THE CHANGES OF SPECIES RICHNESS AND DIVERSITY OF FOXTAIL TYPE STAND DURING LONG-TERM FERTILIZATION*

J. Mrkvička[1], M. Veselá[1], F. Klimeš[2], D. Kocourková[1]

[1]*Czech University of Agriculture, Faculty of Agrobiology, Food and Natural Resources, Prague, Czech Republic*
[2]*University of South Bohemia, Faculty of Agriculture, České Budějovice, Czech Republic*

The influence of fertilization (combination $N_0P_0K_0$, $N_0P_{40}K_{100}$, $N_{100}P_{40}K_{100}$, $N_{200}P_{40}K_{100}$) on species richness, species diversity and stand composition of foxtail stand type was studied in the long-term exact experiments (from 1967 to 2003) for extending of knowledge useful for development of species richness and species diversity of grass stands. The experiment is situated at the altitude 363 m above sea-level and the site is mesophytic to mesohygrophytic. From the long-term point of view the best combination is $N_0P_{40}K_{100}$, when in species diversity expressed by Simpson index the value of Simpson index after 21 to 22 years comes to excess the values of nonfertilized stands. The suitability of the method according to Regal and Veselá (1975) was proved for the stand composition analysis. The experiment confirmed that foxtail stand type is marked by the lower number of species with their higher persistence, which can be the cause of different tendencies of development of its species richness and diversity. The dose of 100 kg N per ha with PK fertilization according to soil fertility is the lowest for the sustainable dominance of *Alopecurus pratensis* L. in community. The doses of nutrients must be corrected according to the stand composition. Extraordinary attention to the foxtail type stands is important because of its role in soil and hydrosphere protection.

foxtail stand type; projective dominance; species richness; species diversity; Simpson's index

INTRODUCTION

The floristic composition of permanent meadow stands (PMS) is the resulting point of the interaction of all ecological factors in the whole ecosystem and the controlled conditions. Each change in stand conditions results in the changes of species composition and representation of agro-botanical groups. Directed management influences species diversity for the benefit of forage valuable species, which are usually dominant in stands. Other species in these communities persist with lower vitality or in latent state (Rychnovská et al., 1985). According to Moravec and Jeník (1994) the number of species present at the locality provides the basic information about the species richness of community which is influenced by site factors when the species richness of phytocenosis is higher in favourable conditions. The most significant influence on species diversity is presented by intensity of fertilization and used mineral fertilizers. N fertilization particularly in higher doses influences the stand composition quickly and most considerably (Velich, 1985; Mrkvička, Veselá, 2002a, b).

MATERIAL AND METHODS

Stand composition, species richness and species diversity were observed in permanent meadow of mesophytic to mesohygrophytic character in the locality of Černíkovice (district Benešov) in the years 1967–2003. Original growth type was *Alopecuretum.* The altitude above sea level is 363 m, the average annual precipitation sum 617 mm, average annual temperature 7.8 °C. Depth of underground water level ranged from 0.1 to 0.5 m. Soil type is gley, soil species (0–0,2 m) loam, pH 5.0; % C_{ox} 2.90; % $N_t = 0.41$; $C_t / N_t = 7.07$. Experiment was established in the randomised blocks de-

Table 1. Variants of fertilization

Variant	Nutrient combination	Fertilizers / aplication / doses of nutrients (kg/ha)		
		ASL	SP	PS
		Spring	autumn	after 1st cut
1	$N_0 P_0 K_0$	–	–	–
2	$N_0 P_{40} K_{100}$	–	40	100
3	$N_{100} P_{40} K_{100}$	100	40	100
4	$N_{200} P_{40} K_{100}$	200	40	100

ASL – ammonia saltpeter with limestone; SP – superphosphate; PS – potash salt

* This study was financially supported by the Research Project of MSM 6046070901.

Table 2. Species richness of stand expressed in total number of vascular plant species (Q), variants 1–4

Variants	Year					$Q_{min.}$	$Q_{max.}$
	1967	1975	1984	1993	2003		
1	**31**	**32**	**33**	**32**	**29**	**29**	**33**
2	27	28	25	31	25	25	31
3	21	19	18	17	18	10	23
4	22	21	20	12	14	7	24

Table 3. Average values and basic statistical characteristics of species richness expressed in total number of vascular plant species (Q), variants 1–4

Variants	$\overline{Q}$	S_Q	V_Q (%)	$Q_{0.25}$	$Q_{0.75}$
1	31.231	1.363	4.364	30.000	32.000
2	27.462	2.025	7.374	25.500	29.000
3	18.000	3.674	20.411	16.000	20.500
4	16.615	4.942	29.744	13.000	20.500

sign with four replications. The plot size was 30 m^2 (5 m x 6 m). The studied variants are presented in Table 1.

Botanical analyses of stands were done by the method of reduced projective dominance (D in % before the first cut harvest). For reducing of inaccuracy of estimation the relevés were evaluated on each replication and the basic agro-botanical groups were separated according to the individual species (Regal, Veselá, 1975). Simpson's index was used for the estimation of species diversity (Begon et al., 1997), the total dominance of vegetation was considered.

For the analysis of observed values of species richness and diversity basic statistical characteristics (average mean, standard deviation, standard error of mean, variation coefficient, variation range and quartile deviation) were used and we made the failure of chronological series of experimental dates using analytical functions (polynoms of 2nd and 3rd degrees) applying mathematic analyses (dQ'/dt; dD'/dt; d^2Q'/dt; d^2D'/dt) and to obtain evidence of their course. For chosen years (because of considerable extensiveness of evaluated data) from which are presented relevés and values of species richness (Q) and species diversity (D) theoretical reconstruction of data with use of created dynamic models was carried out.

RESULTS AND DISCUSSION

Many authors studied the influence of different level of fertilization on the changes in grass stand species composition (Velich, 1985; Klimeš, 2000; Holúbek, 2002; Mrkvička, Veselá, 2002a, b). The number of vascular species in grass stands usually ranges from 2–3 to several decades (Regal, Veselá, 1975; Moravec et al., 1994). In the observed stands these values ranged from 7 (var. 4, 1997) to 33 species (var. 1, 1985; Table 2). The highest average species number (Q) was found in nonfertilized stand (var. 1) in the period under consideration and the lowest variation of Q value (V_Q = 4.364%). Dynamic model analysis of species richness development (Table 4) shows that after 15 years the number of species increase results in the decrease of species richness. It confirms the need of long-term experiments in meadows and pastures (Regal, Veselá, 1975). The gradual decrease of species richness with in consequence of higher fertilization intensity (Tables 2–4) is consistent with the knowledge of many authors (Velich, 1985; Holúbek, 2002, etc.). Different directions of development tendency of species richness values (Q) and their small changes during monitoring (Tables 2–4) contrast with the trends in species diversity values (expressed in Simpson's index) where clear differentiation caused by fertilization was found (Tables 5–7) and homogeneity of development tendencies was explicit (Tables 6–9). Regular PK fertilization seems to be better than treatment without fertilization for stand type *Alopecuretum* from the long-term point of view according to average values (Table 7) and species diversity development tendencies (Tables 6–9). According to dynamic model of value development of Simpson's index (Table 8) it is evident that after 21 to 22 years are higher values of species diversity in stands with PK fertilization in comparison with nonfertilized stands and the differences between the variants are increasing (var. 1 and 2). The inner consistency of value development dynamic model D (Table 8) is confirmation of stand analysis method suitability according to Regal and Veselá (1975). Different directions of development tendency of species richness (Q) and species diver-

Table 4. Dynamic model of stand species richness development, variants 1–4 (*i* = 1 to 4), expressed in total number of vascular plant species (Q)

$Q'_i = f(t)$	I_{Qt}
$Q'_1 = 30.814 + 0.269\,t - 0.008\,789\,t^2$	0.847**
$Q'_2 = 27.473 - 0.517\,t + 0.047\,662\,t^2 - 0.000\,972\,t^3$	0.686**
$Q'_3 = 21.019 - 0.290\,t + 0.005\,662\,t^2$	0.861**
$Q'_4 = 21.599 + 0.542\,t - 0.064\,752\,t^2 + 0.001212\,t^3$	0.812**

Table 5. Theoretical (generated in model) values of species richness in observed stands, expressed in total number of vascular plant species (Q´)

Variants	Year					$Q'_{min.}$	$Q'_{max.}$
	1967	1975	1984	1993	2003		
1	30.812	32.363	32.837	31.864	29.131	29.131	32.862
2	27.571	25.964	27.760	29.271	25.460	25.961	24.273
3	21.023	19.008	17.732	17.300	17.887	17.303	21.023
4	21.602	22.367	18.145	13.212	13.681	12.274	22.839

Table 6. Values of Simpson's index of species diversity (D) in observed stands, variants 1–4

Variants	Year					$D'_{min.}$	$D'_{max.}$
	1967	1975	1984	1993	2003		
1	11.295	3.980	5.810	4.876	4.370	3.322	11.295
2	8.653	4.081	3.911	5.205	10.980	3.399	10.980
3	4.109	1.351	1.950	1.355	1.343	1.109	4.109
4	1.363	1.204	1.573	1.211	1.065	1.042	3.226

Table 7. Average values and basic statistical characteristics of species diversity expressed in Simpson's index (D), variants 1–4

Variants	$\overline{D}$	S_D	$V_D(\%)$	$D_{0.25}$	$D_{0.75}$
1	4.885	2.078	42.538	3.574	4.790
2	5.624	2.161	38.425	3.852	6.264
3	1.800	0.878	48.778	1.340	1.752
4	1.403	0.571	40.410	1.132	1.449

Table 8. Dynamic model of stand species diversity development, variants 1–4 (*i* = 1 to 4), expressed in Simpson's index of species diversity (D)

$D'_i = f(t)$	I_{Dt}
$D'_1 = 10.000 - 0.476\ t + 0.009\ 355\ t^2$	0.697**
$D'_2 = 8.415 - 0.621\ t + 0.019\ 247\ t^2$	0.756**
$D'_3 = 3.667 - 0.195\ t + 0.003\ 773\ t^2$	0.844**
$D'_4 = 1.300 + 0.016\ t - 0.000\ 622\ t^2$	683**

sity (D) cause randomness in fluctuation of equitability indices calculated in the basic version and also in improved version (Klimeš, 2004) consequently the generalisation is not possible.

The development of the species composition is influenced by pratotechnic management, fertilization, exploitation and conservative ecological factors and the most important is water regime of site. The highest persistency of all species in foxtail type meadow provided *Alopecurus pratensis*. The dose of 100 kg N per ha with PK fertilization according to soil fertility is the lowest for the sustainable dominance of *Alopecurus pratensis* L. in community. The subdominant species in stands were *Festuca pratensis, Festuca rubra, Deschampsia caespitosa and Elytrigia repens.* The most expanded leguminous is *Trifolium repens* and from other herbs *Ranunculus repens* and *Sanguisorba officinalis* (Klimeš, 2004). In our experiment lasting 37 years predominant species was *Alopecurus pratensis* in the majority of cases but its dominancy fluctuated in variants N_0 P_0 K_0 and N_0 P_{40} K_{100} (17–50%, 20–50%, respectively), particularly in the first ten years. The highest dominancy of *Alopecurus pratensis* was found in variants with higher doses of nitrogen. Accompanying species in all evaluated variants were *Festuca pratensis*, *Holcus lanatus*, *Poa trivialis* and *Poa pratensis*. The highest dominancy of leguminous and other herbs was found in variants 2 and 1 where dominated *Trifolium repens*, *Trifolium hybridum*, *Ranunculus repens*, *Ranunculus acer* a *Taraxacum officinale* (Tables 10–13).

Table 9. Theoretical (generated in model) values of Simpson's index of species diversity (D´) in observed stands

Variants	Year					$D'_{min.}$	$D'_{max.}$
	1967	1975	1984	1993	2003		
1	10.000	6.761	4.638	3.954	4.972	3.941	10.000
2	8.415	4.659	3.418	5.293	10.962	3.412	10.962
3	3.667	2.317	1.450	1.140	1.523	1.140	3.667
4	1.300	1.382	1.389	1.290	1.073	1.073	1.398

Table 10. The development of botanical composition expressed in reduced projective dominance (%D) of agro-botanical groups and species, control variant 1 ($N_0P_0K_0$)

Species	Years				
Agrobotanical group	1967	1975	1984	1993	2003
Alopecurus pratensis	17	42	34	38	20
Anthoxanthum odoratum	2	1	1	1	5
Festuca pratensis	10	8	3	6	2
Holcus lanatus	7	+	11	11	35
Poa trivialis	3	2	9	1	1
Poa pratensis	11	1	1	1	3
Agrostis stolonifera	8	+	+	+	7
Cynosurus cristatus	4	+	+	1	+
Deschampsia caespitosa	+	+	+	+	+
Festuca rubra	3	+	+	+	+
Trisetum flavescens	+	+	+	+	+
Phleum pratense	+	+	+	1	+
Grasses	**65**	**54**	**59**	**60**	**73**
Trifolium repens	4	10	7	1	2
Trifolium hybridum	5	1	1	+	+
Trifolium pratense	2	1	1	1	+
Lathyrus pratensis	+	+	+	+	+
Legumes	**11**	**12**	**9**	**2**	**2**
Ranunculus acris	4	3	4	3	2
Ranunculus repens	8	17	10	13	+
Taraxacum officinale	3	9	12	5	5
Rumex acetosa	1	1	2	+	+
Cardamine pratensis	1	+	+	+	+
Cerastium vulgatum	+	+	1	+	+
Lychnis flos–cuculi	1	+	+	+	+
Alchemilla sp.	1	+	1	1	+
Polygonum bistorta	+	–	+	–	–
Veronica chamaedrys	+	+	+	+	+
Angelica sylvestris	–	+	–	+	–
Achillea millefolium	+	+	1	+	5
Carum carvi	–	+	+	+	–
Plantago lanceolata	+	+	+	–	1
Hypochoeris radicata	+	+	+	+	+
Symphytum officinale	–	–	+	–	–
Glechoma hederacea	+	+	+	+	–
Lysimachia nummularia	+	+	+	+	+
Other herbs	**19**	**30**	**31**	**32**	**13**
Total dominance	**95**	**96**	**99**	**94**	**88**
Uncovered places	5	4	1	6	12

Table 11. The development of botanical composition expressed in reduced projective dominance (%D) of agro-botanical groups and species, variant 2 ($N_0P_{40}K_{100}$)

Species	Years				
Agrobotanical group	1967	1975	1984	1993	2003
Alopecurus pratensis	20	40	28	32	15
Anthoxanthum odoratum	2	2	1	1	4
Festuca pratensis	12	7	3	3	10
Holcus lanatus	2	6	27	13	15
Poa trivialis	10	1	7	1	1
Poa pratensis	15	2	3	2	5
Agrostis stolonifera	2	+	1	+	+
Cynosurus cristatus	1	+	+	+	–
Deschampsia caespitosa	+	+	–	+	–
Festuca rubra	1	+	+	+	+
Trisetum flavescens	–	+	–	1	+
Phleum pratense	–	+	–	–	–
Grasses	**65**	**58**	**70**	**53**	**50**
Trifolium repens	5	9	6	8	10
Trifolium hybridum	5	3	4	3	+
Trifolium pratense	4	1	+	+	+
Lathyrus pratensis	1	+	+	4	15
Legumes	**15**	**13**	**10**	**15**	**25**
Ranunculus acris	5	2	1	+	+
Ranunculus repens	8	12	12	8	1
Taraxacum officinale	2	2	5	4	4
Rumex acetosa	+	2	+	+	+
Cardamine pratensis	+	+	+	+	–
Cerastium vulgatum	+	+	+	+	+
Lychnis flos-cuculi	+	+	+	+	+
Alchemilla sp.	+	+	+	1	1
Polygonum bistorta	+	–	–	+	+
Veronica chamaedrys	+	+	+	+	+
Angelica sylvestris	–	–	–	–	–
Achillea millefolium	–	–	–	3	4
Carum carvi	–	–	–	+	–
Plantago lanceolata	–	–	–	+	+
Hypochoeris radicata	+	+	+	+	–
Glechoma hederacea	+	+	+	+	+
Lysimachia nummularia	+	+	+	+	–
Other herbs	**15**	**18**	**18**	**16**	**10**
Total dominance	**95**	**89**	**98**	**84**	**85**
Uncovered places	5	11	2	16	15

Table 12. The development of botanical composition expressed in reduced projective dominance (%D) of agro-botanical groups and species, variant 3 ($N_{100}P_{40}K_{100}$)

Species	Years				
Agrobotanical group	1967	1975	1984	1993	2003
Alopecurus pratensis	44	84	82	79	70
Anthoxanthum odoratum	1	+	+	–	+
Festuca pratensis	13	2	+	3	+
Holcus lanatus	5	3	6	3	10
Poa trivialis	10	1	5	1	3
Poa pratensis	10	+	+	6	2
Agrostis stolonifera	5	+	+	+	+
Cynosurus cristatus	1	+	–	–	–
Deschampsia caespitosa	+	+	–	–	–
Festuca rubra	+	+	+	+	1
Trisetum flavescens	+	–	–	–	–
Phleum pratense	–	–	–	–	–
Grasses	**89**	**90**	**93**	**92**	**86**
Trifolium repens	3	+	+	+	+
Trifolium hybridum	1	–	+	–	–
Trifolium pratense	+	–	–	–	–
Lathyrus pratensis	1	–	–	+	–
Legumes	**5**	**+**	**+**	**+**	**+**
Ranunculus acris	+	1	+	+	1
Ranunculus repens	4	6	4	2	3
Taraxacum officinale	1	1	1	2	+
Rumex acetosa	+	+	+	+	+
Cardamine pratensis	+	–	+	–	–
Cerastium vulgatum	–	+	1	+	+
Lychnis flos-cuculi	–	–	–	–	–
Alchemilla sp.	–	+	–	+	1
Polygonum bistorta	–	–	–	–	–
Veronica chamaedrys	+	+	+	–	+
Angelica sylvestris	–	–	–	–	–
Achillea millefolium	–	–	+	+	1
Carum carvi	–	–	–	–	–
Plantago lanceolata	–	+	–	+	+
Hypochoeris radicata	–	–	–	–	–
Glechoma hederacea	–	–	–	–	–
Lysimachia nummularia	–	–	–	–	–
Other herbs	**5**	**8**	**6**	**4**	**6**
Total dominance	**99**	**98**	**99**	**96**	**92**
Uncovered places	1	2	1	4	8

Table 13. The development of botanical composition expressed in reduced projective dominance (%D) of agro-botanical groups and species, variant 4 ($N_{200}P_{40}K_{100}$)

Species	Years				
Agrobotanical group	1967	1975	1984	1993	2003
Alopecurus pratensis	85	90	89	91	75
Anthoxanthum odoratum	–	+	+	–	–
Festuca pratensis	10	1	+	1	–
Holcus lanatus	3	+	1	1	2
Poa trivialis	+	2	3	1	2
Poa pratensis	+	+	+	3	15
Agrostis stolonifera	+	+	+	+	+
Cynosurus cristatus	+	+	–	–	–
Deschampsia caespitosa	+	–	–	–	+
Festuca rubra	+	+	–	–	+
Trisetum flavescens	–	–	–	–	–
Phleum pratense	–	–	–	–	–
Grasses	**98**	**93**	**93**	**97**	**94**
Trifolium repens	+	+	+	–	–
Trifolium hybridum	+	–	+	–	–
Trifolium pratense	+	–	–	–	–
Lathyrus pratensis	+	–	–	–	–
Legumes	**0**	**+**	**+**	**–**	**0**
Ranunulus acris	2	+	+	1	+
Ranunculus repens	+	6	2	+	+
Taraxacum officinale	+	+	1	+	+
Rumex acetosa	+	+	+	+	–
Cardamine pratensis	–	–	+	–	+
Cerastium vulgatum	+	+	+	+	+
Lychnis flos-cuculi	–	–	–	–	–
Alchemilla sp.	+	+	+	–	+
Polygonum bistorta	–	–	–	–	–
Veronica chamaedrys	+	+	–	–	+
Angelica sylvestris	–	–	+	–	–
Achillea millefolium	+	+	+	–	–
Rumex obtusifolius	–	+	+	+	–
Carum carvi	–	–	–	–	–
Plantago lanceolata	–	+	–	–	–
Hypochoeris radicata	–	–	–	–	–
Symphytum officinale	–	–	–	–	–
Glechoma hederacea	–	–	–	–	–
Lysimachia nummularia	+	+	+	–	–
Other herbs	**2**	**6**	**3**	**1**	**0**
Total dominance	**100**	**99**	**96**	**98**	**94**
Uncovered places	0	1	4	2	6

REFERENCES

BEGON, M. – HARPER, J. L. – TOWSEND, C. R.: Ecology – individuals, populations and communities. Olomouc, Univ. Palackého 1997. 949 pp.

HOLÚBEK, R.: Production potential of semi-natural grasslands in the Strážovská vrchovina mountain area. In: Zbor. mezin. ved. konf. "Ekológia trávneho porastu VI", Banská Bystrica, 10.–11. 12. 2002: 59–67. (In Slovak)

KLIMEŠ, F.: Dynamics of species richness of floodplain meadows. Rostl. Výr., *46*, 2000: 198–208.

KLIMEŠ, F.: Grassland and pasture management. Biodiagnostic and special pratotechnics. České Budějovice, ZF JčU 2004. 157 pp. (In Czech)

MORAVEC, J. – JENÍK, J.: Composition and structure of plant community. In: MORAVEC, J. et al.: Phytocenology. Praha, Academia 1994: 41–61. (In Czech)

MRKVIČKA, J. – VESELÁ, M.: The influence of long-term fertilization on species diversity and yield potential of permanent meadow stand. Rostl. Výr., *48*, 2002a: 69–75.

MRKVIČKA J. – VESELÁ M.: The species composition, yields and nutrients values of long-term fertilized meadow foxtail sward. In: Zbor. mezin. ved. konf. "Ekológia trávneho porastu VI", Banská Bystrica, 10.–11. 12. 2002b: 20–25. (In Czech)

REGAL, V. – VESELÁ, M.: The research of typology of grasslands and pastures. [Final report.] Praha, AF VŠZ 1975. 105 pp. (In Czech)

RYCHNOVSKÁ, M. – BALÁTOVÁ-TULÁČKOVÁ, E. – ÚLEHLOVÁ, B. – PELIKÁN, J.: Ekology of grasslands. Praha, Academia 1985. 292 pp. (In Czech)

VELICH, J.: The study of development of production capacity of permanent meadow stands and sod process in long-time fertilization and its optimization. [Thesis.] Praha, AF VŠZ 1985. 412 pp. (In Czech)

Received for publication on May 31, 2005
Accepted for publication on January 4, 2006

MRKVIČKA, J. – VESELÁ, M. – KLIMEŠ, F. – KOCOURKOVÁ, D. (Česká zemědělská univerzita, Fakulta agrobiologie, potravinových a přírodních zdrojů, Praha; Jihočeská univerzita, Zemědělská fakulta, České Budějovice, Česká republika):

Změny druhové pestrosti a diverzity psárkového porostu během dlouhodobého hnojení.

Scientia Agric. Bohem., *37*, 2006: 41–48.

V intencích požadavků na prohlubování teoretických poznatků, využitelných pro rozvíjení druhové pestrosti a druhové diverzity travních porostů byly v rámci dlouhodobých exaktních pokusů (1967 až 2003) v nadmořské výšce 363 m studovány vlivy hnojení (kombinace $N_0P_0K_0$, $N_0P_{40}K_{100}$, $N_{100}P_{40}K_{100}$, $N_{200}P_{40}K_{100}$) na vývoj druhové pestrosti, diverzity a porostové skladby psárkové louky na mezofytním až mezohygrofytním stanovišti. Z hlediska dlouhodobého časového horizontu se jeví jako nejvhodnější kombinace živin $N_0P_{40}K_{100}$, kdy v druhové diverzitě, vyjádřené Simpsonovým indexem, dochází cca po 21 až 22 letech k překročení hodnot tohoto indexu přes hodnoty dosahované u nehnojených porostů. Vedle potvrzení požadavku na potřebu dlouhodobých sledování vývoje druhové pestrosti a diverzity byla pro analýzu porostové skladby prokázána vhodnost uplatnění metody podle autorů Regal a Veselá (1975). Sledování zároveň potvrdilo, že psárkové porosty se vyznačují nižším počtem druhů s vyšší stálostí, což se jeví jako příčina různosměrných tendencí ve vývoji jejich druhové pestrosti a druhové diverzity.

Pro setrvale dominantní postavení a udržení *Alopecurus pratensis* L. v luční cenóze se jako nejnižší potřebná dávka ukazuje 100 kg N/ha s odpovídajícím PK hnojením v závislosti na úrodnosti půdy. Dávky živin je nutné korigovat podle porostové skladby. Psárkovým loukám je třeba věnovat mimořádnou pozornost ve vztahu k ochraně půdy a hydrosféry.

psárkový porost; projektivní dominance; druhová pestrost; druhová diverzita; Simpsonův index

Contact Address:

Doc. Ing. Jiří Mrkvička, CSc., Česká zemědělská univerzita v Praze, Fakulta agrobiologie, potravinových a přírodních zdrojů, katedra pícninářství a trávníkářství, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika, e-mail: mrkvicka@af.czu.cz