Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 Spl Issue III 2014: 69-74

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

Full Length Article

Comparing efficiency of Whittaker and Stoglern design for measuring species richness

Fateme Noori[1]*, Bahram Gholinejad[2] and Hamed Jonaidi[2]
[1] – Department of Rangel and Management, University of Natural Resources of Kurdestan
[2] - Scientific Membership University of Natural Resources of Kurdestan
Tel: 09355433729 Email: bahramgholinejad@yahoo.com

ABSTRACT
One way to evaluate the status of ecosystems is the assessment of species richness. In this regard, the use of appropriate methods to measure species richness is very important. The purpose of this study is to compare the two methods of Whitaker and modified Whitaker for species richness measurements in Ariz, Sanandaj, Iran. This study was conducted with three replications in grassland vegetation type. In the beginning, site was parceled for the methods under comparison by means of woody nails and rope. This was then proceeded to count the species in the plots. Statistical method used for analyzing data was factorial randomized complete block design applied via spss software version 17 the results showed that Stolgern compared with Whitaker results in less variance. Regression model to determine the species richness of Stolgern plan showed higher level of R^2 compared with Whitaker's. Data Analysis of this study showed that sub-plots of the two experimental designs are significantly different when it comes to showing the number of plant species based on biological spectrum.
Keywords: species richness, Whitaker design, Stolgern design, Ariz Sanandaj

Received 12.04.2014 Revised 11.05.2014 Accepted 19.06. 2014

INTRODUCTION

Rangeland is a natural ecosystem that includes high sources of genetic reservoirs and diversity of plant species and allocated large portion of biodiversity. On the other hand, biodiversity in rangeland ecosystems are affected by vegetative properties and diversity of plant species directly that always guarantee the sustainability of this ecosystem against environmental and biological variables (Harrison et al, 2004). Sampling with quadrats (plots of a standard size) can be used for most plant communities (Cox, 1990). In vegetation cover studies, selecting the appropriate shape and level of plot is very effective in performance of sampling and causes to minimize variance and time of sampling. Moreover, understanding, knowledge and experience of the researcher from studied vegetation cover properties is very important to achieve the appropriate shape and level of plot [1]. The selection of an appropriate sampling technique depends upon the type of data needed, the size of the sampling site and the number of available workers. [2] Were used from plot to measurement of vegetation cover properties in the beginning. They used 5m2 plots for counting plant species in Nebraska region and their results showed that plot dimension is important factor in estimating quantitative parameters of vegetation covers. [5] Showed rectangular plot has a lower variance than square plot in measurement of vegetation cover. [7] Reported plot should be two times larger than most common moderate canopy in a region. Circular and square quadrates have a low accuracy in comparison to narrow and elongate quadrat because they show lower heterogeneity along the environmental gradients [9]. Presented plan by Whittaker for estimating plant species has problems. Major problems in main plot of Whittaker are including: shape and placement of sub-plots that more located in center of plot 100m2, proximity to each other in square sub-plots 1m2 and the other hand, overlapping sub-plots 1, 10 and 100 m2 together causes high inter-correlations between the measured data and then had in impact on the results and causes the deviation of the results. Therefore [10] revised main plan of plot and solved existing problems by testing and revising the original plan of Whittaker plot. They used modified Whittaker frame in two selected regions (Colorado and Dakota) in order to determination of species richness and their results showed modified Whittaker frame

has a best estimating of vegetation cover and analyzing diversity patterns. [10] Used four methods for estimation of species diversity and richness in four states of America and in four plant types including: Parker transect, Daubenmeyer transcect (revised by America forestry service), new transcect with high quadrat (suggestion by America agricultural service) and revised plots of Whittaker. The results showed that in Parker, Daubenmeyer transcect and transcect with high quadrat methods only achieved total numbers of species and species richness. [11] studied the effect of plot shape on species diversity by comparing three sampling plan: main frame of Whittaker, revised frame of Whittaker and Killy Whittaker in three sites in forest ecoton, cattle grazing grassland and not grazed grasslands of savanna. Their results showed that not existed any significant difference between square and rectangular plots and in total cases, rectangular plots not showed species richness more than square plots. [4] Stated optimum sizes of plot for measurement of the standing crops are $1m^2$ and $1.5m^2$ in steppe and highland steppe of Iran. Also optimum sizes for semi-steppe of Iran achieved 0.5 m^2 and 1 m^2. [3] Reported revised Whittaker plot showed species richness more accuracy than main plot of Whittaker significantly. [6] in studying the compare of plot size in estimating the quantitative characteristics of species in enclosure and non enclosure rangelands of Calpush plain stated vegetation type, plants distribution and measuring variable type have high effect on plot size and shape, according as optimum plot size is different for estimating the quantitative characteristics of species in two enclosure and non enclosure area and emphasized Daubenmeyer plot and plot $1m^2$ are suitable for estimating canopy cover in enclosure and non enclosure respectively. Studied region is one of the most important rangeland in Iran and this area should be protected with special attention. The aim of this study is comparing two Whittaker and Stolgern plan in determining species richness with emphasis on changing distribution and shape of the plots.

MATERIAL AND METHODS

Site description

Studied region is located in old road of Sanandaj to Marivan city. Studied area is about 1300 ha and reaches to west of Sanandaj city (27 km from Sanandaj). Height from sea surface in this region is 1320m. Average annual rainfall and temperature are 600mm and 10°c respectively. Region climate is ultracold semi-humid by Ambrege method [8]

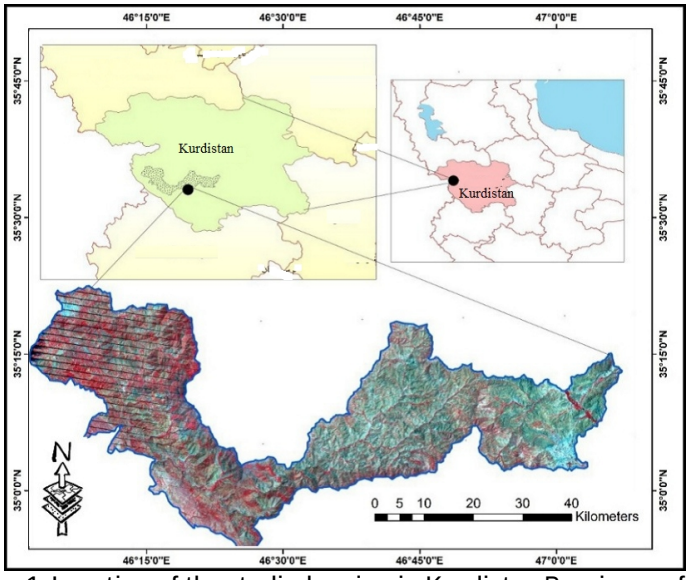


Figure1. Location of the studied region in Kurdistan Provinces of Iran

Research methodology

Field measurement was done within plots by field visits and surveys in studied region. Vegetation cover sampling was done by systematic-random method. This research was performed in three replication for plant type *Bromus tomentellus - Prangus ferulacea*.

Each of the designs was conducted in the study area by ropes and wooden sticks. For implementation of these plans, initially based on Whittaker and Stolgern method, was established plot 20*50 and then created sub-plots (Figure 2). It is remarkable that main plot (50*20) in each replication was shared for two plan and sub-plots established within the main plot in both plans separately. The size and number of sub-plots in each design are summarized in table 1.

Table1. Number and area of plot in both Stolgern and Whittaker plans

Number of plots	Stolgern	Whittaker
10	———	0.2*0.5
10	0.5*2	1*1
2	2*5	2*5
2	5*20	10*10
1	20*50	20*50

Distribution patterns and placement of sub-plots in both Stolgern and Whittaker methods are specified in figure 2.

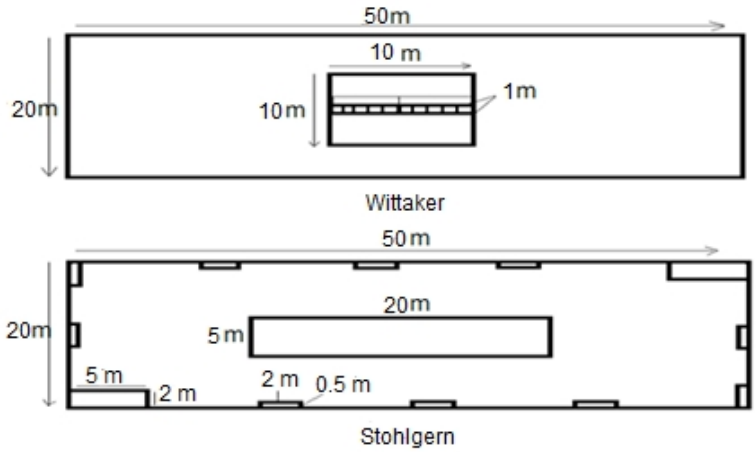


Figure2. Distribution and dimension of plots in both Stolgern and Whittaker plans.

For collecting data in Whittaker plot, were counted number of species in sub-plot 0.1m^2 and were recorded in field forms and then surveyed the number of existing plant in plot 1m^2 that not existed in plot 0.1 m^2 and thereafter searched new plants in quadrat 10m^2. In the next step, was evaluated plot 100m^2 and recorded new existing plants and entered into field form. For sampling in Stolgern method, recorded data similar to Whittaker method. After field sampling, data were extracted and analyzed. To determine the interaction between two factors (distribution and shape) of sub-plots in both Whittaker and Stolgern was used factorial test based on completely randomized designs and was used T-Test for comparing two Stolgern and Whittaker plans.

RESULTS

Data analysis showed that the average number of species in the Whitaker and Solgern designs were significantly different so that in the sub-plots of 1 and 10 square meters there was a significant difference at the 0.01 level and in the plot of 100 square meters it was significantly different at the 0.05 level. The mean comparison of the species richness in both designs of Whitaker and Astolgern at the levels of 1, 10 and 100 m^2 is shown in Figure 3.

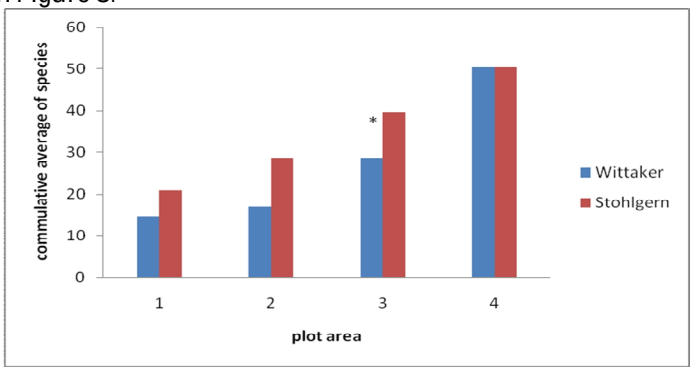


Figure 3 mean compares of the cumulative average of species richness at different levels in Stolgern and Whitaker designs (** Indicates significance at the 0.01 and * indicates significance at the 0.05 and ns stands for non-significant differences)

As Figure 3 shows, in all of the sub-plots of Stolgern frame compared with that of the Whitaker's, species richness was better shown.

Table 2 ANOVA analysis of two factors of distribution (factor A) and plot area (factor B) on the species richness value

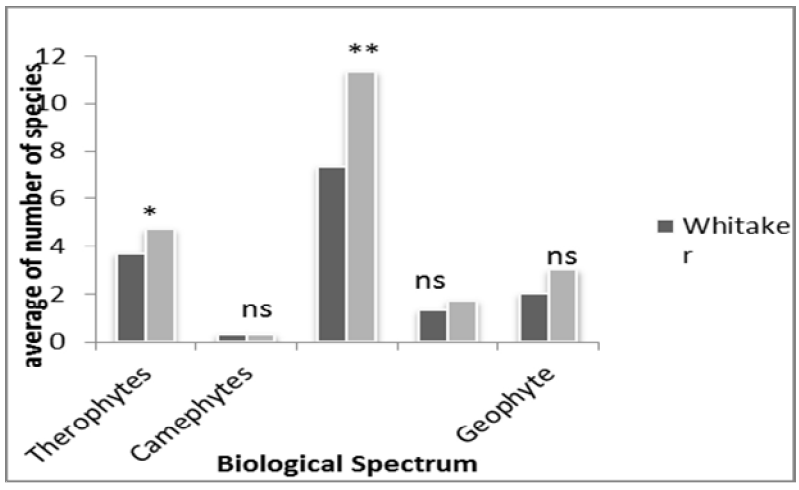
Level of significance	F-test	Mean of squares	df	Sum of squares	Source of variation
0.000	82.485**	450.000	1	450.000	Factor A
0.000	73.208**	399.389	2	798.778	Factor B
0.270	1.497ns	8.167	2	16.333	A*B
		5.456	10	54.556	Experimental error
			18	12724.000	total

Data analysis provided in Table 2 shows that two factors of shape and distribution only have direct effects on the species richness but mutual interactions was not significant.

Table 3 regression model of species richness in the plots of 1, 10 and 100 square meters in the two designs of Stolgern and Whitaker

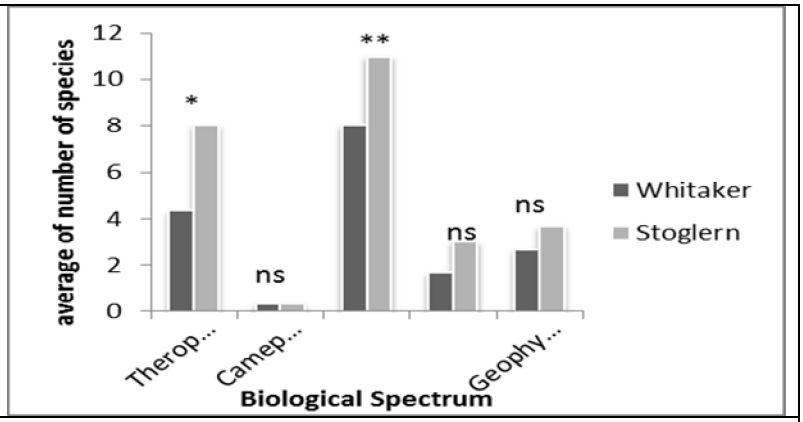
Type of design	Regression model	R^2	Estimated species richness at 1000 m^2 plot	Observed species richness at 1000 m^2 plot	Subtraction of estimated by observed species richness at 1000 m^2 plot
Wittaker	S=13.1 + 7 LogX	0.87	34.01	50.33	16.32
Stohlgern	S=20.44+9.33 LogX	0.98	48.43	50.33	1.9

From the results in Table 3 it can be noted that the regression model of Stolgern plan better estimate species richness than that of Whitaker's. As is clear from Table 3, in the Stolgern design determination coefficient (R^2) is greater. Results of analyzing biological spectrum of species in the plots of Whitaker and Stolgern showed that the sub-plots in expressing biological spectrum are not alike. The results of this study are shown in Figure 4 for all sub-plots.

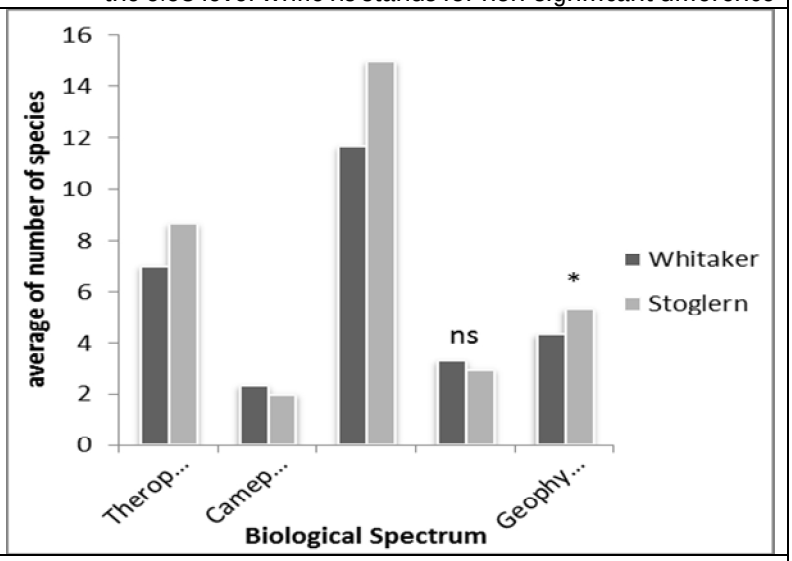


A: mean comparison of number of species based on biological spectrum at 1 m^2 sub-plot

** Indicates significance at the 0.01 level and * denotes significance at the 0.05 level while ns stands for non-significant difference



B : mean comparison of number of species based on biological spectrum at 10 m^2 sub-plot
** Indicates significance at the 0.01 level and * denotes significance at the 0.05 level while ns stands for non-significant difference



C : mean comparison of number of species based on biological spectrum at 100 m^2 sub-plot
** Indicates significance at the 0.01 level and * denotes significance at the 0.05 level while ns stands for non-significant difference

Figure 4 mean comparison of number of species based on biological spectrum in both designs of and Whitaker and Stolgern

As shown in Figure 4, all sub-plots are significantly different in showing some of the biological spectrums.

DISCUSSION AND CONCLUSIONS

In understanding and managing rangelands, getting to know species richness is of great importance. Therefore, the accuracy of measurement and estimation methods of species richness of grassland ecosystems is inevitable. The Whitaker's main frame is one of the ways to measure species richness. Studies carried out by some researchers are indicative of the drawbacks of Whitaker's method such as overlapping sub-plots. In this regard, Stolgern attempted to troubleshoot the Whitaker's plot limitations by proposing a modified version of the previous plot. [2] Shows the modified frame of Whitaker's compared with the main frame yields higher values for species richness which corresponds to the findings of this study. The reason behind Stolgern's project (modified Whitaker frame) can be expressed as the shape of the plot. As indicated in Figure 2, Whitaker's sub-plots are designed square-shaped while those of Stolgern's are rectangle in design. In fact, one of the major factors changed in modified Whittaker design by Stolgern is the shape of the plot.

In this regard and according to the results of Table 2 it can be acknowledged that the rectangular compared with the square plots express species richness more effectively which is affirmative of the results of [4,7] Rectangular plot, having greater length than the square plots of the same area, can show

greater environmental changes. It makes a rectangular plot measuring less variance in vegetation measurement than the square and circular plots and showing greater species richness.

According to Figure 2, another factor altered from the Whitaker's original design by Stolgern is distribution of plots being less scrutinized in researches. In Whitaker's main design, plot distribution is centralized with overlapping sub-plots being the cause of their internal correlation. By eliminating overlapping sub-plots and changing their distribution, Stolgern was able to promote Whitaker's design to show species richness more accurately.

Results provided in Table 2 show that distribution factor is an influential one in Stolgern's design in determining species richness; being sporadically referred to in the previous studies. Thus, plot placement and distribution are the two factors influencing overall species richness, being also reported by [8] as a proof for this claim. Results of table 2 are indicative of significance of the mutual interactions between the shape and distribution of plots.

It comes from the results in Table 3, the regression model of Stolgern plan provide better results than plan of Whitaker's and shows less variance. Based on Figure 4 graphs, sub-plots in showing the number of plant species based on biological spectrum act significantly different which with respect to the role of plots distribution and shape in determining species richness, it seems quite reasonable. Dwelling on the findings of this study and given the importance of determination of species richness, Stolgern plan is suggested to carry out the same researches.

REFERENCES

1. Akhavan, R. Zobairi , M., ZahediAmiri, Gh., Namiranian, M. and Mandallaz, D, 2006. Spatial structure and estimation of forest growing stock using geostatistical approach in the Caspian region of Iran, Iranian Journal of Natural Resources, 59 (1): 89-102 (In Persian).
2. Carroll, S. S. and D. L. Pearson, 2000. Detecting and modeling spatial and temporal dependence in conservation biology. Journal of Conservation Biology 14: 1893–1897.
3. Conan, G. Y., F. Maynou and F. Sarda, 1992. Direct assessment of the harvestable biomass from a stock of *Nephropsnorvegicus*, seasonal and spatial variations. ICES Conference Meetings K:22.
4. Jost, A., 1993. Geostatistisch eanalyse des Stich proben fehlers systematischer Stichproben, Ph.D. thesis, University of Freiburg in Berisgau, 90pp.
5. Goovaerts, P., 1997. Geostatistics for Natural Resources Evaluation. Oxford University Press, New York.
6. Gunnarsson, F., S. Holm, P. Holmgren and T. Thuresson. 1998. on the potential of kriging for forest management planning. Scan. Journal of Forest Research.13:237-245.
7. Maravelias, C. D., D. G. Reid, E. J. Simmonds and J. Haralabous, 1996. Spatial analysis and mapping of acoustic survey data in the presence of high local variability: geostatistical application to North Sea herring (Clupeaharengus). Canadian Journal of Fisheries and Aquatic Sciences. 53: 1497–1505.
8. Moghadam, M.R, 2001. Descriptive and statically ecology of vegetation, University of Tehran, 285p.
9. Rossi, R. E., D. J. Mulla, A. G. Journel and E. H. Franz, 1992. Geostatistical tools for modeling and interpreting ecological data spatial dependence. *Ecological Monographs*. 62: 277–314.
10. Sokal, R. R. and N. L. Oden, 1978. Spatial autocorrelations in biology. 1. Methodology. Biological Journal of Linnean Society. 10: 199–228.
11. Zimmrman, D. L. and M. B. Zimmrman, 1991. A comparison of spatial semivariogram estimators and corresponding ordinary kriging predictors. – Technimetrics. 33: 77–92.
12. Cox, G. Laboratory manual. Of general ecology 6th Ed. Dubuque, Iowa: WIlliam C. Brown; 1990.