METHOLOGICAL TASKS OF EVALUATION OF HOMOGENEITY OF GRAZING STANDS*

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In the years 1997 to 1999 in submontane region of the Šumava Mountains (Kaplice, 680m above sea level) methodological tasks of exact determination of homogeneity of grazing stands were studied together with tasks of relationships between homogeneity of pastures and relative amount of left-overs. To determine the frequency of different species for experimental studies the need to place repeatedly 30 times a square of the 0.30 m side into the stand, then on operational plots 12 times per 1 ha (with unified stand type), whereas a preliminary method of randomizing seems to be the most suitable one. A gradual decrease of proportion of left-overs in the total yield of pastures at growth of their homogeneity was proved. The percentage of left-overs falls below 15% (in statistical expression) at the values of homogeneity index over 5.5.

grazing stands; species frequency; homogeneity of stands; selectivity of grazing; left-overs; analysis of stands

INTRODUCTION

Solution of pratotechnic tasks in CR from the very beginnings when meadow and pasture managements was constituted as scientific disciplines, is closely connected particularly due to well-defined biological and ecological orientation of the founder of the Czech grassland school of academician Antonín Klečka with a wide application of phytocenologic and ecological approaches. However, application of methodological approaches of these disciplines in grassland management is corrigated by Klečka and Fabian (1934) by the following principles: (1) If a question is to be answered which

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method to use, it is necessary to specify firstly that the purpose of our researches is much different from those of pure scientific sociology, (2) In grassland management methods used are only a means to understand the effect of intervention on the stand. Therefore the method used has to be not only simple, but also accommodated for special purpose of certain experimental investigation.

In the given intentions in the presented contribution an attention was paid to methodological tasks of the study of homogeneity of grazing stands with a special regard to utilization of data on homogeneity to selection prediction of grazing and its consequences manifested by amount of left-overs. The paper is connected to solution of tasks of the study of frequency of plant species in grasslands as starting points for judging of their homogeneity (Klečka, Fabian, 1934; Braun-Blanquet, 1964; Kubíková, 1971; Gazda, 1977; Klimeš, 1983; Slavíková, 1986; Dykyjová et al., 1989; Moravec et al., 1994 etc.).

MATERIAL AND METHODS

In the years 1997 to 1999 in the submontane region of the Šumava Mountains (Kaplice, 680 m above sea level) methodological tasks of exact determination of homogeneity of grazing stands were studied. Within these studies three sets of starting hypotheses related to: (1) selection of necessary number of replications at determination of frequency of different species as in experimental, as in operational plots (2) selection of suitable way of randomizing at replicated allocation of square for determination of frequency in operational plots and (3) importance of finding of homogeneity of grazing stands as an indicator suitable for prediction of selectivity of grazing whose consequence is an amount of left-overs.

To determine frequency of different species square of the 0.30 m side was used (Gazda, 1977; Klimeš, 1983). On experimental plots for randomizing at allocation of square to determine frequency of different species chessboard method was used. On operational plots of area 0.5 ha (2 stands) and 1 ha (6 stands) the following systems of allocation were tested: (1) random throws into the stand (2) diagonal system of allocation of squares (3) continuous method of allocation of squares. In operational plots communities which belong to the field of union *Cynosurion* (*cristati*) T x 1947 with dominant species combination of *Festuca rubra*, *Poa pratensis*, *Phleum pratense* and *Trisetum flavescens* were represented uniformly. These arepolydominant phytocenoses with small differences in projective dominance 3 to 4 dominant or subdominant species, resp. (15 to 25% D). In summer season projective dominance of *Trifolium repens* also ranged in the given interval.

In testing of the suitable number of replications as in experimental, as in operational plots the following numbers of replications were chosen: 12 times, 18 times, 24 times, 30 times and 36 times. In spring biological control of operational plots in 1999 the investigation was extended for comparison for 2 ways of determination of the frequency of different species: simultaneously with determination of frequency using the square of 0.30 m side using the square of 1 m side, distributed into 9 squares of 0.33 m, frequency was determined in these different partial squares. In this investigation in total 135 replications were used. Comparison was included too for the reason that in newer studies more authors start to use for determination of dominance also the frequency of 1 m side, divided into 9 partial squares. To evaluate the results the methods of variation statistics and the testing of statistic hypotheses together with the methods of correlation and regression analyses were used.

To express homogeneity of tested stands the summary indicator of the rate of homogeneity – homogeneity index (I_h) was introduced in solution:

$$I_H = \frac{n_{IV, V}}{n_{I, II}} \quad (1)$$

where: $n_{IV, V}$ – total number of species, represented in higher frequency classes, i.e. in IV and V frequency class

$n_{I, II}$ – total number of species, represented in lower frequency classes, i.e. in I and II frequency classes

whereas classification of different species into frequency classes is as follows (Braun-Blanquet, 1964; Gazda, 1977):

Frequency class	Frequency in different species in %
I	till 20
II	20.1–40
III	40.1– 60
IV	60.1– 80
V	80.1–100

Analyses of tested grazing stands were carried out in different grazing cycles always before grazing off alone. After grazing off of stands the total amount of left-overs was finding, which was simultaneously determined as the share of left-overs in the total yield. Tested stands were grazed differentially according to earliness (early, semi-early and late) in 5 pasture cycles by the herd of meat cattle of the Hereford breed.

Loading of pastures was 2.7 DJ/ha as in experimental, as in operational plots and in both the cases rational grazing was applied in time of grazing of one rational grazing for 2 days.

RESULTS

It is showed from conducted investigations and their evaluation that on experimental plots due to growth of repeated insertion of square into stands in ascending line from 12 to 30 replications gradual exacting of homogeneity index ($I_h - \bar{y}$) occurs, what is documented by the data on mean error of average ($S_{\bar{y}}$), as well as variation coefficient (V_y) presented in Table I.

I. Average values of homogeneity index ($I_h - \bar{y}$) and its basic statistic characteristics on experimental plots at different number of repeated finding of frequency of different species

Statistic characteristics	Number of replications				
	12	18	24	30	36
$\bar{y}$	1.153	1.058	0.939	0.719	0.745
S_y	1.328	1.134	1.021	0.600	0.731
V_y (%)	115.160	107.200	108.670	83.530	98.060
$S_{\bar{y}}$	0.192	0.164	0.147	0.087	0.106

The process of gradual exacting of homogeneity index at increasing number of repeated finding of frequency is expressed in the following regression model:

$$S_{\bar{y}} = 0.423\,462 - 0.091\,473 \ln x \qquad (2)$$

$$(Is_{\bar{y}}x = -0.929^{**})$$

where: x – number of replications
$S_{\bar{y}}$ – mean error of average

For exact judgement of suitable number of replications on experimental plots at determination of homogeneity of grazing stands another verification – comparison of homogeneity index, found at different number of replications using pair t-test (Table II) – was carried out.

Similarly like from the course of values $S_{\bar{y}}$ (Table II), analyzed using correlation and regression analyses, it also follow from performed statistic testing (Table II), that on experimental plots for determination of homogeneity of grazing stands it is suitable to choose 30 replications in total (repeated insertion of square into the stand). Further increase of of the number of replications already does not bring statistically significant exacting of finding homogeneity index, because the difference between homogeneity index (I_h) found at 30 and 36 replications is no more significant. On the contrary, lower number of replications (12 times to 24 times) gives highly significantly different results and hence also the selection of such lower numbers of replications leads to inexact results.

II. Comparison of homogeneity indexes found at different number of replications with homogeneity index at highest number of replications (on experimental plots)

Compared pairs according to the number of replications		t (calculated)
12	36	3.063^{**}
18	36	3.564^{**}
24	36	2.852^{**}
30	36	0.763
t-critical values		$t_{0.05} = 2.010$ $t_{0.01} = 2.680$

It was found on experimental plots that without respect to the method used randomizing at allocation of the square into the stand gives already 12 replications on areas of 0.5 to 1 ha when all this area formed by one stand type sufficiently exact results, what is also confirmed by the results of statistic testing (Table III).

It is evident from the data in Table III that the best harmony between homogeneity index values, found at 12 to 36 replications, is obtained at the use of continuous method of randomizing. With respect to 1.6 to 10.6 times higher values of tested criterion in the method of random throws and in the diagonal method than in the continuous method at compared number of replications (12 to 36 times), both these methods of randomizing seem to be as little suitable ones. This prerequisite is confirmed also by the data presented in Table IV, from which it is evident, that average values of homogeneity index, found at the use of the continuous method of randomizing are loaded by 2.6 to 2.8 times lower error than in the use of the method of random throws and diagonal method which therefore seem also as inexact and unsuitable for analysis of operational areas of pastures.

It seems from supplementing investigation on suitability of the use of the square of 1 m side with division into 9 partial squares à 0.33 m side for determination of frequency, that this method gives always significantly (statistically significantly) lower values of homogeneity index compared with the standard method, at which always one square of 0.3 m side is inserted into the stand. At the use of continuous method on 1 ha area of pastures when different squares were repeatedly inserted 135 times, homogeneity index in the standard method it was 0.36, at the use of compared method with squares 9 x 0.33 m x 0.33 m, only the value I_h 0.23 was recorded. It seems from

III. The found values of homogeneity index (I_h) on operational plots at different number of replications and at different way of randomizing at insertion of square into the stand

Locality	Method of randomizing					
	random throws		diagonal		continuous	
	number of replications					
	12	36	12	36	12	36
	Ih					
1	0.36	0.46	0.20	0.36	0.57	0.33
2	0.67	0.60	0.57	0.55	0.40	0.20
3	0.86	1.14	0.83	0.33	1.00	0.71
4	1.75	1.50	2.00	1.20	0.50	0.75
5	0.33	0.60	0.50	0.67	0.29	0.50
6	0.22	0.38	0.27	0.14	0.50	0.31
7	0.50	0.36	0.30	0.45	0.50	0.45
8	1.40	1.14	1.00	1.00	0.44	0.88
$\bar{x}$	0.76	0.77	0.71	0.59	0.53	0.52
t calculated	0.144		0.962		0.091	
t-critical values	$t_{0.05} = 2.36$ $t_{0.01} = 3.50$					

IV. Average values of homogeneity indexes of grazing stands ($\bar{x}$), found by different methods of randomizing at allocatoin of different squares on tested operational localities, supplemented by basic statistical characteristics

Statistic characteristics	Method of randomizing		
	random throws	diagonal	continuous
$\bar{x}$	0.761	0.709	0.525
S_x	0.549	0.591	0.210
V_x (%)	72.150	83.44	39.930
$S_{\bar{x}}$	0.194	0.209	0.074

evaluation of frequency of different species using the pair *t*-test ($t = 4.331^{**}$) that both these methods at identical number of replications give statistically different results. It is evident from further comparisons when different lower numbers of replications were tested that the standard method against compared method (9 x 0.33 m x 0.33 m) 1.63 to 2.31 times higher values of homogeneity index.

It followed from the study of mutual relationship between homogeneity of grazing stands, expressed by homogeneity index ($I_h - x$) and amount of left-overs, expressed by their percentage in the total yield (y – in %), that the most suitable form of explanation and prediction of this relationship is exponential function:

$$y = 22.154 \cdot e^{-0.070x} \quad (I_{yx} = -0.274^{*}) \qquad (3)$$

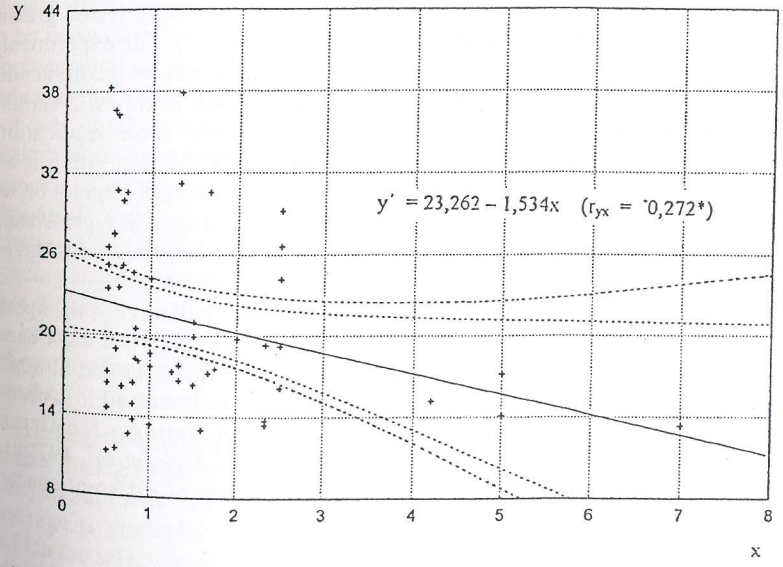
For illustration are presented the values calculated from the given relationship:

x	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0
y'	21.40	20.65	19.26	17.96	16.74	15.61	14.55	13.57

The studied dependence can be proximated using the linear model and that is possible only with slightly less exact results (Fig. 1):

$$y' = 23.262 - 1.534x \quad (r_{yx} = 0.272^{*}) \qquad (4)$$

Statistic significance of mutual relationship between homogeneity index and relative amount of left-overs is on the level $P_{0.05}$ fulfilled for the interval



1. Relationship between homogeneity of experimental grazing stands (expressed by homogeneity index ($I_h - x$) and relative amount of left-overs (percentage of left-overs from forage biomass – y) expressed by regression line supplemented with confidence zone for $P_{0.05}$ and $P_{0.01}$ (- - - -)

of homogeneity index ranging from 0.5 to 7. Outside this interval prediction is loaded by greater error.

It seems from investigations that homogeneity index can be used in pasture cenoses for prediction of selectivity of grazing whose consequence is the percentage of left-overs in the total biomass. Exception are only stands in which the rate of homogeneity is very low ($I_h > 0.5$) or extremely, very high ($I_h < 7$) and when evidently other factors are asserted by greater degree entering into interaction of mutual relationships between homogeneity of stands and selectivity of their grazing.

DISCUSSION

Up to now more extensive works, concentrated on the study of homogeneity of grasslands using the data on frequency of different species were focused altogether on the study of meadow communities (Gazda, 1977; Klimeš, 1983), when 12 replications were enough in insertion of square of the 0.30 m side into tested stands. The above number of replications allows very well to classify different species into frequency classes without reaching the results which are close to the limit of different frequency classes. While in meadow communities according to great majority of phytocenologic studies this number of replications is sufficient, in experimentally tested grazing stands such number seems to be insufficient (Tables I, II). For experimental study of grazing cenoses based if the results obtained it can be recommended repeatedly to insert square of 0.30 m side into the stands 30 times. 2 variants seem to be as suitable: (a) allocation of squares into three replications a 10 times or (b) allocation of squares à 15 times. At the same time it has been proved that the required number of replications does not depend on the stand type and that general regularities can be applied also for grasslands, which are formulated in rules on quantitative aspects of limiting the selection set (Klečka, Fabian, 1934; Rybáček et al., 1970).

It was showed from testing of different ways of randomizing on operational plots that the continuous method of randomizing gives the most exact results at finding of homogeneity of grazing stands. Regarding that at application of continuous method of allocation of squares in the stand it is necessary to define the distance interval (Iv) for conducting of different investigations, standard formula was specified (Rybáček et al., 1970) to form, directly utilizable for determination of frequency of different species on operational plots of pastures as follows:

$$Iv = \sqrt{\frac{Pl \,.\, 10\,000}{Pl \,.\, 12}} \qquad (5)$$

where: Pl – area of pasture with unified stand type in ha

Calculated value is then: $Iv = 28.867$ m $\doteq$ 29 m. However, it is necessary to emphasize that in the cases when more stand type are represented in certain locality, it is necessary to determine the type of frequency of different species separately for each stand type.

It seems from comparison newly at the study of grasslands asserting methods when for determination of the frequency square of 1 m side is used with division into 9 squares of the 0.30 m side with the standard method when square of the 0.30 m side is allocated (Gazda, 1977) that this new method gives fully different results. At determination the frequency greatly depends on the size of the used square and in addition, the method when 9 squares are always concentrated, fully does not correspond to required principles of randomizing (Rybáček et al., 1970).

Applied indicator on homogeneity of grasslands – homogeneity index (I_h) it is explicitly expressed form of homogeneity of stands which was in up to the present time described only implicitly and which was evaluated only generally on the basis of the total configuration of frequency diagrams (Braun-Blanquet, 1964; Slavíková, 1986; Gazda, 1977 etc.). However, if we want to study the quantitative relationships between homogeneity of stands and results of grazing off of the stands themselves, it seems to be necessary the introduction of explicit form of expression of the rate of homogeneity of grazing stands. Proved statistically significant correlations between the values of homogeneity index and relative amount of left-overs not only confirm the idea on necessity of grazing stands as a prerequisite of limitation of selective grazing (Voisin, 1960), but at the same time it is also a confirmation of suitability of evaluation of the rate of homogeneity of grasslands using the homogeneity index (I_h) and suitability of the use of square of the 0.30 m side to determine frequency of different species in grazing stands. From standpoint of testing of statistic hypotheses the finding that different values of homogeneity indexes show normal distribution seems to be significant. The decrease of percentage of left-overs in the total yield of pastures below 15% (in biometric concept on the level $P_{0.05}$) to range the level of homogeneity index between 5.5 and 7.

Testing of gradual increase of the number of squares inserted into the stands during finding the frequency of different species proved also validy of the general trend, valid also for other phytocenoses that however the selection average is gradually fluently close to the real value of the basic set from which the selection set was defined. This gradual approximation also explains similar tendency of gradual decrease of mean error of average of selection set (Rybáček et al., 1970; Slavíková, 1986; Dykyjová et al., 1989; Moravec et al., 1994 etc.).

It seems from comparison of homogeneity indexes and percentage of left-overs in different stand types that the stand type has no direct effect on any of these indicators. It is showed from the connecting investigations that as homogeneity of grazing stands, as percentage of left-overs are further affected particularly by microrelief of the site and preciseness of pratotechnics (uniformity of fertilization, regular cuts of left-overs, distribution of excrements, suitable way of pasture technics etc.). It is showed from indicated knowledge that it will be necessary to deepen the knowledge on structural parameters of grazing stands. The first phase of application of more detail phytocenologic analyses of grazing stands can be expected particularly in the field of experimental pratotechnics.

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Metodologické otázky posuzování homogenity pastevních porostů.

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V intencích české klasické lukařské školy (Klečka, Fabian, 1934), požadující přizpůsobit fytocenologické analytické metody účelům, pro které jsou určeny, byly v letech 1997 až 1999 na experimentálních plochách různých druhových kombinací pastevních porostů a dále na provozních plochách pastevního areálu v podhorské oblasti Šumavy (Kaplice, 680 m n. m.) studovány metodologické otázky exaktního stanovení homogenity pastevních porostů. Byly ověřovány tři okruhy hypotéz, vztahující se k: (1) volbě potřebného počtu opakování při stanovení frekvence jednotlivých druhů, (2) volbě vhodného způsobu znáhodnění pro stanovení frekvence jednotlivých druhů na provozních plochách a (3) významu vlastního zjištění homogenity pastevních porostů jakožto ukazatele vhodného pro predikci selektivity spásání, jejímž důsledkem je množství nedopasků. Pro stanovení frekvence byl použit čtverec o straně 0,30 m. S uplatněním metod induktivní statistiky byla stanovena pro experimentální práce vhodnost volby 30násobného vkládání čtverce do porostu (tab. I a II). Na provozních plochách pastvin bylo na základě testování statistických hypotéz (tab. III a IV) zjištěno, že u porostů o výměře do 1 ha je účelné opakovat vkládání čtverce do porostu 12krát, přičemž jako nejvhodnější metoda znáhodnění se ukazuje průběžná metoda. Pokud se na lokalitě vyskytuje více porostových typů, je třeba analyzovat každý porostový typ zvlášť.

Byla navržena explicitní forma hodnocení homogenity travních porostů pomocí indexu homogenity (I_h):

$$I_H = \frac{n_{IV,\,V}}{n_{I,\,II}} \qquad (1)$$

where: $n_{IV,\,V}$ – celkový počet druhů zastoupených ve vyšších frekvenčních třídách, tj. ve IV. a V. frekvenční třídě

$n_{I,\,II}$ – celkový počet druhů zastoupených v nižších frekvenčních třídách, tj. v I. a II. frekvenční třídě

V oboru hodnot indexu homogenity $0{,}5 < I_h < 7$ byl prokázán statisticky významný postupný pokles množství nedopasků se vzrůstem hodnoty I_h ($r_{yx} = -0{,}272^{*}$). Podíl nedopasků na celkovém výnosu klesl pod 15 % (ve statistickém pojetí) při hodnotách $I_h > 5{,}5$ (obr. 1). Zároveň byla potvrzena účelnost explanace homogenity travních porostů pomocí hodnoty I_h i vhodnost použití čtverce o straně 0,30 m ke stanovení frekvence jednotlivých druhů. Nelze doporučit měnit velikost těchto čtverců a rovněž není vhodné sdružovat více čtverců těsně k sobě, jak se v poslední době začíná mnohdy prosazovat (9 x 0,33 m x 0,33 m).

pastevní porosty; druhová frekvence; homogenita porostů; selektivita spásání; nedopasky; analýza porostů

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