

**SPECIES AND FUNCTIONAL DIVERSITY OF THE
LEGUME COMPONENT IN YELLOW BLUESTEM
PASTURES (TYPE *BOTHRIOCHLOA ISCHAEMUM*)**

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Abstract

The present study aims to research the species and functional diversity of legume species in phytocoenoses of the yellow bluestem, developing under the conditions of Central Northern Bulgaria. The work was conducted in 2021–2023 on a pasture that is representative of the ecological conditions of the region. According to the results, the studied pasture type is characterized by a high species diversity of legumes, which give it a good forage value. Clearly expressed complementarity was observed, as well as functional diversity of the established species in terms of phenological development, growth rate, productivity of fresh and dry biomass. A relative abundance was observed in the range of 20–50% for five perennial species in the following descending order: *Astragalus onobrychis*, *Dorycnium herbaceum*, *Onobrychis alba*, *Medicago falcate*, *Bituminaria bituminosa*. The indices of functional divergence (FDs) that were calculated for the observed morphological and reproductive traits of the indicated dominant species were high. They fall in the range 0.55–0.83, with an average value for the observed grassland type of FDs = 0.64. The results obtained can be linked to a stable condition and a very good forage and self-recovery potential of the yellow bluestem pastures under the conditions of Central Northern Bulgaria.

Key words: yellow bluestem pastures, type *Bothriochloa ischaemum*, legumes, species and functional diversity

Introduction. The yellow bluestem pastures (type *Bothriochloa ischaemum*) are the main type in our country, with a relative share of the permanently grassed areas amounting to 34% [1]. The study and maintenance of yellow bluestem

pastures is of economic interest, as they are a natural regional fodder resource with high value for sheep. Legumes are a major functional group in meadow ecosystems, occupying a separate and important niche compared to other plants. ROUSAKOVA and TZONEV [2] indicate that the following legumes are characteristic of the yellow bluestem pastures in Bulgaria: *Astragalus onobrychys*, *A. spruneri*, *A. monspessulanus*, *Lotus aegaeus*, *Medicago minima*, *Trifolium scabrum*, *T. angustifolium*, *T. arvense*, *T. setiferum*. While the species diversity of the egume component in xerothermic grasslands on the territory of our country and on the Balkan Peninsula is also presented in other current studies [3], there are no studies on the functional diversity. It is indicative, first of all, of the complementarity of the functions of plant species in grassland communities, being a better indicator of the stability of meadow ecosystems than species diversity [4]. According to CZORTEK et al. [5] morphological characteristics of the formed aboveground biomass are among the main functional traits related to strategies for acquisition, use and allocation of resources between species in grassland communities. Other such traits are: seed productivity, as related to competitive and invasive ability; life cycle and life form, as related to overlapping or differentiation of temporal and spatial niches in grassland ecosystems, as well as to the acquisition of temporal resources [6].

The present study aims to research the species and functional diversity of legume species in phytocoenoses of the yellow bluestem, developing under the conditions of Central Northern Bulgaria.

Material and methods. A yellow bluestem pasture was studied in the area of the highest point of the Danube Plain in Central Northern Bulgaria. The geographical data for the grassland recorded by a GPS receiver are: 491 m a.s.l., 43°08'39" N and 25°05'32" E. The natural vegetation in the area is forest-steppe. The observed grassland is open – trees and shrubs have a rare mosaic distribution. It is used for grazing by sheep, a local breed, representing a dairy cross. The pasture load in recent years has been low. The study was conducted in 2021–2023, and in the period April–August of the three experimental years, phytocenotic observations were conducted and the species forming the legume group in the cenosis were determined. Their life form according to Raunkiær were determined. Species cover was assessed using a 6-point scale: (0) the species absent; (1) the species has a cover of < 1%; (2) the species has a cover from 1 to 12%; (3) the species has a cover from 12 to 25%; (4) the species has a cover from 25 to 50%, and (5) the species has a cover > 50%. A mean cover score was calculated for each species by averaging their cover in four randomly selected plots of the grassland, which were different for the two experimental years. In the third experimental year, phenological data were collected for each legume species present in the grassland during the previous two experimental years. By means of samples from unit area square metre (1 m²), taken in quadruplicate, the yield of fresh mass (kg/m²), the dry matter content (%) and, respectively, the yield of dry mass (kg/m²) in

the phenophase beginning of flowering for each species were determined. Average samples from all replicates were subjected to morphological analysis averaging – relative share of individual morphological parts (leaves, stems and flowers) in the formed above-ground biomass; height/length of generative stems (cm); number of branches on a generative stem; number of inflorescences on a generative stem; number of flowers in an inflorescence; length of the inflorescence (cm). When the seeds ripened, from plots with an area of 0.25 m² and the same location, samples were taken for seed yield from species with a relative participation in the pasture over 12%. Seed samples were prepared, through which the mass of 1000 seeds – m₁₀₀₀ (g) was estimated. In order to determine the reproduction coefficient of individual species, the number of seeds obtained per unit area (0.25 m²) was calculated.

Since the characteristics of the dominant species largely determine the effects of plant communities on the functioning of the ecosystem [5], to assess the functional diversity of the legume component, the traits of legume species that had a relative abundance above 12%, respectively, an average score for species cover > 2, were observed. The following indices of functional diversity are presented [7]: functional range (FR_R) and functional divergence (One-dimensional functional divergence – FDs). The functional range (FR_R) was calculated by the difference between the largest and smallest values observed in the sample. To determine the one-dimensional functional divergence (FDs) index, the boxplot method was used, which is a graphical summary of the central tendency and the range of the frequency distribution.

Results and discussion. In the observed yellow bluestem, nine species of leguminous grasses belonging to eight different genera were identified (Table 1). According to the comparative study by MARUȘCA [8] the species identified by us are characterized by medium to high values of the forage value. Thus, it can be considered that they provide good forage value to the grass stand. The identified legumes differ in life form and cycle, with hemicryptophytic perennial species prevailing, which have higher estimates for species cover, relative participation in the grass stand, and constancy in the studied yellow bluestem pasture, respectively. The perennial species *Astragalus onobrychis*, *Onobrychis alba* and *Bituminaria bituminosa* can be defined as specific for the observed yellow bluestem coenosis, since they have not been observed in the other most widespread xerothermic grasslands in the region – the *Chrysopogon gryllus* meadows. The first two of the mentioned species belong to the richest genera of the *Fabacea* family, from which a very large number of wild nitrogen-fixing and soil-strengthening grasses are known, with high drought tolerance, adaptability to marginal lands and potential for use in ecological regeneration of degraded pastures [9]. Drought resistance is also characteristic of all established annual species (therophytes) in the pasture. They are distinguished by a short life cycle, which ends in early summer, before severe summer droughts.

T a b l e 1

Biological and productive characteristics of legume species in yellow bluestem pasture

Species	Plant life forms of Raunkiaer systems	Flowering time, days after start of vegetation	Score for species coverage*	FMY, kg/m ²	DM, %	DMY, kg/m ²
<i>Astragalus onobrychis</i>	Hemi	48	4.0	0.840	29.0	0.244
<i>Bituminaria bituminosa</i>	Hemi	69	2.6	2.060	31.5	0.649
<i>Onobrychis alba</i>	Hemi	72	3.4	1.000	25.0	0.250
<i>Medicago falcata</i>	Hemi	95	2.8	1.352	24.0	0.324
<i>Dorycnium herbaceum</i>	Hemi	98	3.8	1.480	35.1	0.520
<i>Medicago minima</i>	Th	35	1.6	0.460	22.4	0.103
<i>Trifolium campestre</i>	Th	75	1.8	0.348	28.0	0.098
<i>Lathyrus aphaca</i>	Th	54	1.4	0.600	21.7	0.130
<i>Vicia villosa</i>	Th	63	1.8	2.080	25.0	0.520
Mean		67.7	2.6	1.136	26.9	0.315
Sd		20.6	1.0	0.650	4.4	0.244
CV%		30.5	38.3	57.3	16.5	64.5

Hemi – Hemicryptophyte; Th – therophyte; FMY – fresh biomass yield; DM – dry mass content; DMY – dry biomass yield; *Score (0) – the species is absent; (1) has coverage < 1%; (2) 1–12%; (3) 12–25%; (4) 25–50% and (5) > 50%

According to the phenological observations, the legumes in the yellow bluestem pasture enter the flowering phenophase from 35 (*Medicago minima*) to 98 days (*Dorycnium herbaceum*) after the beginning of the vegetation period – April 1. Until the full development of the yellow bluestem at the end of July, a distinct turnover of species and almost equivalent total dry mass productivity of the legume component by months are observed (Fig. 1). In May it is 0.998 kg/m², in June – 0.996 kg/m², and in July – 0.844 kg/m². Thus, the available species diversity can be associated with maintaining the productivity of high-protein dry matter and, accordingly, the levels of nitrogen fixation at a stable level, which is important for the ecological function and value of this type of pasture.

The results presented show a clear complementarity, respectively, functional diversity of legume species in the yellow bluestem pasture in terms of important biological features, namely growth rate and biomass accumulation and timing of phenological development. LUO et al. [10] also conclude that the temporal stability of productivity is positively related to the functional divergence of the grass association.

According to the data presented in Table 1, over half of the identified legumes have an average species cover score in the range of 2.6–4.0 points, which corresponds to a relative participation in the grass stand of 20 to 50% in the following descending order: *Astragalus onobrychis*, *Dorycnium herbaceum*, *Onobrychis alba*,

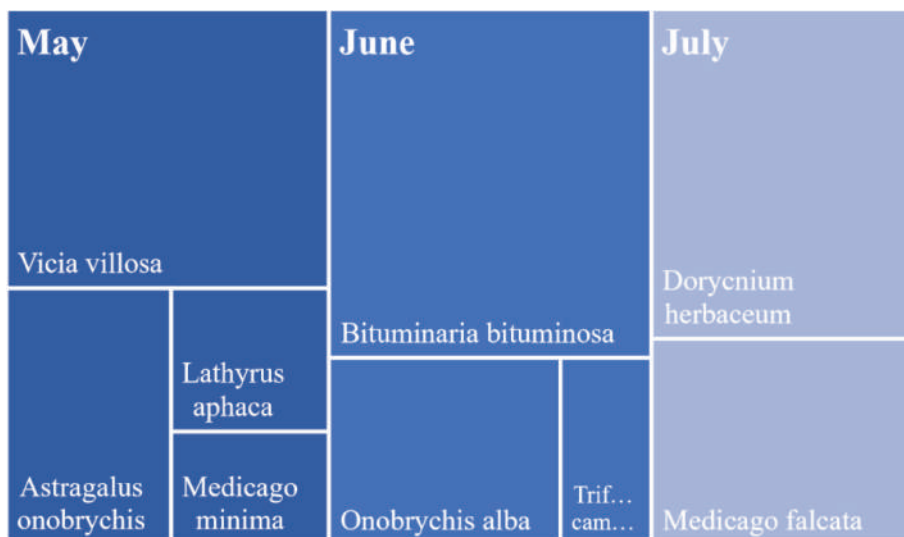


Fig. 1. Productivity (kg/m²) of the legume component and its constituent species by month

T a b l e 2

Morphological and reproductive traits of the dominant legumes and functional diversity indices

Species	Height of generative stem, cm	Number of inflorescences per generative stem	Number of flowers per inflorescence	Leaf, %	Stems, %	Flowers, %	Seed ripening period, days after start of vegetation	Seed yield, g/0.25 m ²	m ₁₀₀₀ , g	Number of seeds harvested from 0.25 m ²
<i>Astragalus onobrychis</i>	31.1	2.8	20.0	25	50	25	105	2.01	1.83	1162
<i>Bituminaria bituminosa</i>	80.3	10.2	15.7	19	35	8	115	1.59	27.20	56
<i>Onobrychis alba</i>	39.7	4.6	39.0	32	50	18	115	11.52	8.07	1396
<i>Medicago falcata</i>	44.0	20.8	10.0	16	69	15	145	2.95	1.27	2323
<i>Dorycnium herbaceum</i>	47.3	16.7	26.8	18	63	19	140	2.44	1.65	1480
FR_R	59.2	18.0	29.0	16.0	34.0	17.0	9.9	25.9	2267	9.9
FDs	0.58	0.83	0.69	0.72	0.69	0.62	0.55	0.62	0.57	0.55

Medicago falcata, *Bituminaria bituminosa*. Accordingly, these are the species identified as dominant legumes in the studied pasture. They were characterized by morphological and reproductive traits (Table 2) in order to assess the functional diversity of the legume component (Fig. 2).

The indices of functional divergence (FDs) that were calculated for the observed morphological and reproductive traits of the indicated dominant species were high. They fall in the range 0.55–0.83, with an average value for the observed pasture type of FDs=0.64 (Table 2). High functional divergence is indicative of good ecosystem functioning, as it reflects increased complementarity in resource use between species [4]. The highest values for FDs are observed for the following traits: number of inflorescences per generative stem; relative share of leaves and stems in the formed biomass, and number of flowers per inflorescence (Fig. 2).

Our results are indicative of the advantageous complementarity of legumes in terms of floral resources for maintaining insect populations, which are an impor-

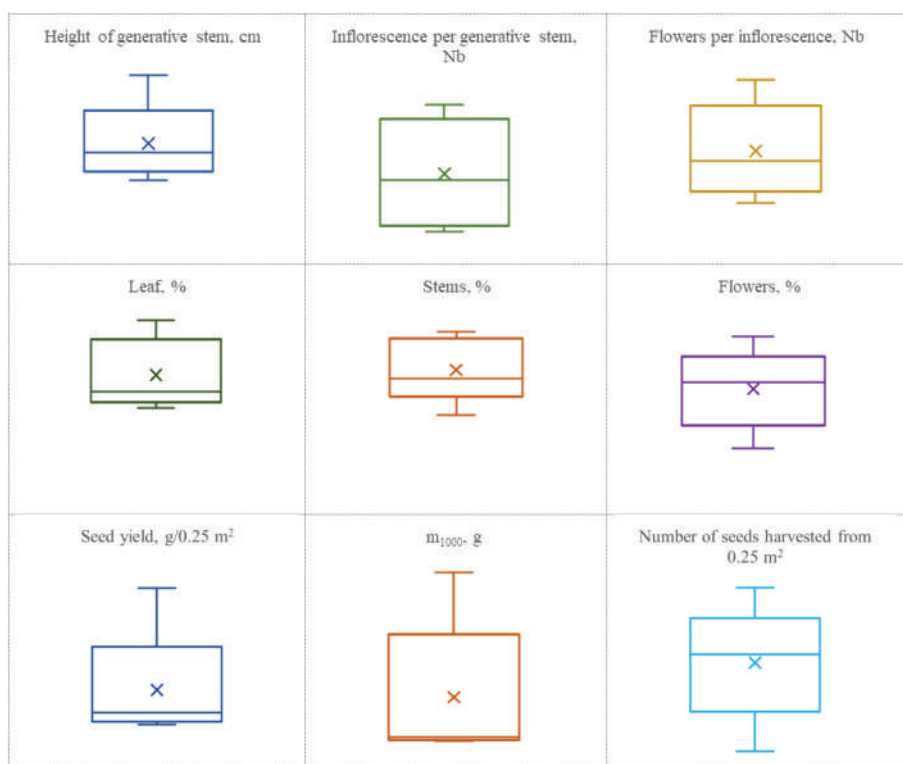


Fig. 2. Central tendency and range of the frequency distribution for the observed functional traits

tant part of food chains and a major factor in the conservation of biodiversity in the dry grasslands and their ecological function for the entire region. According to the results of the morphological analysis, the most abundantly flowering are *Astragalus onobrychis* and *Dorycnium herbaceum* (Table 2), in which the relative share of inflorescences/flowers in the formed above-ground biomass is 25 and 19%, respectively. These are also the species with the highest scores for species cover in the studied pasture. *Dorycnium herbaceum* is reported as the most preferred by the honey bee (*Apis mellifera*) in Romania [11].

Diversity in terms of foliage, in turn, positively affects photosynthesis rates, nutrient cycling and the rate of detrital mineralization. The relative share of foliage mass to the biomass formed is low (average value 22%), which is characteristic of species adapted to dry and nutrient-poor habitats. However, the differences in this indicator between the dominant legumes in the pasture are high ($FR_R = 16\%$), which corresponds to the finding of ERDŐS et al. [12] that forest pastures have low values of general functional diversity, but high values for certain traits, with specific leaf area being one of them.

The traits generative stem height and seed yield per unit area, respectively, reproductive ability, are related to competitive ability, invasiveness or persistence

of species in grass communities. For these traits of the dominant legumes in the yellow bluestem pastures, high values of the functional divergence index (FDs) were also found – 0.58 and 0.62, respectively. Luo et al. [10] linked functional diversity in terms of reproductive characteristics with higher drought tolerance of plant communities. According to our results, the functional divergence of the legume component in the studied phytocoenoses in terms of specific seed mass and number of seeds harvested per unit area is also high. This is indicative of a high self-restoration potential of the yellow bluestem pastures in the area, as the presence of a large number of seeds of adapted nitrogen-fixing leguminous grasses is of paramount importance for the restoration of grasslands under any type of disturbance [5].

Conclusion. The studied pasture type is characterized by a high species diversity of legumes, which give it a good forage value. Clearly expressed complementarity was observed, as well as functional diversity of the established species in terms of phenological development, growth rate, productivity of fresh and dry biomass. The indices of functional divergence (FDs) that were calculated for the observed morphological and reproductive traits of the dominant legume species were high. The results obtained can be linked to a stable condition and a very good forage and self-recovery potential of the yellow bluestem pastures under the conditions of Central Northern Bulgaria.

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