Scientific Papers. Series B, Horticulture. Vol. LXV, No. 1, 2021
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

VITALITY DYNAMICS OF POPULATIONS OF SOME LEGUME SPECIES IN FLOODPLAIN MEADOWS OF THE PSEL RIVER BASIN UNDER GRAZING AND HAYMAKING (UKRAINE)

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Abstract

The results of the study of the vitality structure and its dynamics in the three species of the Fabaceae family (Trifolium repens L., Medicago falcata L. and Vicia cracca L.) in the floodplain meadows of the northeastern Forest-Steppe of Ukraine under grazing and haymaking are presented. The analysis of the vitality structure of the populations of the three studied species of legumes in the control areas of the pascual and fenisicial gradients has shown that they are well adapted for existence in conditions without anthropogenic loads. It has been established that Trifolium repens is more resistant to both grazing and haymaking loads. This is evidenced by the preservation of the equilibrium status of the populations until the last stages of both gradients, as well as the obtained indices of vitality dynamics (IVD, in most cases less than 1, with the positive and negative signs). The Vicia cracca populations are characterized by considerable vulnerability to pasture loads, which is manifested in the sharp transition of populations to the category of depressed at the stages of PD1. This species completely falls out of the composition of the meadow phytocoenosis at the stage of the gradient PD2. In relation to the haymaking load, the species is quite resistant and can withstand both one-time (FD1 stage) and two-time (FD2 stage) haymaking per season, where the populations have the status of equilibrium, and IVD is less than 1. Haphazard haymaking causes significant changes in the vitality composition (IVD is greater than 1 with the negative sign) and the transition of populations to the category of depressed. The populations of Medicago falcata are well adapted to moderate grazing loads (stages PD1 and PD2), as evidenced by IVD less than 1 and maintaining the status of populations at the level of prosperous and equilibrium. Starting with the stage PD3, the populations undergo significant changes in vitality composition (IVD = -1.5060) and transfer to the category of depressed. On the fenisicial gradient, the Medicago falcata populations demonstrate resistance at the FD1 and FD2 stages. Only under haphazard haymaking (FD3), vitality composition is significantly transformed, as evidenced by the depressed status of their populations. The data obtained indicate the need to regulate both grazing and haymaking loads in order to preserve the integrity of meadow ecosystems and ensure the sustainable, long-term and effective provision of a range of ecosystem services by them.

Key words: *index of vitality dynamics, Medicago falcata, population quality index, Trifolium repens, Vicia cracca, vitality structure.*

INTRODUCTION

The conservation of biodiversity as a primary and critical indicator of the efficient operation of ecosystems is the centerpiece of a list of global environmental problems, the solution of which is the objective of a significant amount of research (Kaur, 2018; Rahman, 2018; Sui et al., 2018; Cardinale et al., 2011; Wilsey, 2018; Segelbacher, 2018).

Floodplain meadow ecosystems, the formation of which is the result of both natural processes and human economic activities, act as a reserve of unique biodiversity, and are also stabilizers of the natural environment and valuable forage lands. The conservation of their population-species integrity is the basis for the sustainable operation of the biosphere as a whole (Reine et al., 2014; Tilman and Downing, 1994; Wilsey, 2018; Huhta and Rautio, 2014; Hofman et al., 2001; Harvolk et al., 2015). Floodplain meadows are in a state of constant dynamic development - edaphogenic changes, which occur primarily under the influence of river flooding (alluvium sediments, groundwater level, surface sediment washing-off, etc.) (Hölzel and Otte, 2004). This process is also affected by the mode of use of meadows, the main forms of which are grazing and haymaking (Rui et al., 2010; Sizykh, 2016; Biró, 2014; Rusev et al., 2007; Kahmen and Poschlod, 2008; Harvolk et al., 2015; Mathar et al., 2016; Díaz et al., 2007). The result of a significant anthropogenic impact is the marked transformation of meadow ecosystems and a decrease in their productivity (Huhta and Rautio, 2014; Wellstein et al., 2007). In this regard, the problem of conservation of floodplain meadows has both regional and global significance (Liira et al., 2009; Rui et al., 2010; Biró, 2014; Mathar et al., 2014; Mathar et al., 2016). This is precisely why the parameters of meadow areas and their condition are used as the indicators for agricultural greening, and some countries are actively developing different approaches to meadow restoration and conservation (Magda et al., 2014; Trnka et al., 2016).

It is known that the main form of species existence is the population, at the level of which all the processes and mechanisms associated with the response of organisms to various environmental impacts are implemented (Zlobin, 2009). That is why one of the ways to organize scientifically grounded natural resource management, including floodplain meadows, is the widespread use of population analysis (Begon et al., 1986; Zlobin, 2009; Gibson, 2014; McCall, 2017). The most important component of population monitoring is the assessment of the life status of individuals and plant populations. One of the tools of this assessment is a vitality analysis (Zlobin, 2018). Recently, it has become widespread in population studies due to its informative value (Sherstyuk, 2017; Skliar, 2013; Tikhonova, 2011; Vöge, 2015; Thazaplizheva and Chadaeva, 2010; Gavrilova, 2008). In particular, part of works is devoted to the study of the vitality structure of meadow species (Kyrylchuk, 2007; Bondarieva and Bjelan, 2010; Kyrylchuk and Bashtovyi, 2018). Legumes, as one of the most important components of meadow phytocenoses, along with cereals and herbs, ensure the integrity of a meadow ecosystem, and the conservation of the full floristic, population and cenotic diversity of floodplain meadows is an urgent scientific problem. Within this framework, the goal of this study is to assess the features of operation of the populations of some species of legumes, which are part of the floodplain meadow phytocenoses of North-Eastern Ukraine by establishing patterns of change in their vitality parameters in terms of grazing and haymaking.

MATERIALS AND METHODS

The analysis of vitality dynamics of populations of meadow legume species was carried out in the pascual and fenisicial gradients in floodplain meadows of the Psel River (forest-steppe zone of North-Eastern Ukraine). The objects of the study were the populations of the three species of legumes typical for meadow stands of the study region: *Trifolium repens* L., *Medicago falcata* L. and *Vicia cracca* L. In two of the studied species (*T. repens* and *V. cracca*) the accounting units were ramets, and in *M. falcata* - genets.

Areas corresponding to different stages of pasture and haymaking digressions were chosen to study the dynamics of changes in vitality parameters of individuals and populations under increasing pasture and haymaking loads. Pasture or pascual digression (PD) is all changes in vegetation and soils that occur under the influence of increasing grazing intensity. Pascual digression gradient (PD) included the five stages chosen on the basis of a set of features, among which the main place was occupied by data from farms on the actual load on pasture, as well as the floristic analysis of species, the ratio of projective cover of dominant and minor species, a decrease in the height of grass stand, the transformation of population parameters of individuals of indigenous species towards their oppression, the appearance of synanthropic species as part of the plant population, etc.: PD0 - control area (CA) - areas without anthropogenic impact; PD1 - the initial stage of grazing (moderate grazing with a load of 2-3 heads of cattle per 1 ha; PD2 - intensive grazing; PD3 - the stage of heavy grazing, where the number of cattle heads increases to 10-12 per 1 ha; PD4 - outrageous haphazard grazing (failure).

Haymaking or fenisicial digression (FD) represents all changes in floristic composition and structure of meadow coenosis phytopopulations occurring as a response to the growth of haymaking loads. The fenisicial gradient included four stages: FD0, or control area (CA); FD1 - the initial stage (haymaking once a year); FD2 - moderate haymaking (twice

a year); FD3 - excessive haymaking (multiple haphazard haymaking).
The vitality analysis was made by the three stages provided for by the algorithm developed by Yu. A. Zlobin (Zlobin, 2018). The first stage included the morphometric analysis of individuals of legume meadow plant populations (Zlobin et al., 2009). A set and number of morphoparameters were determined by the peculiarities of the species morphology (they were about 10 dimensional parameters in the studied species). The key parameters, which provided an integral assessment of the vitality of individuals, were selected from the obtained number of quantitative indicators characterizing the life state of individuals (Zlobin, 2009). For the studied species such parameters were: W - total aboveground phytomass of an individual (g), A - leaf surface area (cm^2) and Re -reproductive effort (%). The assessment of the vitality of some individuals was carried out at the second stage. According to the methodology of vitality analysis, individuals of populations of the studied species at each stage of pascual and fenisicial gradients were referred to one of the three classes of vitality: "a" - high, "b" - medium and "c" - low. The integral assessment of vitality of populations is a third stage of vitality analysis, on which each population receives a certain vitality status - prosperous, balanced and depressed, based on the generalized indexes of population quality (Q).
The comprehensive assessment of dynamics of vitality parameters of the studied species populations on the pascual and fenisicial gradients and the study of vitality flexibility were carried out on the basis of the index of vitality dynamics (IVD), which was calculated by the following formula (Skliar, 2013):

$$IVD = (Q_n - Q_p) / 0.166,$$

Where: Q_n is the value of the population quality index at the next stage of the gradient;

Q_p is the value of the population quality index at the previous stage of the gradient;

0.166 is the value of the quality index, at which there is the transition of populations from one qualitative type to another (according to the classical vitality analysis, when the value of the quality index Q ranging from 0 to 0.166 the population is depressed; at Q ranging from 0.167 to 0.332 this population is equilibrium; at Q ranging from 0.333 to 0.50 it is prosperous).
The value of the index of vitality dynamics (IVD) lies in the range from -3.012 to + 3.012. At IVD = 0, there are no changes in the value of the quality index Q by pascual and fenisicial gradients in populations. If IVD (in magnitude) is less than 1, changes are insignificant. If IVD (in magnitude) is between 1 and 2, changes are significant. If IVD (in magnitude) is greater than 2, changes are progressive. If values of IVD are negative, there is some deterioration in the population state, if values of IVD are positive, there is some improvement (Skliar 2013).

RESULTS AND DISCUSSIONS

The obtained research results have shown a more or less pronounced transformation of the vitality structure of populations of the studied legume species on the pascual and fenisicial gradients. The analysis of vitality structure of such populations as *T. repens, M. falcata* and *V. cracca* in the control areas has shown that they belong to the category of prosperous populations with the population quality index of 0.48; 0.48 and 0.45, respectively. This indicates a good adaptation of species to existence in meadow areas without anthropogenic impact (Figure 1).
Subsequently, on both gradients the population quality index is gradually decreasing that is connected with change in a ratio of individuals of different vitality classes, and the populations change their status (Figures 2-4). Figure 2 shows the dynamics of changes in the ratio of individuals of different vitality classes in the populations of *T. repens* both on the pascual and fenisicial gradients. The proportion of individuals of "a" and "b" classes in the populations of this species remains quite high even at the last stages of the gradient. Thus, at the stage of the gradient PD4 the proportion of individuals of "a" and "b" classes are respectively 0.28 and 0.24. On the fenisicial gradient, qualitative changes in the species populations are associated with a gradual decrease in the proportion of individuals of "a" class to 0 on FD3 with a sufficiently high proportion of individuals of "b" class - 0.50 (Figure 2). According to this, the populations of

T. repens on both gradients change their status to a minor degree, and transfer from the category of prosperous to equilibrium and retain it until the last stages.

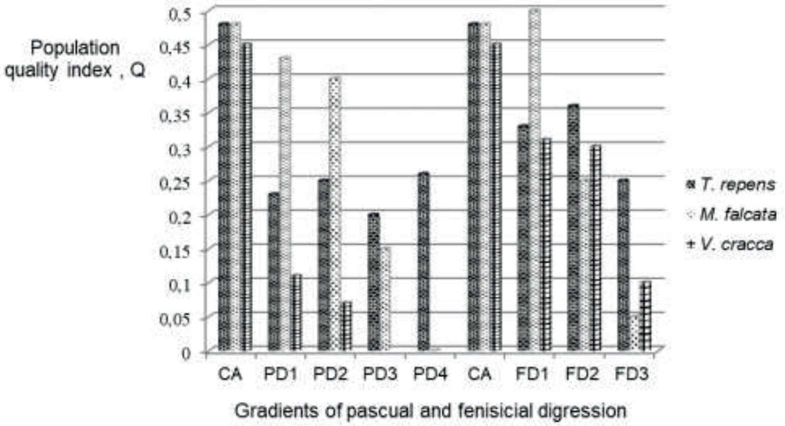

Figure 1. Quality indices (Q) of populations of *Trifolium repens, Medicago falcata* and *Vicia cracca* on the gradients of pascual and fenisicial digression

The vitality structure of the *M. falcata* populations varies in a greater degree, in contrast with *T. repens* (Figure 3). By the pascual digression gradient, the population quality indices are gradually decreasing, and the most significant decrease is observed at the stage of PD3, where the population quality index is 0.15, and at PD4 it is already equal to 0 (Figure 1). By the gradient there is a gradual decrease in the proportion of individuals of “a” and “b” classes (up to 0 per PD4) against the background of an increase in the proportion of individuals of “c” class. As a result, the populations transfer to the category of depressed at the stage of PD3. On the fenisicial gradient, an increase in haymaking load leads to a natural decrease in the quality index to 0.05 on FD3 (Figure 1). This is also due to an increase in the populations of individuals of the lower vitality class. It should be noted that at the initial stage of grazing PD1 and the first stage of fenisicial gradient FD1, the populations retain the status of prosperous that indicates the efficient operation of the populations of the studied species under moderate economic loads.

The greatest vulnerability to grazing is observed in the populations of *V. cracca* - this species split from the meadow grass stand at the stages of PD3 and PD4. The vitality structure of this species is significantly transformed on the grazing gradient - the quality indices are reduced by the gradient from 0.45 per TA to 0.07 per PD2 (Figure 1). At the stage of PD1, the population *V. cracca* already belongs to the category of depressed. They are characterized by a significant decrease in the proportion of individuals as “a” and “b” classes (Figure 4). In contrast to grazing loads, the population of *V. cracca* is more tolerant of haymaking loads. At the FD1 and FD2 stages, the populations retain the status of equilibrium and only at the FD3 stage become depressed, as the proportion of individuals of “a” and “b” classes decreases (Figure 4).

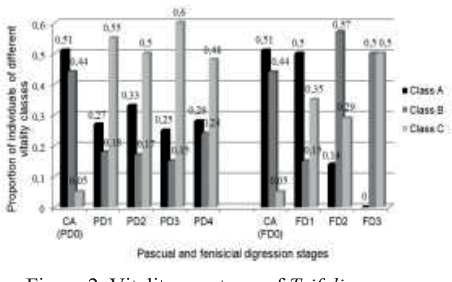

Figure 2. Vitality spectrum of *Trifolium repens* populations on the pascual and fenisicial gradients

The results obtained on the vitality structure of legumes reflect their adaptation to different types of economic loading, which is manifested in a change in the proportion of individuals of different vitality classes (“a”, “b” and “c”) and demonstrates the implementation of vitality variability. In general, with outrageous grazing and haymaking loads, there is an increase in the total proportion of individuals of the middle and lower classes of vitality, while reducing the proportion of individuals of the higher class, sometimes to their complete disappearance.

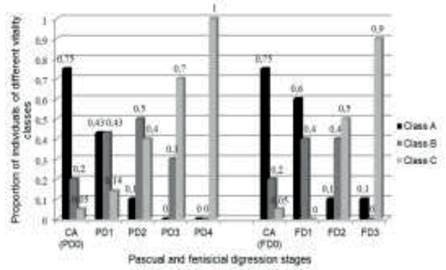

Figure 3. Vitality spectrum of *Medicago falcata* populations on the pascual and fenisicial gradients

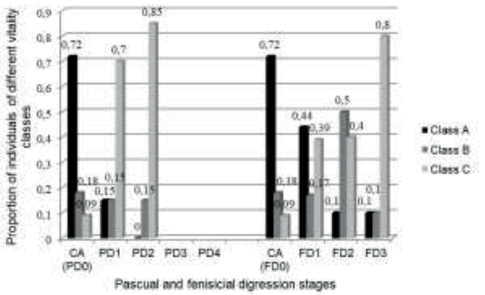

Figure 4. Vitality spectrum of *Vicia cracca* populations on the pascual and fenisicial gradients

The vitality variability of the studied species of legumes on the pascual gradient manifests itself in the form of three variants (Figures 2-4). The first of them demonstrates the populations *T. repens*, in which there is a sharp increase in the total proportion of individuals “b” and “c” at the stage of the gradient PD1 and further by the gradient this parameter is almost unchanged: 0.49 (PD0); 0.73 (PD1); 0.67 (PD2); 0.75 (PD3); 0.72 (PD4). In the *T. repens* populations, the proportion of individuals of “a” class remains unchanged until the last stage of the gradient (PD4), where their proportion is 0.28. The second variant is characteristic of *M. falcata,* in the populations of which this parameter naturally increases by the gradient. This trend has the following form: 0.25 (PD0); 0.57 (PD1); 0.9 (PD2); 1 (PD3); 1 (PD4). In the populations of this species, individuals of “a” class disappear at the stage of PD3. The last variant of manifestation of vitality variability is presented by the populations *V. cracca,* in which there is the sharpest increase in a total proportion of individuals “b” and “c” at the stage of PD1. At the stage of PD2, this sum is already equal to 1 that indicates the absence of individuals of class “a” in the population. The changes are as follows: 0.27 (PD0); 0.85 (PD1); 1 (PD2). Subsequently, by the gradient the populations of this species completely fall out of the grass stand, demonstrating a significant vulnerability to grazing.

The acute similarity is observed in the response of all three species of legumes to haymaking load that is manifested in a gradual natural increase in the total proportion of individuals of the middle and lower classes of vitality. This trend is as follows: in *T. repens* – 0.49 (FD0); 0.5 (FD1); 0.86 (FD2); 1 (FD3); in *M. falcata* – 0.25 (FD0) – 0.4 (FD1) – 0.9 (FD2) – 0.9 (FD3); in V. *cracca* – 0.27 (FD0) – 0.56 (FD1) – 0.9 (FD2) – 0.9 (FD3). In the populations of *M. falcata* and *V. cracca*, individuals of “a” class remain even at the last stage of the FD3 gradient (Figures 2-4).

In addition to vitality variability, the operation of legume populations on the pascual and fenisicial gradients is accompanied by the manifestation of vitality flexibility, which is associated with a change in the quality index Q by the stages of gradient. The index of vital dynamics (IVD) and change in the status of populations during their transition from one stage to another have been used for its evaluation (Tables 1, 2).

Table 1. Values of the index of vitality dynamics (IVD) and change in the qualitative type of legume populations on the pascual gradient

Vitality parameters	Transition by the stages of gradient			
	CA (PD0) → PD1	PD1 → PD2	PD2 → PD3	PD3 → PD4
Trifolium repens				
IVD value	-1.5060	0.12048	-0.3012	0.3614
Change in population type	P→B	B-B	B-B	B-B
Medicago falcata				
IVD value	-0.3012	-0.1807	-1.5060	-0.9036
Change in population type	P-P	P→B	P→D	D-D
Vicia cracca				
IVD value	-1.8072	-0.2409	-	-
Change in population type	P→D	D-D	-	-

Table 2. Values of the index of vitality dynamics (IVD) and change in the qualitative type of legume populations on the fenisicial gradient

Vitality parameters	Transition by the stages of gradient		
	CA (FD0) → FD1	FD1 → FD2	FD2 → FD3
Trifolium repens			
IVD value	-0.9036	0.1807	-0.6626
Change in population type	P→B	B → P	P→B
Medicago falcata			
IVD value	0.1205	-1.5060	-1.2048
Change in population type	P-P	P→B	B→D
Vicia cracca			
IVD value	-0.8434	-0.0602	-1.2048
Change in population type	P→B	B-B	B→D

Depending on trends in the vitality dynamics indices by the pascual digression gradient, legumes implement two response tactics (Table 1). The first of them belongs to *T. repens* and *V. cracca*, in the populations of which there is a significant decrease in IVD at the first stage of the PD1 gradient. It should be noted that a sharper decline is typical for *V. cracca*, the populations of which change their status immediately from prosperous to depressed. The populations *T. repens* transfer to the category of equilibrium. Further, IVD by the gradient changes slightly. In this case, in *T. repens* during the transition PD1 → PD2 → PD3 → PD4, the index of vitality dynamics has the positive sign that indicates even a slight improvement in the state of individuals of the populations. *M. falcata* shows the second variant of response to the increase in pasture loads, which manifests itself in the form of minor changes during the transitions PD0→PD1 and PD1→ PD2 (in the first variant, the status does not change and remains prosperous, and in the second one it changes to equilibrium). Significant changes in the qualitative vitality composition of the populations of this species are observed during the transition of PD2 → PD3, when the populations change their status to depressed. The transition to the last stage of the gradient is accompanied by minor negative changes in the vitality structure of the populations at maintaining the depressed type (Table 1).

The analysis of the indices of vitality dynamics on the pascual gradient has enabled to distinguish the two groups by the features of response of the studied legume species (Table 2). The first group is represented by the populations of *T. repens*, the IVD value of which indicates minor changes in vitality structure until the last stage of gradient, mostly with the negative sign. At the same time, the status of populations after its change to PD1 remains unchanged - equilibrium. The second group is represented by *M. falcata* and *V. cracca*, in the populations of which there are significant changes in the index of vitality dynamics at different stages of gradient. Thus, in *M. falcata*, these abrupt changes occur at the transitions of FD1 → FD2 (the population changes its status to equilibrium) and FD2 → FD3, whereupon the population turns into depressed. In the populations *V. cracca*, significant changes are characteristic during the transition to the last stage of the gradient FD2 → FD3, where the population changes its category to depressed (Table 2).

The analysis of the indices of vitality dynamics and transformation of the quality type of legume populations by both gradients has shown that most indices have the negative sign (78.9% of the total number that indicates the marked deterioration in the populations state under the influence of economic loading (primarily outrageous). The share of indices with the positive sign was 21.1%. Most of the indices of vitality dynamics (68.4%) were less than 1 that, according to the IVD scale, corresponds to minor changes in the vitality structure of populations. Indices with significant changes in the vitality structure of populations (from 1 to 2) account for 31.6%. The type of populations changed in 57.0% of the cases. The most common changes were P→B (31.6%), B-B (21.0%) and B→D (15.8%). The types of changes D-D (10.5 %), P-P (10.5 %), P→D (5.3%) and B→P (5.3%) rarely occurred.

Haymaking and grazing at the present stage in many regions are indeed powerful factors in the transformation of meadow communities and populations of coenosis forming species (Shushpannikova, 2014; Biró, 2014). The obtained results of study on the dynamics of the vitality structure of legume populations in floodplain meadows under the influence of the above economic loads indicate the availability of certain adaptive mechanisms that are involved in the populations to ensure their survival. Pronounced tolerance to various environmental factors was also observed in other species of the *Fabaceae* family. Thus, *Hedysarum alpinum* L. (the territory of Baikal Siberia) can grow both in favorable conditions of floodplain meadows and extreme permafrost conditions due to significant anthropopressing (Karnauhova and Sandanov, 2015; Karnauhova, 2018). The transition of populations from the category of prosperous to depressed with the increase of anthropogenic loads is typical not only for the populations of *M. falcata* and *V. cracca*. Similar changes in the conditions of floodplain meadows of the Forest-Steppe of Ukraine under the influence of excessive grazing and haymaking are typical for other legumes as well (Zlobin and Kirilchuk, 2005; Kyrylchuk, 2007; Kyrylchuk and Bashtovyi, 2018; Bondarieva et al., 2019), and for meadow grasses, in particular for the populations of *Dactylis glomerate* L. (Bondarieva and Bjelan, 2010, Zlobin et al., 2010). Moreover, a significant transformation of vitality spectra under the influence of pasture loads with the transition of populations from the status of prosperous to depressed was observed in the populations of such legume species as *Gueldenstaedtia monophylla* Fisch in the desert steppes of northwestern Mongolia (Seljutina et al., 2017) and *Oxytropis sulphurea* (Fisch. ex DC.) Ledeb. (Ore Altai and Saur Ridge) (Seljutina and Zibzeev, 2016). The populations of *T. repens* are characterized by pronounced stability in relation to economic loads that is manifested in the fact that the vitality status has changed only from prosperous to equilibrium and remained the same until the last stage of the gradient. Some meadow grasses, in particular *Festuca pratensis* Huds and *Phleum pratense* L. show similar resistance (Bondarieva and Bjelan, 2010). The ability of populations of coenosis forming species, including *T. repens, M. falcata* and *V. cracca*, to implement certain adaptation mechanisms and to show a certain level of resistance to anthropogenic impacts, are the factors that contribute to the sustainable provision of ecosystem services by meadow phytocenoses. The assessment of this aspect of meadow operation is also a relevant scientific problem, especially provided that the anthropocentric approach to assessing services is increasingly changing to an ecological one in modern conditions (Didukh, 2018).

CONCLUSIONS

The analysis of the vitality structure of the populations of the studied legume species in the control areas of the pascual and fenisicial gradients has shown that they are well adapted to existence in conditions without anthropogenic loads. *T. repens* is the most resistant species both to grazing and haymaking loads, as evidenced by the preservation of the equilibrium status of populations by the species until the last stages of both gradients, as well as the obtained indices of vitality dynamics (IVD, in most cases, less than 1, both with the negative and positive signs). The populations of *V. cracca* are characterized by significant vulnerability to grazing loads, which is manifested in a sharp transition of populations to the category of depressed at the stage of PD1. This species completely falls out of the meadow phytocoenosis at the stage of the gradient PD2. In relation to haymaking loads, the species is quite resistant and can withstand both one-time (FD1 stage) and two-time (FD2 stage) haymaking per season, where the populations have the status of equilibrium, and IVD is less than 1. Haphazard haymaking causes significant changes in the vitality composition (IVD is greater than 1 with the negative sign) and the transition of populations to the category of depressed. The populations of *M. falcata* are well adapted to moderate grazing loads (stages PD1 and PD2), as evidenced by IVD less than 1 and maintaining the status of populations at the level of prosperous and equilibrium. Starting with the stage PD3, the populations undergo significant changes in vitality composition (IVD = -1.5060) and transfer to the category of depressed. On the fenisicial gradient, the *M. falcata* populations demonstrate resistance at the FD1 and FD2 stages. Only under haphazard haymaking (FD3) vitality composition is significantly transformed, as evidenced by the depressed status of their populations. The data obtained indicate the need to regulate both grazing and haymaking loads in order to preserve the integrity of meadow ecosystems and ensure the sustainable, long-term and effective provision of a range of ecosystem services by them.

REFERENCES

Begon, M., Harper, J.L., & Townsend, C.R. (1986). *Ecology: Individuals, Populations and Communities. Ecology: individuals, populations and communities*. Blackwell Scientific Publications, Oxford.

Biró, M. (2014). Floodplain hay meadows along the river Tisza in Hungary. *Grasslands in Europe of high nature value*, 238–245. KNNV Publishing, Leiden. doi: 10.1163/9789004278103_027

Bondarieva, L.M., & Bjelan, S.S. (2010). Comparative analysis of the vital structure of cenosis forming cereals populations in the territories of the Sula River floodplain and areas with anthropogenic using. *Visnyk SNAU,* 4, 15–21 (in Ukrainian).

Bondarieva L.M., Kyrylchuk K.S., Skliar V.H., Tykhonova O.M., Zhatova H.O., & Bashtovyi M.G. (2019). Population dynamics of the typical meadow species in the conditions of pasture digression in flooded meadows. *Ukrainian Journal of Ecology*, 9(2), 204–211.

Cardinale, B. J., Matulich, K. L., Hooper, D. D., Byrnes, J. E., Duffy, E., Gamfeldt, L., Balvanera, P., O'Connor, M. I., & Gonzalez, A. (2011): The functional role of producer diversity in ecosystems. *American Journal of Botany,* 98, 572–592. doi: 10.3732/ajb.1000364

Díaz, S, Lavorel, S, McIntyre, S., Falczuk, V., Casanoves, F., Milchunas, D. G., Skarpe, C., Rusch, G., Sternberg, M., Noy-Meir, I., Landsberg, J., Zhang, W., Clark, H., & Campbell, B.D. (2007). Plant trait responses to grazing-a global synthesis. *Global Change Biology*, 13, 313–341. doi: 10.1111/j.1365-2486.2006.01288.x

Didukh, Ya.P. (2018). Biotope as a system: structure, dynamics, and ecosystem services. *Ukranian Botanical. Journal*, 75, 405–420 (in Ukrainian). doi: 10.15407/ukrbotj75.05.405

Gavrilova, M.N. (2008). The vitality structure of coenopopulations of some shrubs in different regions of the Mari El Republic. *Vestnik of Kazan State Agrarian University*, 7, 106–111 (in Russian).

Gibson, D.J. (2014). *Methods in Comparative Plant Population Ecology*. Oxford Univ. Press, New York. doi: 10.1093/acprof:oso/9780199671465.001.0001

Harvolk, S., Symmank, L., Sundermeier, A., Otte, A., & Donath, T.W. (2015). Human impact on plant biodiversity in functional floodplains of heavily modified rivers – A comparative study along *German Federal Waterways. Ecological Engineering*, 84, 463–475. doi: 10.1016/j.ecoleng.2015.09.019

Hölzel, N., & Otte, A. (2004). Inter-annual variation in the soil seed bank of flood-meadows over two years with different flooding patterns. *Plant Ecology*, 174, 279–291.

Hofman, N., Kowarsch, N., Bonn S., Isselstein J. (2001). Management for biodiversity and consequences for grass-land productivity. *Grassland Science in Europe,* 6, 113–116.

Huhta, Ari-Pekka, & Rautio, Pasi (2014). Flood meadows in Finland – their development during the past century. *Nordic Journal of Botany*, 32, 858–870. doi: 10.1111/njb.00505

Kaur, A. (2018). Conservation of Plant Biodiversity Current Strategies and Future Needs. International *Journal of Scientific Research in Biological Sciences*, 5, 109–113. doi: 10.26438/ijsrbs/v5i4.109113

Kahmen, S., & Poschlod, P. (2008). Effects of grassland management on plant functional trait composition. *Agriculture Ecosystem and Environment*. 128, 137–145.

Karnauhova, N.A., & Sandanov, D. V. (2015). A comparative assessment of the population strategy of *Hedysarum alpinum* L. (*Fabacea*) in Baikal Siberia. *Siberian ecological journal,* 22, 875–882 (in Russian). doi: 10.15372/sej20150607

Karnauhova, N.A. (2018). Population Status Assessment of *Hedysarum austrosibiricum* (*Fabaceae*). *Plant Life of Asian Russia*, 1, 9–13 (in Russian). doi: 10.21782/RMAR1995-2449-2018-1(9-13)

Kyrylchuk, K.S. (2007). Age and vital structure of legume populations in the floodplain meadows of the Psel River (forest-steppe zone) in farming using]. *Ukranian Botanical. Journal*, 64, 418–425 (in Ukrainian).

Kyrylchuk, K.S., & Bashtovyi, M.G. (2018). Complex analysis of populations of *Trifolium pratense* L. in the floodplain meadows of the Forest-Steppe zone of Ukraine. *Lesya Ukrainka Eastern European National University Scientific Bulletin. Series: Biological Sciences*, 4, 5–15 (in Ukrainian). doi: 10.29038/2617-4723-2018-377-5-15

Liira, J., Issak, M., Jogar, U., Mandaja, M., & Zobel, M. (2009). Restoration management of a floodplain meadow and its cost-effectiveness – the results of a 6-year experiment. *Annales Botanici Fennici*, 46, 397–408. doi: 10.5735/085.046.0504

McCall, A. C. (2017). *Plant Population Ecology.* Oxford Univ. Press, New York. doi: 10.1093/OBO/9780199830060-0191

Magda, D., de Sainte Marie, C., Plantureux, S., Agreil C., Amiaud B., Mestelan P., & Mihout, S. (2015). Integrating Agricultural and Ecological Goals into the Management of Species-Rich Grasslands: Learning from the Flowering Meadows Competition in France. *Environmental Management,* 56, 1053–1064. doi: 10.1007/s00267-015-0553-6

Mathar, W., Kleinebecker, T., & Hölzel N. (2014). Environmental variation as a key process of co-existence in flood-meadows. *Journal of vegetation science,* 26, 480–491. doi: 10.1111/jvs.12254

Mathar, W.P., Kämpf, T., Kuzmin, I, Tolstikov, A., Tupitsin, S., & Hölzel, N. (2016). Floristic diversity of meadow steppes in the Western Siberian Plain: effects of abiotic site conditions, management and landscape structure. *Biodiversity and Conservation,* 25, 2361–2379. doi: 10.1007/s10531-015-1023-4

Rahman, M.A. (2018). Plant diversity in Hazarikhil Wildlife Sanctuary of Chittagong and its conservation management. *Journal of Biodiversity Conservation and Bioresource Management*, 3, 43–56. doi: 10.3329/jbcbm.v3i2.36027

Reine, R., Barrantes, O., Chocarro, C., Juarez, A., Broca, A., Maestro, M., & Ferrer, C. (2014). Pyrenean meadows in Natura 2000 network: grass production and plant biodiversity conservation. *Spanish Journal of Agricultural Research*, 12, 61–77. doi: 10.5424/sjar/2014121-4617

Rui, X., Shuxia, Z., & Yongfei, B. (2010). Impacts of grazing intensity and management regimes on aboveground primary productivity and compensatory growth of grassland ecosystems in Inner Mongolia. *Biodiversity Science,* 18, 300–311. doi: 10.3724/sp.j.1003.2010.300

Segelbacher, G. (2018). Genetic, genomic, synthetic – new approaches for biodiversity conservation. *Proceedings 5th European Congress of Conservation Biology*, Jyväskylä, Finland. doi: 10.17011/conference/eccb2018/107508

Seljutina, I.Ju., & Zibzeev, E.G. (2016). Ontogenetic structure and vitality of coenopopulations *Oxytropis sulphurea* (Fisch. ex DC.) Ledeb. in the various ecological-centric conditions of the Altai Ore and the Saur Range. *Siberian ecological journal*, 3, 422–435 (in Russian). doi: 10.15372/SEJ20160313

Seljutina, N.Ju., Konichenko, E.S. Darihand, D., Zibzeev, E. G. (2017). *Gueldenstaedtia monophylla (Fabaceae)* in North-Western Mongolia: distribution, vitality, ontogenetic and spatial structure of populations. *Siberian ecological journal,* 2, 27–35 (in Russian). doi: 10.21782/RMAR1995-2449-2017-2(27-35)

Sherstyuk, M.Yu. (2017). Analysis of vitality structure of *Chimaphila umbellata* (L.) W. Barton coenopopulations in forest phytocenoses of Novgorod-Siversky Polissya. *ScienceRise. Biologial Science*, 1, 40–45 (in Ukrainian). doi: 10.15587/2519-8025.2017.94019

Sizykh, A.P. (2016). Determination of the Degree of Pasture Factor Digression in the Communities of Environment Contact Sites (Some Methodological Approaches). *Open Access Library Journal*, 3, 1–4. doi: 10.4236/oalib.1103025

Skliar, V.H. (2013). Dynamics of vitality parameters of populations of forest-forming species of Novgorod-Siversky Polissya: theoretical principles and methods of estimation. *Ukranian Botanical. Journal*, 70, 624–629 (in Ukrainian).

Sui, X., Mao, L., Liu, Y., & He, F. (2018): Mapping relative extinction risk for biodiversity conservation. *Biological Conservation,* 226, 168–176. doi: 0.1016/j.biocon.2018.07.012

Shushpannikova, G. S. (2014). Formation and degradation of meadows under the impact of hay harvesting and grazing in the Vychegda and Pechora floodplains. *Russian Journal of Ecology,* 45(1), 33–37 (in Russian). doi: 10.7868/S0367059714010120

Tikhonova, O. M. (2011). Vitality structure of populations of some weed species in cereal crops. *Visnyk of Dnipropetrovsk University. Biology, ecology,* 1, 123–129 (in Ukrainian). doi: 10.15421/011115

Tilman, D., & Downing, J. A. (1994). Biodiversity and stability in grasslands. *Nature*, 367, 363–365. doi: 10.1038/367363a0

Trnka, M., Eitzinger, J., Gruszczynski, G., Buchgraber, K., Resch, R., & Schaumberger, A. (2016). A simple statistical model for predicting herbage production from permanent grassland. *Grass and Forage Science*, 61, 253–271. doi: 10.1111/j.1365-2494.2006.00530.x

Thazaplizheva, L.H., & Chadaeva, V.A. (2010). Vitality structure of species of populations of the genus *Allium* L. in Kabardino-Balkaria. Vestnik of the Orenburg State University*,* 6, 42–46 (in Russian).

Vöge, M. (2015). Monitoring the vitality of *Isöetes lacustris* by using a non-destructive method. *Limnological Review*, 14, 153–158. doi: 10.1515/limre-2015-0005

Wellstein, C., Otte, A., & Waldhardt, R. (2007). Impact of site and management on the diversity of central European mesic grassland. *Agriculture Ecosystems and Environment*, 122, 203–210.

Wilsey, B.J. (2018). *Biodiversity of Grasslands*. Oxford Scholarship. Online. doi: 10.1093/oso/9780198744511.003.0002

Zlobin, Yu.A., & Kirilchuk, K.S. (2005). Population structure of floodplain meadow phytocenoses. *Bulletin of the Homel State University*, 6, 65–70 (in Russian).

Zlobin, Yu.A., Skliar, V.H., Bondarieva, L.M., & Kyrylchuk, K.S. (2009). Morphometry concept in modern botany. *Chornomorski botanical journal*, 5, 5–22 (in Ukrainian). doi: 10.14255/2308-9628/09.51/1

Zlobin, Yu.A. (2009). Population ecology of plants: current state, growth points. Monograph. University book, Sumy. (in Russian).

Zlobin, Yu.A., Bondareva, L.N., & Kirilchuk E. S. (2010). The state of cereal and leguminous grass coenopopulations on flood-lands meadows (Ukraine) in Forest-Steppe zone under different regimes of grazing and haying. Plant resources 46, 47–56 (in Russian).

Zlobin, Yu.A. (2018). The algorithm for estimating the vitality of plant individuals and the vitality structure of phytopopulations. *Chornomorski botanical journal*, 14, 213–226 (in Ukrainian). doi: 10.14255/2308-9628/18.143/2