish	*Alchemilla vulgaris*	yellow-greenish	*Linum catharticum*	white-yellowish
Brachypodium pinnatum	greenish	*Antennaria dioica*	white	*Lychnis flos-cuculi*	pink
Briza media	greenish	*Arnica montana*	yellow	*Lychnis viscaria*	pink
Bromus arvensis	greenish	*Artemisia austriaca*	yellow	*Lysimachia vulgaris*	yellow
Bromus commutatus	greenish	*Astrantia major*	white-greenish	*Melampyrum pratense*	pink-purple
Bromus hordeaceus	greenish	*Bellis perennis*	white	*Mentha_pulegium*	purple-lilac
Bromus japonicus	greenish	*Bruckenthalia spiculifolia*	pink-violet	*Myosotis sylvatica*	bluish
Cynosurus cristatus	greenish	*Campanula abietina*	violet	*Origanum vulgare*	purplish (lilac)
Dactylis glomerata	greenish	*Campanula glomerata*	violet	*Parnasia pallustris*	white
Danthonia decumbens	greenish	*Campanula persicifolia*	bluish-violet	*Pedicularis verticillata*	red
Deschampsia caespitosa	greenish	*Campanula rotundifolia*	bluish-violet	*Peucedanum oreoselinum*	white
Deschampsia flexuosa	greenish	*Cardus acanthoides*	red-violet	*Phyteuma spicatum*	white
Dichanthium ischaemum	greenish	*Carlina acaulis*	white	*Pimpinella saxifrage*	white
Elymus hispidus	greenish	*Carum carvi*	white	*Plantago laceolata*	white
Festuca pratensis	greenish	*Centaurea jacea*	red-violet	*Plantago media*	white
Festuca pseudovina	greenish	*Centaurea mollis*	bluish	*Polygala vulgaris*	bluish-purple
Festuca rubra	greenish	*Centaurea phrygia*	red-violet	*Polygonum bistorta*	pink
Festuca rupicola	greenish	*Centaurea scabiosa*	red-violet	*Potentilla argentea*	yellow
Festuca valesiaca	greenish	*Centaurea triumfetti*	bluish-violet	*Potentilla aurea*	yellow

Holcus lanatus	greenish	*Centaurium erythraea*	red	*Potentilla cinerea*	yellow
Lolium perenne	greenish	*Cerastium arvense*	white	*Potentilla erecta*	yellow
Nardus stricta	greenish	*Cerastium fontanum*	white	*Potentilla reptans*	yellow
Phleum phleoides	greenish	*Chaerophyllum aromaticum*	white	*Potentilla ternate*	yellow
Phleum pratense	greenish	*Cichorium intybus*	bluish	*Potentilla thuringiaca*	yellow
Poa compressa	greenish	*Cirsium canum*	red	*Primula veris*	yellow
Poa nemoralis	greenish	*Cirsium erisithales*	yellow	*Prunella vulgaris*	bluish-violet
Poa pratensis	greenish	*Cirsium vulgare*	red	*Pseudorchis whiteida*	white
Trisetum flavescens	greenish	*Colchicum autumnale*	violet	*Pteridium aquilinum*	brownish
Vulpia myuros	greenish	*Crataegus monogyna*	white	*Pulsatilla whitea*	white
Legumes		*Crepis biennis*	yellow	*Ranunculus acris*	yellow
Anthyllis vulneraria	yellow	*Dactylorhiza cordigera*	pink	*Ranunculus montanus*	yellow
Astragalus onobrychis	purple	*Dactylorhiza maculata*	pink	*Ranunculus polyanthemos*	yellow
Coronilla varia	pink	*Daucus carota*	white	*Ranunculus repens*	yellow
Dorycnium pentaphyllum	white	*Dianthus barbatus*	red	*Ranunculus sardous*	yellow
Genista tinctoria	yellow	*Dianthus carthusianorum*	red	*Rhinanthus alectorolophus*	yellow
Genistella sagittalis	yellow	*Dianthus superbus*	pink	*Rhinanthus angustifolius*	yellow
Lathyrus nissolia	red	*Digitalis grandiflora*	yellow	*Rhinanthus major*	yellow
Lathyrus pratensis	yellow	*Dipsacus fullonum*	purple	*Rumex acetosa*	reddish
Lathyrus sylvestris	pink	*Echium vulgare*	bluish	*Rumex acetosella*	reddish
Lotus corniculatus	yellow	*Erodium cicutarium*	purple	*Rumex crispus*	reddish
Medicago falcata	yellow	*Eryngium campestre*	whitish-greenish	*Salvia nemorosa*	purple-bluish
Medicago lupulina	yellow	*Eupatorium cannabium*	red	*Salvia officinalis*	purple-bluish
Melilotus officinalis	yellow	*Euphorbia cyparissias*	yellow	*Salvia verticillata*	purple
Onobrychis viciifolia	red-violet	*Euphrasia rostkoviana*	white	*Sanguisorba officinalis*	red
Ononis arvensis	pink	*Euphrasia stricta*	white	*Scabiosa ochroleuca*	yellow
Trifolium alpestre	red	*Fragaria vesca*	white	*Scleranthus annuus*	green
Trifolium arvense	reddish	*Galium mollugo*	white	*Scorzonera rosea*	pink
Trifolium campestre	yellow	*Galium odoratum*	white	*Silene dioica*	red
Trifolium dubium	yellow	*Galium verum*	yellow	*Silene nutans*	white
Trifolium hybridum	pink	*Gentiana asclepiadea*	bluish	*Silene vulgaris*	white
Trifolium medium	red	*Gentiana utriculosa*	bluish	*Stachys germanica*	red
Trifolium montanum	white	*Gentianella austriaca*	purple	*Stachys officinalis*	purplish
Trifolium ochroleucon	yellow	*Geranium pratense*	bluish	*Stellaria graminea*	white
Trifolium pannonicum	white-yellowish	*Geum montanum*	yellow	*Succisa pratensis*	bluish-violet
Trifolium pratense	red-violet	*Gnaphalium sylvaticum*	brownish	*Symphytum officinale*	red-violet
Trifolium repens	white	*Gymnadenia conopsea*	pink-reddish	*Taraxacum officinale*	yellow
Vicia cracca	bluish-violet	*Helianthemum nummularium*	yellow	*Thalictrum simplex*	greenish-purple
Vicia grandiflora	yellow	*Hieracium aurantiacum*	red-orange	*Thymus glabrescens*	pink-reddish
Vicia striata	violet-red	*Hieracium bauhinii*	yellow	*Thymus montanus*	red-violet
Sedges and bulrushes		*Hieracium lactucella*	yellow	*Thymus pannonicus*	red-violet
Carex caryophyllea	greenish	*Hieracium pilosella*	yellow	*Thymus serpyllum*	red-violet
Carex ovalis	greenish	*Holosteum umbellatum*	white	*Tragopogon dubius*	yellow
Carex panicea	greenish	*Homogyne alpina*	red	*Tragopogon pratensis*	yellow
Carex spicata	greenish	*Hypericum maculatum*	yellow	*Trollius europaeus*	yellow
Carex tomentosa	greenish	*Hypericum montanum*	yellow	*Vaccinium myrtillus*	pink
Juncus articulatus	greenish	*Hypericum perforatum*	yellow	*Vaccinium vitis-idaea*	pink
Juncus conglomeratus	greenish	*Hypochaeris maculata*	yellow	*Veratrum whiteum*	white
Luzula alpinopilosa	greenish	*Hypochaeris radicata*	yellow	*Veronica chamaedrys*	bluish
Luzula campestris	greenish	*Hypochaeris uniflora*	yellow	*Veronica officinalis*	violet
Luzula luzuloides	greenish	*Inula britannica*	yellow	*Viola canina*	purple
Luzula sudetica	greenish	*Juniperus sibirica*	brownish	*Viola declinata*	violet
Luzula sylvatica	greenish	*Jurinea mollis*	red	*Viola hirta*	purple

Table 3 presents the identified species and corresponding human-perceived flower color in the permanent grasslands of Rucăr-Bran Corridor. Green color and its tones characterize mostly the flowers of grasses and sedges species. Maximum abundance of flowers was recorded between May and July.

Flower species that are closely related may share both similar flowering times and similar pigmentation, possibly resulting in apparent abundances of particular colors, as perceived by humans, at particular times of year. However, this pattern is not reflected in the trends in flower color as perceived by various pollinators (Arnold et al., 2009). Table 2 shows also the floristic composition based on the pollinator-perceived color, because patterns in flower color based on human perception alone are insufficient. Bees perceive blue, ultraviolet, green, and various combinations of these color.

CONCLUSIONS

In ecological technologies, utilization of grassland canopies extends from the pastoral scope to complementary areas such as multifunctional utilization of natural flora as medicinal and melliferous resources in the context of biodiversity and natural ecosystems conservation, ecotourism and rural tourism development in the space of pastoral heritage.

The melliferous potential of permanent grasslands in Rucăr-Bran Corridor established using GIS support is 5 to 10 t, considering 1-2 kg honey ha^{-1} corresponding to 10-20% canopy cover.

In terms of biodiversity, the space occupied by permanent grasslands in the study area is home to 235 species of plants, which shows an increased complexity. The maximum number of species was recorded at altitudes below 1000 m, in the *Fagus silvatica* sublevel, where *Agrostis capillaris*, and *Agrostis capillaris* + *Festuca rubra* grasslands prevail.

From the total number of species, 36 species were grasses, 29 species were legumes, 12 species were sedges and bulrushes, and 158 species were from other botanical families.

The flowers of species in the grasslands of Rucăr-Bran Corridor create an attractive landscape covering completely the visible spectrum. The predominant color and its corresponding tones in the flowering phenophase were yellow (24.3% of species), followed by green (21.3%), white (17.3%), and red (14%).

The unconventional system of grasslands multifunctional utilization from central and northern sectors of Rucăr-Bran Corridor requires the consideration of new technological sequences regarding the harvesting of medicinal plants and practicing of pastoral beekeeping, the implementation of measures to conserve the landscape and biodiversity.

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