

## PHYTOCOENOTIC DIVERSITY OF GRASSLANDS WITH *BOTHRIOCHLOA ISCHAEMUM* (L.) KENG IN EURASIA

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### Abstract

The phytocoenoses of the grasslands with *Bothriochloa ischaemum* (L.) Keng var. *ischaemum* are common in the Eurasian territory and form the ass. *Bothriochloetum ischaemii* Krist 1937 Pop 1977. The analysis of the synthetic lists, presented by many authors, from various biogeographical regions of the Eurasian area, revealed the presence of discrete communities dominated by yellow bluestem, due to the diversified habitat and the floristic composition appropriate to the given locality. Thus, we have found that, in the steppe biogeographical region, at the altitude of 100-350 m, on soil consisting of chernozem and clay, the association *Euphorbio (seguieriana) Bothriochloetum ischaemum* n.n develops; in the continental one – at the altitude of 100-800 m, on calcareous and gravelly soil, there are phytocoenoses of the association *Asperulo (cynanchica) - Bothriochloetum ischaemii* n.n; in the Pannonian region – the grasslands of the northern part of the Pannonian Basin, at the altitude of 130 m, on sandy soil, there are phytocoenoses of the ass. *Teucrio (botryos) - Bothriochloetum ischaemium* n.n.; and in the floodplain of the Danube River, at the altitude of 135 m, on sandy alluvial soil – the ass. *Syntrichio(ruralis)-Bothriochloetum ischaemii* n. n.; in the alpine region – the mountains of south-eastern Caucasus and Central Asia (Pamir-Alay Mountains), *Bothriochloa ischaemum*, at high altitudes (1500-2000 m), forms vegetation belts with the stable phytocoenoses of the ass. *Glycyrrizo (glabra) - Bothriochloetum ischaemii* n. n., on kastanozem soil. All the above-mentioned associations fit into the phytocoenotic hierarchy with the range of plant species characteristic of cl. *Festuco-Brometea* Br.-Bl. et R. Tx. ex Klika et Hadač 1944; ord. *Festucetalia* Br.-Bl. et R. Tx. ex Br.-Bl. 1949, all. *Festucion valesiacae* Klika 1930.

In the Mediterranean biogeographical region, the plant communities that include yellow bluestem populate various altitudes – from the lowest ones (20-250 m), on the Iberian Peninsula, to the highest ones (610-1050 m), in the Apennine Mountains, that's why there is a great variety of phytocoenoses: ass. *Elymo(hispidus) - Bothriochloetum ischaemii* n. n.; *Festuco (inops)-Bothriochloetum ischaemii* n. n. and *Melico (ciliata) - Bothriochloetum ischaemii* n. n. The plant communities with *Bothriochloa ischaemum* found in the Mediterranean biogeographical region are components of the al. *Bromion erectus*; ord. *Brometalia erecti* Br.-Bl. 1936; cl. *Festuco-Brometea* Br.-Bl. et R. Tx. Klika et Hadač 1944. The phytocoenoses with *Bothriochloa ischaemum* are savannah-like grasslands, which occupy vast areas in the northern hemisphere and make stable, expanding communities supported by the climatic impact of global warming.

**Keywords:** biogeographical region, Eurasian territory, savanoid grassland, boreal grassland, arid grassland.

## INTRODUCTION

*Bothriochloa ischaemum* (L.) Keng. var. *ischaemum* is a species of savanoid grass, which originates from subtropical mountain areas (Цбелев Н.Н., 1969) and is widespread in areas with warm climate of the northern hemisphere. The current phytocoenoses with yellow bluestem are found at the “interference” of the boreal steppes with the tropical (savanoid) ones, forming diverse plant communities in Eurasia, in numerous biogeographical regions (Рубцов Н.И., 1956).

The grasslands with *Bothriochloa ischaemum* (L.) Keng. var. *ischaemum* cover large areas in Europe and Asia. The phytocoenoses that contain this species and its natural range, in latitude, start from the Atlantic Ocean and extend to the Pacific. In North and South America, Australia and New Zealand, it is an introduced plant, and in Puerto Rico – an invasive one. Everywhere, it needs sunny, dry,

calcareous, thermal areas with nutrient-poor and alkaline soils. Within the natural range of yellow bluestem, there are such varieties as *Bothriochloa ischaemum* var. *songarica* with a restricted range – southern China, Taiwan and northern Myanmar, and *Bothriochloa ischaemum* var. *ischaemum*, which is native to a larger area – from Japan to Portugal (Compedium..., 2015).

The study of natural pastures, including the evaluation of the specific components appropriate to the pedoclimatic conditions of the habitat, is the primary task in the planning, use and sustainable development of grassland ecosystems with the purpose of increasing the productivity and the quality of forage, but the understanding of the strong connection of the dominant species, yellow bluestem, with the faithful species of the natural habitat of the given biogeographic region is even more important.

## MATERIAL AND METHOD

While studying the grasslands with *Bothriochloa ischaemum* in the Republic of Moldova, we used relevés (26), which fixed the years 1989-2002, in the Bugeac and Bălți Plains, as

well as literature data (Săvulescu T., 1927; Гейдеман Т.С., 1959; Постолаке Г.Г. and Истратий А.И., 1991, 1992, Руцук А.Д., 2008; Шабанова Г.А., 2012, 2014; Lazu Șt., 2014-2016 and

synthetic lists of grasslands dominated by *Bothriochloa ischaemum* from Romania (Puşcaru-Soroceanu Evd. et al., 1963; Dihoru Gh. and Doniţă N., 1970; Cristea V. and Csuros Şt., 1979; Ivan D. and Doniţă N. et al., 1963; Chifu T., 2014; Oroianu S. et al., 2007); Bulgaria (Apostolova I. and Meshinev T., 2006; Sopotleva D. and Apostolova I., 2014); Ukraine (Solomakha V.A., 1996; Коротченко И.А. et al., 2009); Georgia (Nackhutsrishvili I., 2013); Tajikistan (Сафаров Н.М., 2015); Spain (Miquel de Caceres Ainsa, 1991-2001); Italy (Florineth Florin, 1974; Taffetani F. et al., 2004; Faggi B. et al., 2014); Slovakia (Dubravkova D. et al., 2010); Serbia (Mirjana Kristivojevic Cuk et al., 2015). Thus, there are phytocenoses with *Bothriochloa ischaemum* in five biogeographical regions: Mediterranean, alpine, Pannonian, continental and steppe (figure 1 and 2, table 1).

The phytocenotic evaluation of grasslands with *Bothriochloa ischaemum* in Eurasia is not homogeneous. In the European area, the phytocenotic classification is carried out according to the principles of the Braun-Blanquet J. floristic school, 1933, 1964, i.e. the concept of constancy or fidelity of the species is used for defining in the phytocenotic nomenclature.

Currently, the plant communities with *Bothriochloa*

*ischaemum*, according to the phytosociological classification (Braun-Blanquet J., 1964), are part of the ass. *Bothriochloetum ischaemi* (Kristiansen 1937) I. Pop 1977, al. *Festucion valesiacae* Klika 1931; ord. *Festucetalia valesiacae* Br.-Bl. et. R.Tx. 1943 and cl. *Festuco-Brometea* Br.-Bl. et. R. Tx. 1943, and the faithful and characteristic species are represented by the title species of the plant association.

In the alpine area (the Pamir-Alay Mountains and the south-east Caucasus), the vegetation of the grasslands with *Bothriochloa ischaemum* is presented by authors according to the concept of the ecological-phytocoenological school, which consists in describing the associations based on the dominant species. Thus in the Pamir-Alay Mountains, at the altitude of 1500-2000 m, the grasslands with yellow bluestem are mentioned as *Bothriochloa ischaemum* formations, which comprise two groups of associations – *Bothriochloa ischaemum* with *Glycyrrhiza glabra* and *Bothriochloa ischaemum* dominated by ephemeral species (*Inula macrophylla*, *Poa bulbosa*, *Eremurus olgae*, *Carex pachystylis*, *Ferula gigantea* and *Glycyrrhiza glabra* with lower abundance). Each group includes numerous associations dominated by one of them.

According to the same principle, the evaluation of the vegetation with yellow bluestem was carried out in the southeastern Caucasus, at the altitude of 500-600 m, where the formation *Bothriochloa ischaemum* with *Glycyrrhiza glabra* was found. The analysis of the relevés made

in the natural range revealed a great diversity of phytocoenoses with *Bothriochloa ischaemum* as dominant species, but the constant species, which are the exponents of the conditions of the area, which in the given article are to be identified and laid at the base the phytocoenostic diversity.

## RESULTS AND DISCUSSION

The phytocoenoses of xerophytic grasses including yellow bluestem (*Bothriochloa ischaemum*) are very common in the Republic of Moldova. On 65,000 ha of land (Teleuță, 2000) with steppe vegetation, plant communities with yellow bluestem occur almost everywhere. Depending on the abundance, it grows in the communities of *Agropyron repens*, *Stipa pennata*, *Poa pratensis* and *Chrysopogon gryllus* as a co-occurring species. In this article, we will treat it as dominant species that forms stable associations in various conditions of the vast Eurasian territory, and the species with status of "constant" defines the area.

In the Republic of Moldova, it is widespread in the south (Bugeac Plain), in the centre and the north (Bălți Plain), but on highly eroded slopes, it can form monodominant communities. In the rocky regions on the banks of Prut and Dniester rivers, it is more abundant, as well as on the left bank of Dniester (the nature reserve with steppe vegetation

"Iagorlâc"). The grasslands with yellow bluestem from Bălți Plain (at the north) differ from those found in the Bugeac Plain (the south of Moldova), according to T. Săvulescu [10], in the floristic composition and in their quantitative ratio. The author identified, in the Northern Plain of Bălți, meadow steppes with *Bothriochloa ischaemum*, and in the Bugeac Plain – xerophytic steppes with *Euphorbia seguieriana* (figure 2).

Гейдеман Т. С. (1959) studying the yellow bluestem communities in the Moldavian S.S.R., mentioned that this xerophilous species did not have a distinct zonal range in the hilly landscape of this territory, as it was noted in the North Caucasus and Central Asia.

The author observed that by restoring the steppe vegetation in the fallowed sectors, *Bothriochloa ischaemum* associated with the grass species that grew in the natural phytocoenoses in the centre of the area.

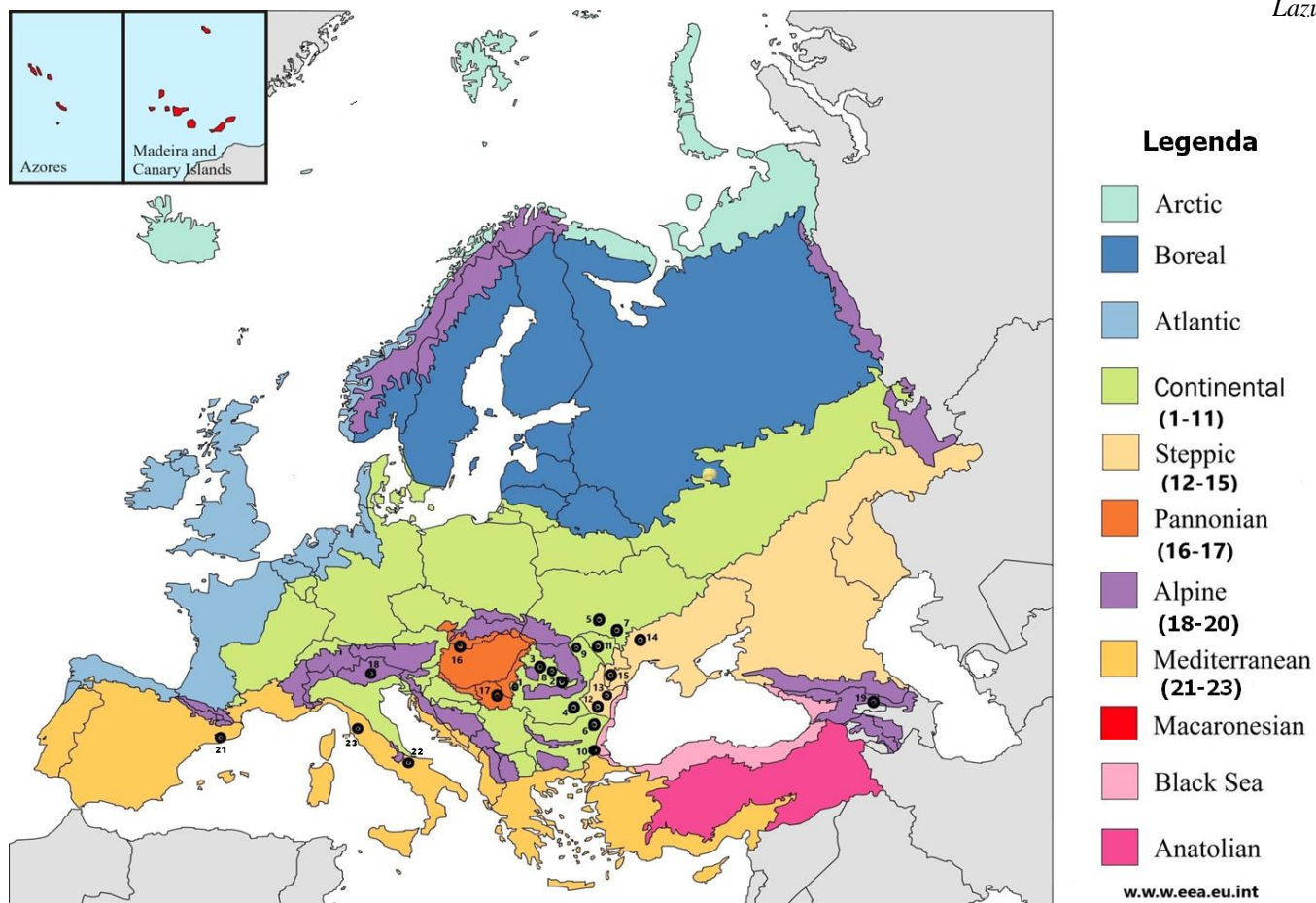


Fig. 1. The distribution of the studied phytoceenoses dominated by *Bothriochloa ischaemum* in Europe

The author studied the phytocoenoses with yellow bluestem (*Bothriochloa ischaemum*) as dominant species and found that it was adapted to the aridized climate (it formed large and compact bushes, based on vegetative reproduction (by rhizomes)) and expanded to new areas that had become available as a result of erosion, superficial landslides or deforestation.

The grass communities with yellow bluestem in the

Republic of Moldova represent primary and anthropized phytocoenoses affected by overgrazing, but all occur on sunny slopes with calcareous, rocky, dry and nutrient-poor soil. The formations with *Bothriochloa ischaemum* of primary type occur in the Central Asia, Anatolia (Asia Minor), the Caucasus and the eastern part of the Mediterranean Basin, but in the rest, including the Republic of Moldova, they expand due to the favourable conditions.



Fig. 2. *Bothriochloa ischaemum* (v. Vrănești, district Sângerei, continental biogeographical region)

In the Republic of Moldova, there are primary and secondary phytocenoses with yellow bluestem, which obviously differ in the floristic composition (Шабанова Г.А., 2012).

The essence of the structure of the first ones has

affinities for a habitat with more calcareous soils, with such species as *Gypsophylla collina*, *Cephalaria uralensis*, *Thymus marschallianus*, *Teucrium chamaedrys*, *Genista tetragona*, *Chamaecytisus ratisbonensis*, *Helianthemum numularium*.

Table 1

Syntaxonomy of the sectors with the association *Bothriochloa ischaemum* in Eurasia

| № | Bio-geographical region | № on the map | Bibliographic source        | Locality                        | Altitude (m) | Number of relevés | Author's association  | Diagnostic species and frequency, according to the author | Name of the proposed association                                 |
|---|-------------------------|--------------|-----------------------------|---------------------------------|--------------|-------------------|---|---|--|
| 1 | 2                       | 3            | 4                           | 5                               | 6            | 7                 | 8   | 9   | 10   |
| 1 | Continental             | 1            | Puşcaru-Sorocianu E., 1963  | Banat (Romania)                 | 200-350      | -                 | ass. <i>Andropogon ischaemum</i>  | <i>Asperula cynanchica</i> L. (+)                         | ass. <i>Asperulo (cynanchica) Bothriochloetum ischaemii</i> n.n. |
|   |                         | 2            | Puşcaru-Sorocianu E., 1963  | Braşov (Romania)                | 350-700      | -                 | ass. <i>Andropogon ischaemum</i>  | <i>Asperula cynanchica</i> L. (+)                         | - " -  |
|   |                         | 3            | Cristea V. et al., 1979     | Transylvanian plateau (Romania) | 400-500      | 13                | ass. <i>Bothriochloa ischaemii</i> (Krist. 1937) I. Pop 1977  | <i>Asperula cynanchica</i> L. (III)                       | - " -  |
|   |                         | 4            | Doina Ivan et al., 1993     | Dobrogea (Romania)              | 100-150      | 219               | ass. <i>Bothriochloa ischaemii</i> (Krist. 1937) I. Pop 1977  | <i>Asperula cynanchica</i> L. (II)                        | - " -  |
|   |                         | 5            | Solomaha V.A., 1996         | Western Podolia (Ukraine)       | -            | -                 | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977   | -   | -  |
|   |                         | 6            | Apostolova I. et col., 2006 | NE Balkans (Bulgaria)           | 122-333      | 172               | ass. <i>Bothriochloetum ischaemii</i> Pop 1977 ( <i>typicum</i> ), subass. nov <i>Thymetosum pannonicum</i> | <i>Asperula cynanchica</i> L. (IV)                        | - " -  |
|   |                         | 7            | Рущук A.D. et al., 2006     | Iagorlic R.Moldova              | 100-160      | -                 | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977   | <i>Asperula cynanchica</i> L. (IV)                        | - " -  |
|   |                         | 8            | Oroian S. et al., 2007      | Transylvanian plateau (Romania) | 472-598      | 6                 | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977   | <i>Asperula cynanchica</i> L. (V)                         | - " -  |
|   |                         | 9            | Chifu T., 2014              | Carpathians (Romania)           | 280-800      | 54                | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977   | <i>Asperula cynanchica</i> L. (I)                         | - " -  |
|   |                         | 10           | Sopotleva D. et al., 2014   | SE Balkans (Bulgaria)           | 88-350       | 176               | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977   | <i>Asperula cynanchica</i> (III)                          | - " -  |

|   |           |    |                                     |  |          |    |   |  |  |
|---|-----------|----|-------------------------------------|--|----------|----|---|--|--|
|   |           | 11 | Lazu Șt. et al., 2016               | Bălți Plain (R.Moldova)                                      | 200-250  | 13 | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977                               | <i>Asperula cynanchica</i> (II)  | - " -  |
| 2 | Steppe    | 12 | Pușcaru-Sorocianu E. et al., 1963   | Muntenia, southern Moldova (Romania)                         | 100-200  | -  | ass. <i>Andropogon ischaemum</i>  | <i>Euphorbia seguieriana</i> Neck (±2)   | ass. <i>Euphorbia (seguieriana) Bothriochloetum ischaemii</i> n.n. |
|   |           | 13 | Dihoru G. et col., 1970             | Babadag (Romania)  | 200-350  | 81 | ass. <i>Bombicyleno-Bothriochloetum ischaemii</i> Dihoru 1970                             | <i>Euphorbia seguieriana</i> Neck (+)  | - " -  |
|   |           | 14 | Коротченко И.А. et al. 2009         | Northwestern steppe (Ukraine)                                | -        | 5  | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977                               | <i>Centaurea scabiosa</i> L. (IV)  | -  |
|   |           | 15 | Lazu Șt. et al., 2016               | Bugeac (R.Moldova)   | 150-200  | 12 | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977                               | <i>Euphorbia seguieriana</i> Neck. (III)   | - " -  |
| 3 | Pannonian | 16 | Dubrovkova D. et col., 2010         | Western Carpathians and Northern Pannonian Basin (Slovakia)  | 130      | 25 | ass. <i>Teucrio(botryos) Andropogonetum ischaemii</i> Sauberer et Wagner în Sauberer 1942 | <i>Teucrium botryos</i> L.   | ass. <i>Teucrio (botryos) – Bothriochloetum ischaemii</i> n.n.     |
|   |           | 17 | Mirjana Kristivoj Cuk et col., 2015 | The floodplain of Danube, with dry sands (Vojvodina, Serbia) | 135      | 2  | ass. <i>Bothriochloetum ischaemii</i> (Krist 1937) Pop 1977                               | <i>Syntrichia ruralis</i> (25) <i>Euphorbia seguieriana</i> Neck. L. (20)        | ass. <i>Syntrichio (ruralis) Bothriochloetum ischaemii</i> n.n     |
| 4 | Alpine    | 18 | Florineth Florin, 1974              | Alps, South Tyrol (Italy)                                    | 960-1410 | 16 | Ass. <i>Bothriochloa ischaemum</i>  | variants:<br>- <i>Festuca valesiaca</i> -Gaudin;<br>- <i>Stipa capillata</i> L.; | -  |
|   |           | 19 | Nakhutsrishvili G., 2013            | South-eastern Caucasus Mountains (Georgia)                   | 500-600  | -  | Group ass. <i>Glycyrrhizeto (glabra) + Bothriochloa ischaemum</i>                         | <i>Glycyrrhiza glabra</i> L.   | ass. <i>Glycyrrhizo (glabra)-Bothriochloetum ischaemii</i> n.n     |



|   |               |    |                                       |  |               |    |  |  |  |
|---|---------------|----|---------------------------------------|--|---------------|----|--|--|--|
|   |               | 20 | Сафаров H.M.,<br>2015                 | Pamir-Alay<br>Mountains<br>(Tajikistan)                            | 1500-<br>2000 | -  | Group ass. <i>Glycyrrhizieto (glabra) +<br/>Bothriochloa ischaemum</i> | <i>Glycyrrhiza glabra</i> L.   | - " -  |
| 5 | Mediterranean | 21 | Miquel de Caceres<br>Ainsa, 1999-2001 | The plain of<br>Barcelona (Spain)                                  | 10-250        | 26 | ass. <i>Lactuco (vineae) -<br/>Bothriochloetum ischaemii</i>           | - <i>Elymus hispidus</i><br>(Opiz) Melder;<br>- <i>Allium sphaerocephalon</i><br>L.;<br>- <i>Onobrychis</i><br><i>arenaria/tommasinii</i> Kit.<br>DC<br>- <i>Melica ciliata</i> L. | ass. <i>Melico</i><br>( <i>ciliata</i> )-<br><i>Bothriochloetum ischaemii</i><br>n.n |
|   |               | 22 | Taffetani E. et al.,<br>2004          | Central Apennine<br>Mountains with<br>Adriatic exposure<br>(Italy) | 455           | 2  | ass. <i>Dichanthium ischaemum</i>                                      | - <i>Dichanthium</i><br><i>ischaemum</i> (L.) Beauv.<br>- <i>Plantago argentea</i><br>Chaix<br>- <i>Festuca inops</i> De Not.  | ass. <i>Festuco</i><br>( <i>inops</i> ) -<br><i>Bothriochloetum ischaemii</i><br>n.n |
|   |               | 23 | Faggi B. et al.,<br>2014              | Northern<br>Apennines –<br>Tuscany (Italy)                         | 610-<br>1060  | 71 | ass. <i>Bothriochloa ischaemum +<br/>Melica ciliata</i>                | - <i>Melica ciliata</i> L.<br>- <i>Avena barbata</i> Pott ex.<br>Link<br>- <i>Galactites tomentosus</i><br>Moench  | ass. <i>Melico</i><br>( <i>ciliata</i> )-<br><i>Bothriochloetum ischaemii</i><br>n.n |

The author (Шабанова Г.А., 2012) points out that in large areas covered with yellow bluestem from the "Iagorlâc" Reserve, in sectors with lime-rich soil, stony at the surface, or with carbonate clays, components of these phytocoenoses appear or the abundance of some calcicole species increases, for example: *Astragalus pseudoglaucus*, *Carex humilis*, *Centaurea marschalliana*, *Cephalaria uralensis*, *Chamaecytisus ratisbonensis*, *Cleistogenes bulgarica*, *Euphorbia glareosa*, *Euphorbia stepposa*, *Genista tetragona*, *Gypsophylla collina*, *Haplophyllum suaveolens*, *Helianthemum nummularium*, *Jurinea stochadifolia*, *Koeleria moldavica*, *Linum austriacum*, *Linum linerifolium*, *Linum tenuifolium*, *Minuartia setacea*, *Onosma macrochaeta*, *Seseli annuum*, *Seseli tortuosum*, *Silene exaltata*, *Thymus marschallianus*, *Thymus moldavicus*. By analyzing the plant lists published by T. Săvulescu (1927), Гейдеман Т. С. (1959), Постолаке Г. Г., Истратий А. И., 1991, 1992, Шабанова Г. Г., 2012, 2014, as well as our lists (Lazu Șt. et al. 2015, Lazu et al. 2016), we would like to mention that the meadow steppes of the North Moldavian Plain (Bălți), with *Bothriochloa ischaemum* as dominant species, include species that do not occur in the Bugeac Steppe or have lower abundance-dominance.

These species are: *Achillea millefolium*, *Artemisia austriaca*, *Berteroa incana*, *Caragana mollis*, *Carduus themeri*, *Centaurea diffusa*, *Eryngium campestre*, *Galium verum*, *Inula britanica*, *Iris halophila*, *Potentilla impolita*, *Salvia austriaca*, *Salvia nemorosa*, *Phleum tuberosus*, *Nepeta parviflora*, *Plantago lanceolata*, *Verbascum phoenaceum*, *Bromopsis inermis*, *Campanula sibirica*, *Elytrigia intermedia*, *Hypericum perforatum*, *Jurnea calcarea*, *Medicago romanica*, *Melilotus officinalis*, *Potentilla argentea*, *Potentilla recta*, *Salvia verticillata*, *Thymus marschalianus*, *Trifolium medium*.

On the left bank of Dniester River ("Iagorlâc" Nature Reserve), Шабанова Г. А. (2012) pointed out phytocoenoses with yellow bluestem that were a variant of the more xerophytic steppes, which included numerous petrophilic species, characterized by higher abundance – *Thymus marschalianus*, *Thymus moldavicus*, *Teucrium chamaedrys*, *Gypsophylla collina*, *Jurinea stoechadifolia*, *Koeleria moldavica*, *Carex humilis*, *Chamaecytisus ratisbonensis*, *Genista tetragona*. Ephemeroïd and ephemeral grass species stand out in spring – *Androsace elongata*, *Androsace maxima*, *Euphorbia verna*, *Hyacinthella leucophaea*, *Meniocus linifolius*, *Muscari neglecta*, as well as the

species of the genera *Gagea*, *Thlaspi*, *Veronica* etc.

The continental biogeographical region (according to European biodiversity – Biogeographical regions and seas – 2002 – further on EB-BR-2002) – the grassy vegetation constitutes 14 % and tends to decrease.

It occurs on hilly areas and plateaus with altitudes of 100-500 m. The soil – chernozem on clay and loess. This type of vegetation is found mostly in the central part of Europe.

The grasslands with *Bothriochloa ischaemum* on Bălți plain (on the Map and in the Table – 11) (Lazu et al., 2016) and “Iagorlâc” Nature Reserve (Map, table 7) (Рущчук А. О. et al., 2006) have many floristic similarities to those in the continental biogeographical region. The characteristic and faithful species of the association with *Bothriochloa ischaemum* (V) was identified – *Asperula cynanchica* (I-V), and we propose the ass. *Asperulo (cynanchica)-Bothriochloetum ischaemii* n.n; of the alliance *Festucion valesiaca* Klika 1931; order *Festucetalia* Br.-Bl. et R.Tx. 1943 and cl. *Festuco-Brometea* Br.-Bl. et R.Tx. 1943.

The most frequent plant species of this community – *Festuca valesiaca* (IV), *Medicago*

*falcata* (III), *Eryngium campestre* (IV), *Teucrium chamedrys*, *Plantago lanceolata* (III), *Potentilla argentea* (III), *Medicago lupulina* (II), *Thymus pannonicus* (III), *Cynodon dactylon* (II), *Artemisia austriaca* (II), *Trifolium montanum* (II), *Campanula sibirica* (II), *Coronilla varia* (II), *Fragaria viridis* (II), *Chondrilla juncea* (III), *Adonis vernalis* (IV), *Veronica prostrata* (I), *Onobrychis arenaria* (I), *Iris pumila* (I), *Achillea setacea* (II), *Linum tenuifolium* (I), *Galium verum* (II), *Euphorbia cyparissias* (II), *Sanguisorba minor* (II), *Caragana molis* etc. (figure 2, 3).

The study of yellow bluestem grasslands included synthetic lists of plants found in areas with hilly relief and altitudes of 100-350 m from R. Moldova, Western Podolia, Dobrogea, Banat, Balkans (Map and table 1, 4-7, 10, 11) and the Transylvanian Plateau with altitudes of 350-700 m (Map and table 2, 3, 8) and the Carpathian Mountains – 800 m (Map and table 9).

The steppe biogeographical region, in Europe, comprises 17% of the area covered with grasses (*Stipa lessingiana*, *S. capillata*, *Festuca valesiaca*). In this area, grasses are found on chernozem soil, at altitudes of 100-350 m, the climate is warm and droughty (EB-BR-2002).



Fig. 3. Grassland with *Bothriochloa ischaemum* in Bălți Plain (v. Nihoreni, d. Râșcani). Continental biogeographical region

In the Republic of Moldova, the steppes are characterised by true vegetation of xerophilic grasses and include the whole Bugeac, which is totally assimilated by agriculture, and the present pastures are degraded grasslands or abandoned agricultural land (fallow land). The current meadows with xeric grasses are the result of the interaction of the regional climatic conditions with the vegetation, and the sectors with steppe vegetation protected by the state, such as the "Bugeac" Nature Reserve – 60 ha, "Dezghingea" – 15 ha, "Ciumai" – 50 ha and the representative sector "Andriașevca nouă" – 71 ha, demonstrate the pedoclimatic capacities of these communities,

which include the savanoid species *Bothriochloa ischaemum* (figure 4).

In the Southern Moldavian Plain (Bugeac), on the map and in the table – 15 (Lazu *et al.*, 2016), the grasslands with yellow bluestem are characterized by the presence of herbaceous species that give them a southern, more xerophilous peculiarity: *Ajuga laxmani*, *Asperula glauca*, *Echinops retro*, *Erysinum Marschalianum*, *Euphorbia seguieriana*, *Euphorbia stepposa*, *Isatis tinctoria*, *Knautia arvensis*, *Kochia prostrata*, *Koeleria cristata*, *Linaria vulgaris*, *Nepeta parviflora*, *Phlomis pungens*, *Poa angustifolia*, *Poa bulbosa*, *Potentilla arenaria*, *Poterium*

*polyganum*, *Pyretrum millefolium*, *Salvia austriaca*, *Teucrium chamaedrys*, *Thymus pannonicus*, *Vinca herbacea*, *Caragana frutex*, *Achillea ochroleuca*, *Achillea setacea*, *Acinos arvensis*, *Campanula sibirica*, *Carex liparicarpus*, *Carex michelii*, *Cleistogenes bulgarica*, *Crepis rhoedifolia*, *Crepis tinctorium*, *Eremogone bibersteinii*, *Euphorbia glareosa*, *Festuca rupicoa*, *Filago arvensis*, *Onobrychis arenaria*, *Pleconax conica*, *Poa compressa*, *Ranuunculus arvensis*, *Rumex fascilobus*, *Tanacetum millefolium*, *Taraxacum erythrospermum*, *Thymus demorphus*, *Trifolium arvensis*, *Vicia angustifolia*. In the grasslands with *Bothriochloa ischaemum* found in Bugeac (the nature reserve, Bugeac, Ciulai, Dezghingea), *Euphorbia*

*seguieriana* also occurs. This fact confirms the statement of T. Savulescu that *Euphorbia seguieriana* is a characteristic species of the steppes from Bugeac. Thus, such phytocoenoses could be included in the ass. Euphorbio (*seguieriana*) - *Bothriochloetum ischaemum* n.n.

The phytocoenoses with *Bothriochloa ischaemum* in the steppe biogeographical region constitute communities of the ass. Euphorbio (*seguieriana*) - *Bothriochloetum ischaemii* n. n., which was treated differently by various authors. Puşcaru-Sorocian E. et al. (1963) (Map and table – 12) identified grasslands with *Andropogon ischaemum*, found in Muntenian and southern part of Moldova at the altitude of 100-200 m, where *Euphorbia seguieriana*, was also present.



Fig. 4. Grassland with *Bothriochloa ischaemum* in Bugeac (v. Largața, d. Cantemir).  
Steppe biogeographical region

Dihoru G. *et al.* (1970; Map and table 13) mentioned *Bombycilaena erecta* (L.) Smolj. (*Micropus erectus* L.) as a constant species in the xeric grasslands with *Bothriochloa ischaemum*, on the Babadag Plateau, at the altitude 200-350 m. *Bombycilaena erecta* (L.) Smolj. is a therophyte that remains after intensive grazing, but *Euphorbia seguieriana* is also present in these pastures.

The phytocoenoses with *Bothriochloa ischaemum* in the steppe biogeographical region correspond to the ass. *Euphorbio (seguieriana)-Bothriochloetum ischaemii* n. n.

In the Pannonian biogeographical region, the habitat of the steppe grasses constitute 8%, 30% of which are alkaline steppes on dry sands.

The Western Carpathians and the north of the Pannonian Basin (table and Map – 16) include areas with the lowest altitude (130-135 m), and the xerophytic grassy vegetation usually grows on higher land. Yellow bluestem grows in warm and sunny areas and prefers soils that have been formed on alluvial sands. In Western Carpathians and in the northern part of the Pannonian Basin (Dubrovkova D. *et al.* 2010) (table and Map – 16), there are phytocoenoses of the ass. *Teucrio (botrys) - Andropogontum ischaemii* Sauberer et Wagner in Sauberer 1942, but the

contemporary nomenclature is also suitable, with the ass. *Teucrio (botrys) - Bothriochloetum ischaemii* n. n.

In the floodplain of Danube, with dry sands, *Bothriochloa ischaemum* (Map and table 25 and 7) forms communities with *Syntrichia ruralis* (25) and *Euphorbia seguieriana* (20), *Stipa borysthena* (5), *Festuca rupicola* (3), *Cynodon dactylon* (5), *Festuca vaginata* (1, 5), *Carex lyparocarpus* (5). The authors Mirjana Kristivojčuk *et al.* (2015) (Map and table 17) identified communities with yellow bluestem of the ass. *Bothriochloetum ischaemii* (Krist 1937) Pop (1977); al. *Festucion vaginatae* ord. *Sedo acris – Festucetalia vaginata* Tx. 1951 cl. *Festuco-Brometea*. However, the presence of *Euphorbia seguieriana* (20) together with *Bothriochloa ischaemum* (25) convinces us that *Euphorbia seguieriana* (20) and *Syntrichia ruralis* (25) are diagnostic species and helps us identify ass. *Syntrichio (ruralis) – Bothriochloetum ischaemii* n. n. or *Euphorbio (seguieriana)-Bothriochloetum ischaemii*.

In the alpine biogeographical region (Map and table 18-20), the grass vegetation covers 25% of the territory, 90% of which constitute natural and semi-natural habitats dominated by *Bothriochloa ischaemum*. At altitudes of 300-600 m (North

Caucasus, Stavropol), yellow bluestem forms vegetation belts on kastanozem and loess. Besides, in the Pamir-Alay Mountains, *Bothriochloa ischaemum* forms belts at higher altitudes (1500-2000 m).

Florineth Florin (1974) mentioned that, in the Alps, at the altitude of 960-1410 m, there were phytocoenoses of the ass. *Bothriochloa ischaemum*.

The author made a distinction between two variants of dominant species – *Festuca valesiaca* Gaudin (960-1350 m altitude) and *Stipa capillata* L. (1020-1410 m altitude), known as steppe-forming species, widespread throughout the Eurasian territory.

In the southeast of the Caucasus Mountains, Nakhutsrishvili G. (2013) (Map and table 19), at the altitude of 500-600 m, and Cađapov H.M. (2015), at the altitude of 1500-2000 m, mentioned the presence of vegetation belts with *Bothriochloa ischaemum* + *Glycyrrhiza glabra* L. the authors mentioned the presence of the group of ass. *Bothriochloa ischaemum*, *Glycyrrhiza glabra* with the ephemerals – *Inula macrophylla*, *Poa bulbosa*, *Eremurus olgae*, *Carex pachystylis*, *Ferula gigantea*, but among the presented species, the faithful species of this mountain grassland stands out and forms the ass. *Glycyrrhiza* (glabra) - *Bothriochloetum ischaemii* n. n.

al. *Festucion valesiaca*; ord. *Festucetalia valesiaca* and cl. *Festuco-Brometea*.

The Mediterranean biogeographical region, where grassy vegetation constitutes about 11 % of the European territory, includes plains and hills with sandy soil, loess, dry and very warm climate with constant temperatures above 30 °C, precipitation of 600-1200 mm/year, but there are regions with 350-100 mm annually. At various altitudes from 10-250 m (Spain) to 610-1060 m (the Apennines, Italy) (Map and table 21-23), there are communities with *Bothriochloa ischaemum*. In the plain of Barcelona, at the altitude of 20-250 m, Miquel de Caceres Ainsa (1999-2001) identified communities of the ass. *Lactuco* (viminae) *Bothriochloetum ischaemum* with the variants *Elymus hispidus* (10-20 m altitude) and *Allium spheroccephalon* (20-250 m altitude) and *Onobrychis arenaria* (tomasinii (2-50 m altitude). If we give priority to grasses (*Poaceae*), then in this list, *Melica ciliata* stands out as a characteristic species and the ass. *Melico* (ciliata)-*Bothriochloetum ischaemum* n. n. would result.

In the Central Apennine Mountains with Adriatic exposure, at the altitude of 455 m, the communities with yellow bluestem have as differential species *Plantago argentea* Chaix and *Festuca inops* De Not. Taffetani E.

et al. (2004) distinguish the ass. *Dichanthium ischaemum* with the differential species *Plantago argentea* Chaix and *Festuca inops* De Not. The ass. *Festuco* (inops) *Bothriochloetum ischaemum* n.n. could be considered here.

On a sandy and sandy-clayey substrate, in the Northern Apennines (Tuscany), at altitudes of 610-1060 m, communities of the ass. *Melico* (ciliata)-

*Bothriochloetum ischaemum* n.n. are formed.

All the associations of the Mediterranean biogeographical region highlighted above are part of the al. *Bromion erectus*, ord. *Brometalia*, cl. *Festuco-Brometea*, which indicate specific conditions for the development of spontaneous flora and vegetation, and especially grasslands with *Bothriochloa ischaemum*.

## CONCLUSIONS

The phytocoenoses of the grasslands dominated by *Bothriochloa ischaemum* (L.) Keng, which occur in the Eurasian territory, differ depending on the biogeographical region, the location in the relief and the interaction with the local flora. These phytocoenoses are found in areas with hot and dry climate, limestone, clay and sand substrates and that meet the ecological needs of xerophilic, heliophilic, oligotrophic, alkaliphilic and thermophilic plants and are situated at high altitudes (highlands).

By analysing the synthetic lists of phytocoenoses dominated by *Bothriochloa ischaemum* in various biogeographical regions, the following features were identified: the phytocoenoses with yellow bluestem, in the Republic of Moldova, are severely affected by anthropogenic factors; therefore, it is difficult to identify

the characteristic species for the plant association. The grasslands with *Bothriochloa ischaemum* (L.) Keng, according to the results of the phytocenotic analysis, include *Asperula cynanchica* as faithful species and *Jurinea calcarea*, *Potentilla arenaria*, *Hypericum perforatum*, *Salvia nemorosa*, *Salvia austriaca*, *Trifolium campestre*, *Ajuga chia*, *Teucrium polium*, *Caragana molis* have higher frequency. In the continental biogeographical region, the meadow steppes of Bălți form stable communities, at medium altitudes (250-400 m) and on calcareous chernozem soil, with the association *Asperulo (cynanchica) - Bothriochloetum ischaemum* n.n.

In the steppe biogeographical region (Bugeac), the following species are more frequent: *Dianthus carbonatus*, *Caragana frutex*, *Euphorbia seguieriana*, *Verbascum*



*phoeniceum*, *Alyssum calycinum*, *Taraxacum serotinum*, *Linum hirsutum*, *Anthemis ruthenicum*, *Poa bulbosa*, *Dianthus barbasi*, *Euphorbia stepposa* and *Bothriochloa ischaemum* of the ass. *Euphorbio (seguieriana)* - *Bothriochloetum ischaemii* n. n. They grow mostly on chernozem and sandy soil.

In the Pannonian biogeographical region, the yellow bluestem communities grow on sandy, dry soils, forming, in the northeast, the ass. *Teucrio (botryos)* - *Bothriochloetum ischaemii* Sausberer et Wagnez in Sausberer 1942 and the ass. *Syntrichio (ruralis)* - *Bothriochloetum ischaemii* n. n., on Danubian alluvia.

In the alpine biogeographical region, in the Caucasus Mountains, on kastanozem soil, there are phytocoenoses of the ass. *Glycyrrhizo (glabra)* - *Bothriochloetum ischaemii* n. n. with numerous species of the local flora: *Teucrium montanum*, *Hieracium pilosella*, *Carex humilis*, *Phleum phleoides*. In the Pamir-Alay Mountains (Central Asia), at the altitude of 1300-1600 m, it forms belts of steppe vegetation with phytocoenoses of the ass. *Glycyrrhiza (glabra)* - *Bothriochloetum ischaemii* n. n.

In the Mediterranean biogeographical region with calcareous soils (Barcelona), the communities with *Bothriochloa*

*ischaemum* are found in areas situated at various altitudes, with dry and warm climate and nutrient-poor substrate. The altitude: 2-250 m. It forms the ass. *Lactuco vimineae* - *Bothriochloa ischaemii* with the variants *Onobrychis arenaria tomasini* (2-50 m altitude), *Elymus hispidus* (10-20 m altitude) and *Allium spherocephalon* (2-250 m altitude).

In the Apennine Mountains, at the altitude of 610-1060 m – the ass. *Festuco (inops)* - *Bothriochloetum ischaemii* n. n. and ass. *Melico (ciliata)* - *Bothriochloa ischaemii*.

Of all the biogeographical regions, the most favourable climatic conditions for the phytocoenoses with *Bothriochloa ischaemum* are in the Mediterranean, which directly contacts with savanoid meadows and tropical prairies, then the alpine region follows, where at high altitudes there are stable communities, forming vegetation belts; then steppe, continental and Pannonian biogeographical regions follow.

The wide phytocoenotic diversity with the dominance of *Bothriochloa ischaemum* in all the analyzed biogeographical regions (continental, steppe, Pannonian, alpine and Mediterranean) expresses the need to approach the alliance *Bothriochloion (ischaemum)* n. n. with the above-mentioned associations.

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