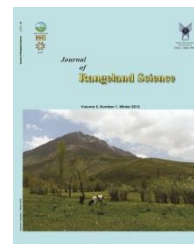


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**Research and Full Length Article:**

## **The Study of Diversity Indices of Plants Species Using SHE Method (Case Study: Javaherdeh Rangelands, Ramsar, Iran)**

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Received on: 26/01/2014

Accepted on: 01/12/2014

**Abstract.** Recent attitude of vegetation assessors is using of new ecologic approaches to evaluate and analyse the complex rangeland ecosystems. Plant diversity is the most important indices to assess the ecological changes of rangelands. In order to survey of plant indices of rangelands, two exclosure areas (long-term and mid-term) and a grazing area in rangelands of Javaherdeh (Ramsar, Iran) were selected. Quadrates size and number were respectively obtained by minimal area and statistical formula methods. The diversity, richness, and evenness indices in each quadrates were calculated. For comparing of these indices, one way ANOVA and Duncan test method were used. Results showed that the higher values of diversity and richness indices were obtained in the long term exclosure and the lower values of evenness index were obtained in the grazed area. The SHE analysis clarifies that the highest species richness and diversity was obtained in lower plots number in the long-term exclosure areas and reversely it needs more plots for assessment of grazed area. Along with time elapsing, the long-term exclosure and grazing area had higher and lower evenness, respectively. The mid-term exclosure, however, needs also long time to reach the maximum species richness and diversity. Hence, in order to achieve the ecologic management of the rangeland ecosystems, knowing of bio-indicators and their components analysis (SHE) can draw future trend of the ecosystem and bring out data to program it.

**Key words:** Bio indicator, Diversity, Richness, Evenness, SHE, Javaherdeh rangelands

## Introduction

Biodiversity conservation, as one of the most important goal in ecosystem management (Mesdaghi, 2000; Yuguang *et al.*, 2001), has a high role to evaluate the natural environment (Coeli and Coddington, 1994). Hence, using of bio indicators, which reveal diversity and variation of species, composition of organism, and ecologic system, is necessary to studying bio-ecosystems (Stirling and Wilsey, 2001). Knowing of interaction relationships between ecosystem components and precise cognition of quality and quantity properties of its plants are important clause of ecological changes of rangelands and stabilize the accurate managerial approaches to conserving of rangelands health (NRC, 1994). Regarding to the rangelands ecosystem, plant diversity is used as an important indicator to determine the application and function of these ecosystems (Mason *et al.*, 2005; Reshi *et al.*, 2009). It is pointed out that the plant diversity is also known as constancy index (Hector *et al.*, 1999), rangeland ecosystems' health as an indicator to show the effects of environmental factors on rangelands that demonstrates ecological perspective of a given area (Lexer *et al.*, 2000). As always, studying of the plant diversity has been along with challenge (Erich and Ollik, 2005) that introducing of different methods of evaluation has been endeavoured at investigation of biodiversity and ecological studies of communities (Horton and Murray, 2006). Since the plant diversity is formed by two different components (Hawksworth, 1995; Buzas and Hayek, 1998) such as species richness (S), which is the number of stock species in the sampling units (Brewer, 1994; Mesdaghi, 2005), and evenness (E), which refers to distribution of species individuals in a given environment (Gosselin, 2006), it can combine two components (Richness and Evenness) into each other and then assess the sharing amount of each composition. This conjunction is known as SHE approach

(Magurran, 1988) which is a simple way based upon the diversity index of Shannon (H) and is formed by Information Theory (Mana, 2005). The SHE index can provide to distinguish the spatial and temporal changes of plant species (Horton and Murray, 2006). Regarding this, Wilson *et al.* (2008) had calculated the diversity index and SHE analysis of species in three marsh regions of Carolina (USA) and their results showed that investigated zones were formed by several sub-regions which did not differentiable by cluster analysis. In fact, the recognition of the mathematical relation between Species Richness and Taxa Abundance, and its meaning in terms of Diversity and Dominance is the basis of the recent SHE approach to the study of biodiversity (Hayek and Buzas, 1998).

Numeric and nonnumeric indices can be used to determine the plant diversity (Baghani, 2007). For instance, Reshi *et al.* (2009) used nonnumeric approaches to estimate the diversity in grassland communities of Kashmir in Himalaya and their results revealed that diversity of grasses in subalpine grassland was less than alpine grassland. Also Burnham and Orton (1978), Chao (1987), Lee and Chao (1994), Coeli and Coddington (1994), Brose *et al.* (2003), and Shein *et al.* (2003) applied the non numeric approaches to determine the diversity. However, Connolly *et al.* (2009) used parametric approaches of the diversity to determine the species diversity of corals in India and pacific oceans by means of different models of frequency-species that the best results obtained from normal distribution of bivariate model (Log normal). Hector *et al.* (1999) and Horton and Murray, (2006) also used the parametric procedure to obtain the diversity. In most cases, biological disturbances such as grazing of animal (West, 1993; Gabriel and Andress, 1998; Sabetpour *et al.*, 2002) and human activities (Zamora *et al.*, 2007) and abiotic disturbances including fire and different pollutants (Barker *et al.*,

2004) were caused to disequilibrate the species richness and diversity in a given area (Coeli and Coddington, 1994).

From past till now in the study area, grazers are the most biotic disturbing factors to plants species (Jouri, 1999). However Sabetpour *et al.*, (2002) and Jouri *et al.*, (2008) had endeavoured to introduce the species diversity assessment as an important components to stability of rangeland ecosystem in upland ranges in northern Alborz Mt., but it seems that numeric and nonnumeric approaches could not able to justify the reality of species diversity's circumstances. Hence, the current study attempts to find out the real interpretation of bio-diversity of the upland rangeland of Javaherdeh by way of SHE analysis.

## Materials and Methods

### Sites traits

In order to study the biodiversity interpretation, three sites, include long term exclosure (32-years), mid-term exclosure (nine-years), and grazed areas in upland rangeland of Javaherdeh (Ramsar, Iran) were selected. The long and mid-term exclosure, and grazed areas are respectively located in 1650-1950, 1950-2100, and 2000-2500 m above the sea level with same edge and along each other. The Javaherdeh rangelands are located in 36°54' N and 50°40' E geographical position in northern Alborz Mt. where has cool-semi humid climate in lowland (first altitudinal level) and subalpine climate in upland with annual average rainfall of 640 mm (Jouri, 2010).

### Research methods

The sampling was done using transect-plot method (Mesdaghi, 2005) and the sample number was also obtained by below formula (Equation 1):

$$N = \frac{t^2 \times S^2}{P^2 \times \bar{X}^2} \text{ (Equation 1)}$$

Shannon index, Evenness (SHE) using Duncan test in SPSS v.22 software.

Where, S is the variance, N is the number of sample, t is the amount of t-student ( $P < 0.10$ ),  $\bar{X}$  is the mean of initial samples, P is the range of error limitation which is generally  $\pm 0.5$  (Mesdaghi, 2000; Krebs, 1998). Determination of rangeland condition was calculated by six-factor method (Daubenmire, 1959, 1968; Sher *et al.*, 2010).

Bio-indicators indices were calculated as follows (Magurran, 1988).

1) Shannon-Wiener Diversity

$$H' = -\sum_{i=1}^s P_i \ln P_i \text{ (Equation 2)}$$

Where,  $H'$ : is the Shannon index as calculated with natural logarithms,  $p_i$ : the proportion of individuals found in the  $i$ -th species, which is stated on the basis of ratio of total species;  $\ln$ : natural logarithm au fond 2;  $n$ : the number of species in the sample.

2) Margalef Richness

$$R_1 = \frac{S-1}{\ln N} \text{ (Equation 3)}$$

Where,  $R_1$ : the richness index,  $S$ : number of species;  $N$ : number of individuals;  $\ln$ : logarithm au fond 2.

3) Sheldon Evenness

$$E = \frac{e^H}{S} \text{ (Equation 4)}$$

Where,  $E$ : the evenness index,  $H$ : the diversity index,  $S$ : the species richness,  $e$ : natural logarithm, so that Shannon-Wiener index is sensitive to rare species and its limitation is swinging between 0 to 4.5 (Krebs, 1998). According to definition, the range of  $E$  is between zero to one ( $0 < E < 1$ ) and hence  $\ln(E)$  will always be negative rate.

### Data analysis

Calculating of bio-indicator was done by PSAT v.2.03 software. Comparing of different elements of sites was also completed by one way ANOVA and means comparisons were made Species Richness,

In order to evaluate the diversity index to its formed components, SHE1 analysis was employed by formula  $H = \ln(S) + \ln(E)$ , (Buzas and Hayke, 2005).

### Results

Investigation of rangeland condition showed that the long term enclosure had the most scores (77.87) as good condition and grazing land had the least score (41.89) as poor condition, as well (Table 1).

**Table 1.** The rangeland condition on the basis of six-factor method in three sites

Site Name	Vegetation Type	Altitude (m)	Condition Score	Rangeland Condition
long term enclosure	<i>Bromus tomentellus</i> Boiss.	1690	77.87	Good
	<i>Dactylis glomerata</i> L. <i>Stachys byzanthina</i> C. Koch. <i>poa pratensis</i> L.			
Mid-term enclosure	<i>Bromus tomentosus</i> Trin <i>Stachys byzanthina</i> C. Koch.	2000	56.32	Fair
	<i>poa pratensis</i> L.			
Grazed area	<i>poa pratensis</i> L. <i>Stachys byzanthina</i> C. Koch.	2500	41.89	Poor

Analysis results of variance in each indices showed a significant difference ( $P < 0.01$ ). So that the long term enclosure and grazed area had the highest and the lowest rates of the diversity indices, respectively. The same arrangement was observed for evenness index (Table 2). The richness of species, were the highest and the lowest in grazing area and long term enclosure (Table 2).

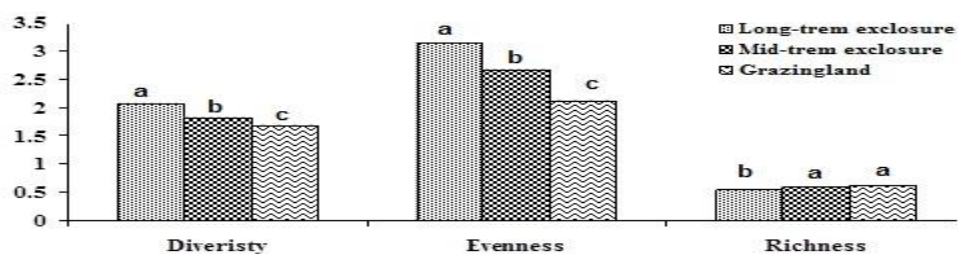
The results of Duncan test showed that three sites had differences on the basis of the diversity and richness indices, but based upon the evenness index, the mid-term enclosure and grazingland were placed in the same group and the long-term enclosure was different group (Fig. 1).

**Table 2.** ANOVA results of comparing of three sites regarding to bio-indicators indices

Site Name	Diversity	Evenness	Richness
Long-term enclosure	2.06 a	3.13 a	0.54 b
Mid-term enclosure	1.81 b	2.67 b	0.59 a
Grazing area	1.64 c	2.12 c	0.62 a
F statistic	22.74**	6.62**	28.24**

\*\* Significant on probable level of 1%

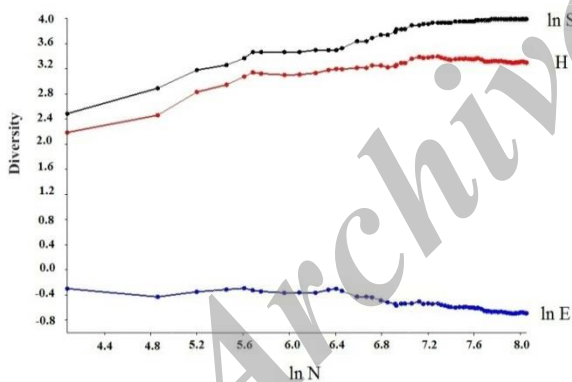
Means followed by the different letters in each column are significantly different ( $P < 0.05$ )



**Fig. 1.** Comparing of bio indicators in three sites

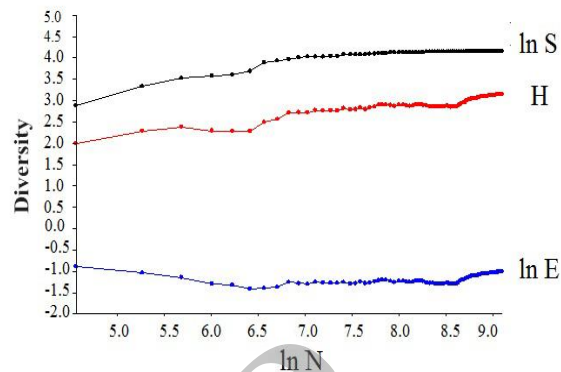
Means followed by the different letters in each bio indicators indices are significantly different ( $P < 0.05$ )

The SHE analysis of three sites showed that in the long-term enclosure, the two diversity indices including the richness (S) and Shannon index (H) had the same increasingly trend lines gradient while the evenness index (E) line was reversely downward line gradient (Fig. 2). This figure precisely showed that with increasing of the sample number, the richness and diversity will raise to maximum rate (about to 4) and if it happened, the evenness of species will descend into less, as well. Reaching to maximum diversity will swiftly happen in this site because of line head which started from 5 (the number of log sample number) and finished to 6.4 Ln (N). On the other hand, there is a limitation to increase the diversity and it cannot arise along the time because of resources restriction and it will pull in the maximum level and then will constantly continue the line.



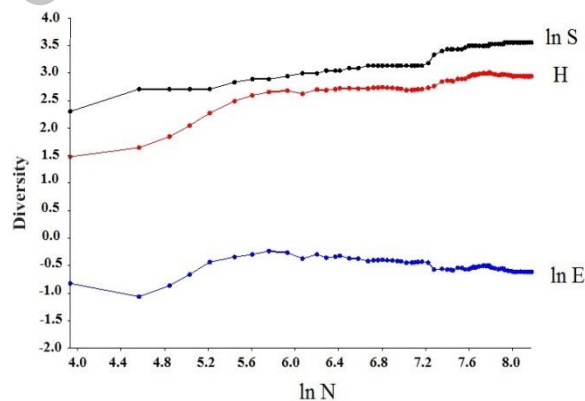
**Fig. 2.** The SHE analysis of lang-term enclosure site

In the second site, mid-term enclosure area, the richness and Shannon indices had also the same behaviour close to long term enclosure. However, head of both lines start from 4.4 Ln (N) and finish in the 5.6 which demonstrates that the range of both indices were less than first site (Long term enclosure area) (Fig. 3). The evenness line, however, had decreasingly gradient from 0 to 4.9 and after quietly increasing from 5 to 5.6 till maximum to 6.4, it silently decline to



**Fig. 3.** The SHE analysis of mid-term enclosure site

The minimum richness and diversity indices are observed in the third site (grazing land area) where had same increasingly line gradient as before sites, but it has less range from 4.5 to 6 Ln (N). The evenness line has too non-unique behaviour from 4 to 5.5 so that the less will happen in the 4.5 point (Fig. 4).



the end.

**Fig. 4.** The SHE analysis in grazingland area

### Discussion and Conclusion

The long-term enclosure had the highest rate of species diversity among two other sites according to differentiation of the means of Shannon-Wiener in three sites by Duncan test. This site was closed about 33 years and now it is passing the successional stage to better rangeland condition.

Lack of grazers and sometimes harvesting of forages by ranchers in full

growing time of herbaceous provide a good situation to species to have a good vigour. Hence, it has the highest species diversity and richness than the other sites. This finding is similar to other researchers' reports such as Reshi *et al.* (2009), Coeli and Coddington (1994), Brose *et al.* (2003), Chao (1987), Lee and Chao (1994), Shein *et al.* (2003), Burnham and Orton (1978), Yuguang *et al.* (2001), West (1993), and Gabriel and Andress (1998) had also pointed out that the grazing lands had the least plant richness and diversity than the other sites. Zao *et al.* (2007) had also revealed that because of overgrazing in the poor grasslands, regeneration and reproduction of plant species had decreased and only bush and unpalatable species increased, and consequently, plants diversity declined. Regarding to balancing activities of human such as equilibrant animal husbandry, species diversity and richness will also be increased in the rangeland ecosystems (Zamora *et al.*, 2007; Barker *et al.*, 2004). The SHE analysis of the long and mid-term exclosures and grazed area (Figs. 2, 3, and 4) showed that curve gradient of the diversity index (H) increased in all sites and then took less slope and after increasing of plot numbers, it became a constant form. However, these curves showed another reality which is along with increasing of the number of plots, the species diversity and richness will be reached to the highest (>4) in the long-term exclosure area. The evenness of this site, however, will be increased, as well. It is because of longevity of the exclosure which can provide a circumstance that plants arise to climax or subclimax positions and these stages will have less diversity and richness and more evenness of species. The mid-term exclosure, on the other hand, had approximately same condition as the long one. However, it needs more number of plots and will get less species diversity and richness, too. Moreover, its evenness

index also had the least level than the others. It seems that this site is recently freed from grazers and requires to more time to rich itself. The grazing area had the least species diversity and richness (1.5-3.2) along with increasing of the number of plots. Its evenness curve, however, is the most from less number of plots and it will decrease when the number of plots increased. As many researchers emphasised, grazers in poor condition of rangelands incline the species diversity and richness and increase the number of some individual species, as are known unpalatable species, and hence, increase the evenness index. The grazing area has this situation now and if the time lapses, and grazers also reduce, then the evenness will decrease to minimum (-0.2). These results are close to other researchers' claims such as Baghani *et al.* (2009), Horton and Murray (2006), and Wilson *et al.* (2008). Time lapsing coincides to increase the number of plots and both of them show that with less number of sampling, interpretation of species bio-indicators could misinform the reality of ecosystem trend. The SHE analysis, however, can clarify the meticulous interpretation of biological indicators in these cases. Therefore, the bio-indicators and the SHE analysis show us obvious vision of rangeland ecosystem and their ecologic reality. Moreover, through interpretation of the SHE analysis, the manager can find out that over-exclosure of rangeland is not fair. In addition, overgrazing is also not fair to the ecosystem because longevity of exclosure can provide the highest evenness because overgrazing can also give us less richness and species diversity. Hence, in order to achieve the ecologic management of the rangeland ecosystems, knowing of bio-indicators and their components analysis (SHE) can draw future trend of the ecosystem and bring out data to program it.

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## مطالعه شاخص‌های تنوع گونه‌های گیاهی با استفاده از آنالیز SHE (مطالعه موردی: مراتع جواهرده رامسر، ایران)

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چکیده. رویکرد اخیر ارزیابان پوشش گیاهی استفاده از شیوه‌های نوین اکولوژیک در تجزیه و تحلیل اکوسیستم‌های پیچیده مرتع است. از جمله شاخص‌هایی که در ارزیابی تغییرات وضعیت اکولوژیک مراتع مد نظر است، تنوع گونه‌های گیاهی است. به منظور بررسی شاخص تنوع گونه‌های گیاهی در مراتع، دو محدوده قرق شده (بلند مدت و میان مدت) و یک محدوده چرا شده در مراتع جواهرده رامسر انتخاب شدند. با استفاده از روش حداقل سطح و فرمول آماری، اندازه سطح پلات و تعداد آن به ترتیب بدست آمد. شاخص‌های تنوع، غنای، چیرگی و یکنواختی برای هر پلات تعیین شد. جهت مقایسه این شاخص‌ها، از روش آنالیز واریانس یک طرفه و آزمون دانکن استفاده شد. نتایج نشان داد که شاخص تنوع و غنا در منطقه قرق بلند مدت و شاخص یکنواختی در منطقه چرای بیشترین مقدار را دارا می‌باشند. بطوریکه آنالیز SHE مشخص کرد که برای رسیدن به بیشترین تنوع و غنای گونه‌ای در قرق بلندمدت افزایش آنچنایی در تعداد نمونه (پلات) ضرورت ندارد و برعکس در منطقه چرای این افزایش نیاز است. همچنین با گذر زمان، قرق بلند مدت به سمت یکنواختی بیشتر پیش خواهد رفت در حالیکه منطقه چرای به سمت کاهش یکنواختی و قرق میان مدت نیاز به زمان بیشتری جهت رسیدن به حداکثر غنا و تنوع گونه‌ای خواهد داشت. بنابراین برای رسیدن به مدیریت اکولوژیک مراتع، آگاهی از شاخص‌های زیستی و اجزاء تشکیل دهنده آن (SHE) تصویر واضحی از گرایش اکوسیستم و برنامه ریزی آتی آنرا به دست می‌دهد.

کلمات کلیدی: شاخص‌های زیستی، تنوع، غنا، یکنواختی، SHE، مراتع جواهرده