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Application of the hemerobicity index of species to assess pasture and recreational pressure on vegetation

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Abstract: The article presents a methodology for applying the hemerobia indicator to assess the level of impact of grazing and recreation on forest, meadow and ruderal phytocoenosis of the territory of the Bashkir State Reserve. It is shown that the use of species hemerobia scales makes it possible to assess the level of anthropogenic load and identify its constituent factors. The paper tests the use of the hemerobia indicator as an estimate of the resulting of anthropogenic impact on the territory. The impact of grazing and recreation on the composition of forest, meadow and ruderal plant communities on the territory of the Bashkir State Reserve was assessed. It has been established that the hemerobicity of communities increases in a series of influences: recreation - grazing - trampling. In this series, the share of species with euhemerobic, polyhemerobic components increases and the proportion with oligohemerobic and mesohemerobic components decreases in the spectrum of their anthropotolerance. Factor analysis (principal component analysis) of the hemerobicity spectra of the flora of the test plots showed that the main factors in the formation of plant communities are the complex impact of recreation and grazing, which leads to soil compaction.

Keywords: *hemeroby, grazing, recreation, evaluation anthropogenic load, factors, Bashkir State Reserve, plant commuties*

INTRODUCTION

The term hemerobia (from Greek. hemeros – manual, cultivated and bios – life) was introduced into ecology by J. Jalas [Jalas, 1955] to classify plant species according to the level of their tolerance to anthropogenic factors, later it was extended to plant communities and ecosystems [Sukopp, 1976]. According to H. Sukopp [Sukopp, 1976], the degree of hemerobia is an integrative measure of the impact of all human interventions in ecosystems, whether they are intentional or not. The degree of hemerobia is the result of exposure to a certain territory and the organisms inhabiting it.

Previously, we the indicator of hemerobia was used to assess the degree of resistance of communities with rare plant species to complex anthropogenic impact [Ishmuratova et al., 2003; Barlybaeva, Ishmuratova, 2020].

In order to improve methods for monitoring the state and dynamics of ecosystems and their constituent plant communities under the influence of anthropogenic factors in a specially protected area, a comparative assessment of the level of anthropogenic pressure (recreation, grazing) was tested using ecological scales of hemerobicity of species.

MATERIAL AND METHODS

Description of investigation area. The study was carried out in 2021-2022 on the territory of the Bashkir State Reserve (Burzyansky district, Republic of Bashkortostan) in the village of Sargaya (Fig. 1), coordinates latitude 53°20′36″N longitude 57°47′03″E.

Methods of research. The resistance of the species to anthropogenic impact was assessed using the hemerobicity index. The hemerobicity of a species was determined by the composition of species in plant communities, in which each species has an individual spectrum of tolerance to anthropogenic factors [Frank, Klotz, 1990]. We used the modified Yalas system [Frank, Klotz, 1990], which includes the following levels: agemerobes, oligo-, meso-, eu-, poly-, and metagemerobes.

Hemerobicity species includes the following levels:

a–agemerobes, species that cannot stand anthropogenic influence (rocks, swamps, tundra);

o–oligohemerobes, types of forests, meadows, raised bogs, etc., enduring a slight anthropogenic impact (selective felling and thinning, poor grazing,

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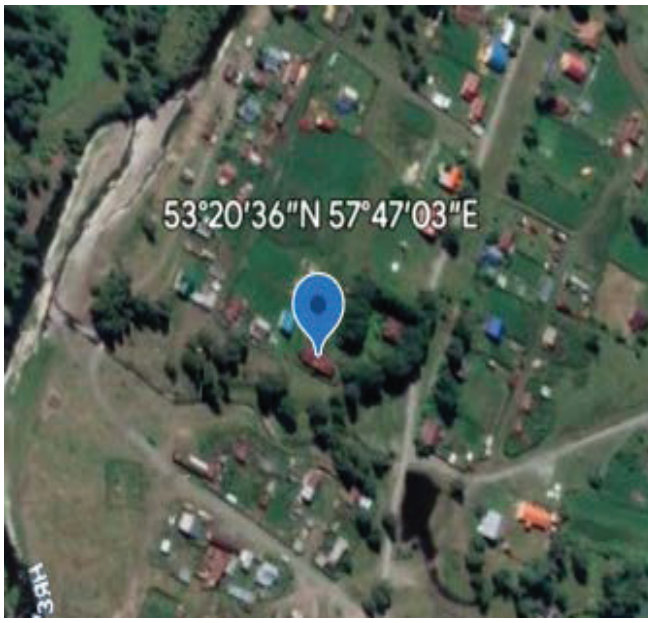

Figure 1. Location of the village of Sargaya (Bashkir State Reserve).

rare haymaking);

m–mesohemerobes, types of forests with preserved grass-shrub layer; meadows, steppe meadows and steppes with extensive use (recreation, rare clearing and clear-cutting of forests; rare fertilization of meadows);

b–β-euhemerobes, types of forests and meadows with intensive grazing and haymaking, meadow lawns (fertilizer, liming, herbicide use, melioration);

c–α-euhemerobes, weeds of fields and species of spontaneous ruderal vegetation, sown meadows, ornamental lawns, intensive forest plantations with a poorly developed grass layer (permanent disturbances, application of mineral fertilizers, sewage pollution);

p–polyhemerobes, specialized weeds of plantations of vegetable and berry crops, vineyards, pioneer species of the initial stages of overgrowth of garbage dumps and municipal solid waste, compacted soils (deep plowing, intensive fertilization, the use of a biocide complex, deep drainage or waterlogging, one-time destruction of the biocenosis and change of the biotope with non-natural overlap material;

t–metahemerobes, species inhabiting poisoned ecosystems, completely sealed areas with the destruction of biocenoses.

Species are individual in terms of the breadth of the continual spectrum of anthropotolerance, therefore, in a discrete scale reduced to seven gradations (*a-o-m-b-c-p-t*), each of them can occupy from one to five steps, for example, *Alchemilla vulgaris* Willd. - ***m*,** *Carduus nutans* Boiss. ex Nyman - ***m-b*,** *Capsella bursa-pastoris* Medik. - *b-c-p*, *Elytrigia repens* (L.) Nevski- ***m-b-c-p*,** *Potentilla anserina* L.- ***o-m-b-c-p*.**

The level of hemerobia of local territories was calculated from the composition of species in the phytocenosis, in each of which a geobotanical description was performed. In total, 8 test plots of forest, meadow and ruderal vegetation with different levels and nature of anthropogenic impact were studied (Table 1). The description area was chosen taking into account the recommendations adopted in phytocenology: 400 m² in forest communities, 25 m² in meadow communities, on the maximum possible area of ruderal communities homogeneous in composition and physiognomy - 4-16 m². In all cases, the size of the trial area was not less than the area of detection of partial flora.

Table 1. Characteristics of trial sites.

Sites, no.	Phyto-coenosis	Localization	Operating factors
1	Forest communities, pine forests	sq. 117, allotment 73, Bolshoy Bashart creek valley	recreation
2		sq. 117, section 67; the lower part of the slope of Mt. Bashart	recreation, grazing
3		sq. 118, division 75; river valley Big Sargaya	grazing, recreation
4		sq. 117, division 61; floodplain terrace	grazing, trampling
5	Meadow and ruderal communities	sq. 117, division 61; central floodplain. Uzen and r. Big Sargaya	grazing
6		territory of the village, short-grass roadside communities with a predominance of meadow species	trampling
7		territory of the village, short-grass meadow-ruderal communities	trampling
8		the territory of the village, ruderal communities with a predominance of knotweed on highly compacted soils	trampling

For each trial plot, the number of species with a certain component in the hemerobicity spectrum was summed up. The level of hemerobia (*H*) was calculated as the ratio of the number of species with *b-c-p-t* components in the spectrum of hemerobia to the number of species with *a-o-m* components (Equation 1):

$$H = (b+c+p+t) / (a+o+m)$$

Equation 1. where *a* – agemerobes, *o* – oligohemerobes, *m* – mesohemerobes, *b* – *β*-euhemerobes, *c* – *α*- euhemerobes, *p* – polyhemerobes, *t* – metahemerobes.

Example of calculation is presented in table 2.

The synanthropic flora of the Bashkir State Reserve was studied earlier [Ishmuratova et al., 2021]. Latin names of plants are given by WFO.

The data obtained were processed by variational-statistical methods using the STATISTICA software package (10.0.228.2).

RESULTS AND DISCUSSION

The results of calculating the level of hemerobia in test plots and the characteristics of plant communities were analysed (Tab. 3). It was revealed that the recreational use of forest communities shows the minimum values of the hemerobia level in the studied series. Grazing, and to an even greater extent trampling with soil compaction, lead to a strong increase in the level of hemerobia of territories. With moderate grazing, the number of species increases due to the loss of oligo-mesohemerobic species of the original communities and the introduction of euhemerobic species (meadow species with a wide range of hemerobicity and weed species). The height of the herbage is greatly reduced with constant trampling and compaction of the soil. The projective grass cover grows in forest communities due to an increase in the proportion of grasses (including meadow grasses) or the introduction of ruderal species (trial plot 4). In trampled communities, the number of species noticeably decreases with an increase in the impact of the factor and an increase in soil density.

Table 2. A training example of calculating the level of hemerobia of a plant community.

Plant species	The breadth of the spectrum of hemerobia						
	a	*o*	*m*	*b*	*c*	*p*	*t*
Melica nutans L.		1	1				
Campanula glomerata L.		1	1				
Aegopodium podagraria L.		1	1	1			
Achillea millefolium L.		1	1	1			
Taraxacum officinale Wigg.			1	1	1		
Poa pratensis L.			1	1	1		
Elytrigia repens (L.) Nevski)			1	1	1	1	
Potentilla anserine L.		1	1	1	1	1	
Polygonum aviculare L.				1	1	1	
Chenopodium album L.				1	1	1	
The number of species with a certain component in the spectrum of hemerobia.	0	5	8	8	6	4	0
Calculation of the level of hemerobia. $H = (b+c+p+t) / (a+o+m)$	H=(8+6+4+0) / (0+5+8)=1.4						

Table 3. Structural changes and changes in the level of hemerobia in plant communities under various anthropogenic impacts and their combinations.

Characteristics of trial sites and plant communities	Trial sites, no.							
	1	2	3	4	5	6	7	8
Trial area size, m²	400	400	400	200	25	16	4	5
Crown density	0.4	0.6	0.5	0.4	-	-	-	-
Grass stand height, cm	30	30	15	20	5	7	15	5
Projective grass cover, %	60	85	50	80	85	80	90	100
Number of species, pcs.	33	41	39	43	19	14	9	5
Hemerobia level (*H*)	0.28	0.39	0.52	0.75	1.10	0.95	3.75	9.00

Table 4. Spectrum of hemerobicity of plant communities on test plots.

Sites, no.	Phyto-coenosis	Operating factors	Hemerobia scale gradations						
			a	*o*	*m*	*b*	*c*	*p*	*t*
1	Forest communitie, pine forests	recreation	0	70	**94**	36	9	0	0
2		recreation, grazing	0	68	**95**	49	15	7	0
3		grazing, recreation	0	64	**95**	62	21	8	0
4		grazing, trampling	0	37	**74**	**60**	23	9	0
5	Meadow and ruderal communities	grazing	0	32	**79**	**79**	42	16	0
6		trampling	0	36	**100**	**93**	36	14	0
7		trampling	0	11	33	**89**	**78**	67	0
8		trampling	0	0	20	80	**100**	60	0

Note: in the cells, the proportion (%) of species with a certain hemerobicity component.

Table 4 shows the data on the total hemerobicity spectrum for each of the eight test plots. It has been established that forest communities (test sites 1, 2, 3) of recreational and pasture use are mesohemerobic. The community with a tree canopy and intensive anthropogenic load (trampling, disturbance of the soil cover), as well as pasture and short grass communities with a predominance of meadow species (test plots 4, 5, 6) were assessed as mesohemerobic – *β*-euhemerobic. Low grass meadow ruderal communities (test site 7) proved to be *β*-*α* -euhemerobic. Knotweed-dominated communities (test site 8) are *α* -euhemerobic. With an increase in anthropogenic influence on the territory, the proportion of species with an eupolyhemerobic component will increase, the proportion of species with an oligomesohemerobic component in the spectrum of hemerobicity decreases (Fig. 2).

In order to identify the main factors that determine the structure of plant communities in terms of the composition of groups of species with different spectrum of anthropotolerance (Tab. 4), a factor analysis was performed. High loads for factor 1 (more than 0.70) were noted for variables (test sites) 1-6 (recreational and grazing areas) and for factor 2 for variables 7-8 (compacted soils of roadside habitats). The graphical result is shown in figure 3. Factor 1 is identified by us as a “complex anthropogenic factor”, factor 2 - as “soil compaction”.

Factor analysis on the composition of the flora did not give satisfactory (interpretable) results. The probable reason for this is the difference in the composition of the flora, mainly forest communities, due, among other things, to ecological differences, different composition of the flora, and different syntaxonomic affiliation of the

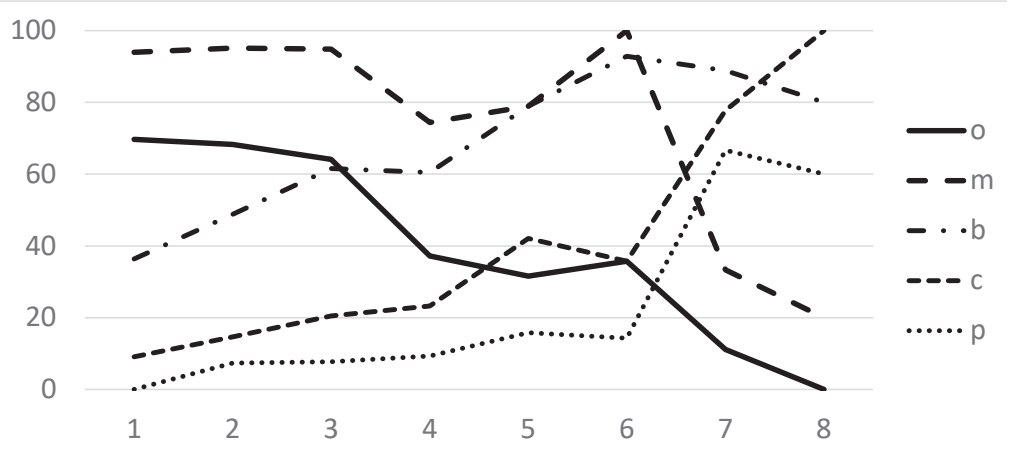

Figure 2. Change in the proportion (%) of species with a certain component of the spectrum of hemerobia along with an increase in the total anthropogenic load.

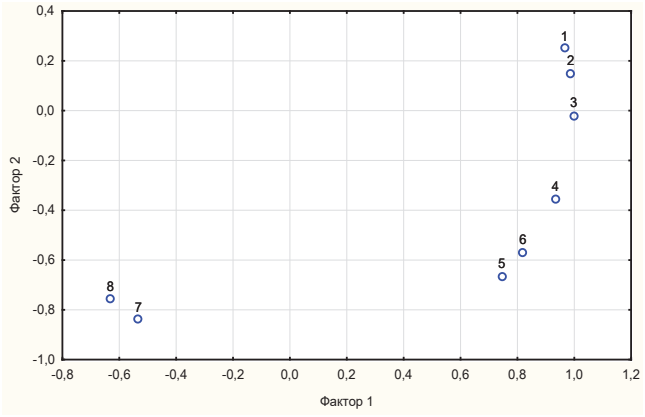

Figure 3. Coordination of trial plots in the axes of leading factors. On the y-axis factor 1 is identified as complex anthropogenic factor, on the abscissa factor 2 as "soil compaction".

original communities [Martynenko et al., 2003].

Thus, forests in the valleys of rivers and streams belong to the association Geo rivali-Pinetum sylvestris Martynenko et al. 2003 (association Trollio europaei-Pinion sylvestris Fedorov ex Ermakov et al., 2000 of the class Brachypodio pinnate-Betuletea pendulae Ermakov, Koroljuk et Latchinsky, 1991), and communities of gentle slopes of ridges to the association Digitali grandiflorae-Pinetum sylvestris Martynenko et al., 2003 (alliance Dicrano-Pinion (Libbert, 1933) Matuszkiewicz, 1962 class Vaccinio-Piceetea Br.-Bl. in Br.-Bl., Sissing et Vlieger, 1939).

The use of ecological scales with indicators of species heterogeneity makes it possible to compare plant communities (territories) in terms of the level of anthropogenic impact on them, regardless of the floristic composition and syntaxonomic affiliation of plant communities. The method can be applied in long-term monitoring studies, in the protected area.

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REFERENCES

Barlybayeva M.S., Ishmuratova M.M. (2020) Monitoring the state of cenopopulation of *Tulipa riparia* Knjasev, Kulikov et Philippov in the Southern Urals. *Plant & Fungal Research*, 3(1): 25-35. DOI: doi.org/10.29228/plantfungalres.65

Frank D., Klotz S. (1990) Biologisch-ökologische Daten zur Flora der DDR / Halle- Wittenberg: Martin-Luter-Universität. 32. 167 pp.

Ishmuratova M.M., Ishbirdin A.R., Suyundukov I.V. (2003) Use of the hemerobia indicator to assess the vulnerability of certain species of orchids in the southern Urals and the stability of plant communities. *Biol. Vestnik* (Ukraine). 7(1-2): 33-35. [Ишмуратова М.М., Ишбирдин А.Р., Суюндуков И.В. (2003) Использование индикатора гемеробии для оценки уязвимости отдельных видов орхидей Южного Урала и устойчивости растительных сообществ. *Биол. Вестник* (Украина). 7(1-2): 33-35]

Ishmuratova M.M., Nabiullin M.I., Ishbirdin A.R. (2021) Identified and potential ways of replenishment of the synanthropic flora of the Bashkir State Reserve. *Flora and vegetation of Altai: Proceedings of the South Siberian Botanical Garden,*13 (Scientific heritage of V. I. Vereshchagin: past, present, future. Barnaul: Alt. university): 10-12 [Ишмуратова М.М., Набиуллин М.И., Ишбирдин А.Р. (2021). Выявленные и потенциальные пути пополнения синантропной флоры Башкирского государственного заповедника. *Флора и растительность Алтая: Труды Южно-Сибирского ботанического сада*, 13 (Научное наследие В. И. Верещагина: прошлое, настоящее, будущее, Спецвыпуск. Барнаул: Изд-во Алт. ун-та.): 10-12]

Jalas J. (1955) Hemerobe und hemechore Pflanzenarten. Ein terminologischer Reformversuch. *Acta Fauna Flora Fenn*., 72(11): 1-15.

Martynenko V.B., Solomesh A.I., Zhirnova T.V. (2003) Forests of the Bashkir State Nature Reserve: syntaxonomy and conservation significance. Ufa: Gilem. 203 p. [Мартыненко В.Б., Соломещ А.И., Жирнова Т.В. (2003) Леса Башкирского государственного природного заповедника: синтаксономия и природоохранная значимость. Уфа: Гилем. 203 с.]

Statistical analysis sofwave package (10.0.228.2).

Sukopp H. (1976) Dynamik und Konstanz in der Flora der Bundesrepublik Deutschland, Schr.-R. f. Vegetationskunde, 9-27.

WFO: http://www.worldfloraonline.org

Bitki örtüyünə otlaq və rekreasiya təzyiqini qiymətləndirmək üçün növlərin hemerobluq indeksinin tətbiqi

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Məqalədə heyvan otarılması və rekreasiyanın Başkir Dövlət Qoruğunun ərazisində meşələrə, çəmənliklərə və ruderal fitosenozlara təsir səviyyəsini qiymətləndirmək üçün hemerobiya göstəricisinin tətbiqi üsulu təqdim olunur. Göstərilir ki, hemerobiya növləri şkalasının istifadəsi antropogen yükü və onu təşkil edən amilləri müəyyənləşdirməyə imkan verir. Məqalədə əraziyə antropogen təsirin nəticəsinin qiymətləndirilməsi üçün hemerobiya göstəricisindən istifadə sınaqdan keçirilir. Başqırd Dövlət Qoruğunun ərazisində otlaq və rekreasiyanın meşə, çəmən və yabanı bitki birliklərinin tərkibinə təsiri qiymətləndirilmişdir. Bu sırada euhemerob, polihemerobik növlərin payı artır və onların antropotolerantlıq spektrində oliqohemerob və mezohemerob komponentlər nisbətin payı azalır. Nümunə sahələrin flora hemerobluq spektrlərinin faktor təhlili (əsas komponent təhlili) göstərir ki, bitki birliklərinin yaranmasının əsas faktorları rekreasiya və otarılmanın birgə təsirləridir ki, bu da torpağın möhkəmlənməsinə (sıxlığının artması) ilə nəticələnir.

Açar sözlər: *hemerobiya, otlaq, istirahət, antropogen yükün qiymətləndirilməsi*

Применение показателя гемеробности видов для оценки пастбищной и рекреационной нагрузки на растительность

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В работе тестируется применение показателя гемеробии, как оценивающего результирующее воздействие антропогенного воздействия на территории. Проведена оценка влияния выпаса и рекреации на состав лесных, луговых и рудеральных растительных сообществ территории Башкирского государственного заповедника. Установлено, что гемеробность сообществ возрастает в ряду воздействий рекреация – выпас – вытаптывание. В этом ряду в растительных сообществах возрастает доля видов устойчивых к антропогенному воздействию (эугемеробы и полигемеробы). Доля видов, выносящих незначительное антропогенное влияние (олигогемеробы и мезогемеробы), в этом градиенте снижается. Факторный анализ (анализ главных компонент) спектров гемеробности флоры пробных площадок показал, что основными факторами формирования растительных сообществ являются комплексное воздействие рекреации и выпаса, приводящее к уплотнению почвы.

Ключевые слова: *гемеробия, выпас, рекреация, оценка антропогенной нагрузки, факторы, Башкирский государственный заповедник, растительные сообщества*