# Comparison of Measurement Indices of Diversity, Richness, Dominance, and Evenness in Rangeland Ecosystem (Case Study: Jvaherdeh-Ramesar)

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**Abstract.** The diversity and richness of species are of important components to evaluate the health of ecologic system of rangelands. This research was conducted to investigate the biodiversity in riparian and neighboring areas via comparison of indices in Javaherdeh rangeland of Ramsar. Plot-transects was randomly used to estimate diversity, richness, dominance, and evenness indices in two regions. Multi Linear regression method was used to analyze the relationships of three indices to rangeland condition. Results of floristic list showed that there were 66 species belong to 19 families and 56 genera. Gramineae and Compositae families with values of (23.24 and 12.1%) had the highest and Boraginaceae and Hypolepidaceae with 2% had the lowest frequency, respectively. Result showed that richness species index in riparian area and diversity index in neighboring area had high correlation with the rangeland conditions. Hence, ecologic management could be used as a tool for evaluation of indices as reflectors of disturbance in rangeland.

**Key words:** Indices, Diversity, Richness, Dominance, Evenness, Riparian area, Mountainous rangeland, Regression.

**Introduction**

An ecologist has to have correct knowledge about the function of different ecosystems by which he/she could manage them ecologically. There are different methods to investigate ecosystem components. Knowledge about natures and functions of ecosystem could help one to having a suitable ecosystem management (Jacobs, 1975). In most of the published studies, species variation as a biological diversity (DeLong, 1996; Williams, 2004) consists of two components: species richness and evenness (Liu *et al.*, 2008, and Omernik, 2003) which can be regarded as sustainability and healthiness factors in the rangeland ecosystems (Williams, 2004; Jouri, 2010). Different factors have been already affected by the community's diversity as follows: sampling size and rate; destruction and human activity, farming, topographical factors, succession, underground waters, rivers and livestock grazing (Afshani *et al.*, 2009). The riparian areas, which held the highest amount of the above situations in rangeland level, can be considered as one of the most sensitive areas where need an ecological and sustained management (Khatibi, 2005, Williams, 2004). Whereas the ampleness concept and situation as well as the species variety have not been understood correctly (Hooper and Vitousek, 1997). Therefore, it needs a wide range of surveys to show the relationships among the mentioned components in an ecosystem. Through this, the researchers can investigate plant species diversity to identify their status by considering management role in different plant colonies (Goodman, 1975; Maguran, 1996). Evaluation of diversity parameters like species combination, dominance, evenness and the amount of species can be used for estimating the ecological status (Goodman, 1975). Identifying ecosystem health, Encoist *et al.* (2002) have pointed out that there are sorts of positive relation among the number of genus, family and species in all sampled units (Enquist *et al.*, 2002) in such a way, increasing of species richness would bring more diversity in genus and family. The results gained by Lorio (2002) showed that livestock grazing, livestock intensity and grazing systems could affect plant diversity so that knowledge of diversity changes has an important role to determine the rangeland conditions of the rangeland ecosystem and managing the impacts. Wilcox *et al.* (1987) studied how different kinds of grazing intensities can affect plant communities. Moreover, they concluded that if there would be moderate grazing in contrast to light and over grazing, it never leads to an increase in the species richness. Light grazing up to mid level could increase the species diversity and also homogeneity in rangeland plant combinations, however, overgrazing would decrease the important rangeland species and if there won't be happened any grazing, the dominant species could occupy all over the area. It has been expressed that there is a kind of direct relationship between species diversity and richness to the rangelands conditions. By surveying of diversity in the rangeland ecosystems, one will be able to know about the rangeland conditions and then use it as an index in management and programming of rangelands (Gillison, 2006; Ludwig & Renollds 1988; Menhinick, 1964; Pimm, 1984). Regarding this, Mahdavi *et al.* (2005) in investigation of the rangeland conditions in Inchebron region using diversity and richness indices, have been found out that the Shannon diversity's index and richness index of Margalof could show a better description for the conditions of rangeland health. With reference to the rangeland analysis, riparian areas as a part of the rangeland ecosystems, had varieties of species which are mesic plants. Secondly, it has high diversity because of its role as buffer zone between water and ground areas in such a way that the biological activities at this ecosystem would be so dynamic (Brodt *et al.*, 2009). Some of managing and human activities on the rangeland ecosystems can lead to decreasing and demolishing of natural habitats and resilience of species diversity and richness, therefore, it require a strong managing strategy in a long time (Hawksworth, 1995). However, vegetarian evenness in nature could be easily reversible (Orians, 1975; Shaojun *et al,* 2001 and Smith, 2001). There is a direct relation between species diversity and richness in mountainous areas (Jouri *et al.*, 1381.) and their increase also could bring more stability, species diversity and raise the forage quality of range species (Pielou, 1975). Consequently, comparing the biological diversity indices and their efficiency to introduce the subjective facts of the rangeland ecosystems can be an important step in preparing and introducing different managing approaches that it is the aim of this research.

## Materials and Methods

In order to compare the biological diversity indicators in riparian ecosystems, the rangeland areas in Javaherdeh (Ramsar) that its geographical coordinates are 36◦54'N and 50◦40'E in northern Alborz was selected. The climate of the area varied from cold and humid condition (in lower altitudes) up to altitude climate in higher areas with annual average of rainfall recorded as 640 mm (Jouri, 2010).

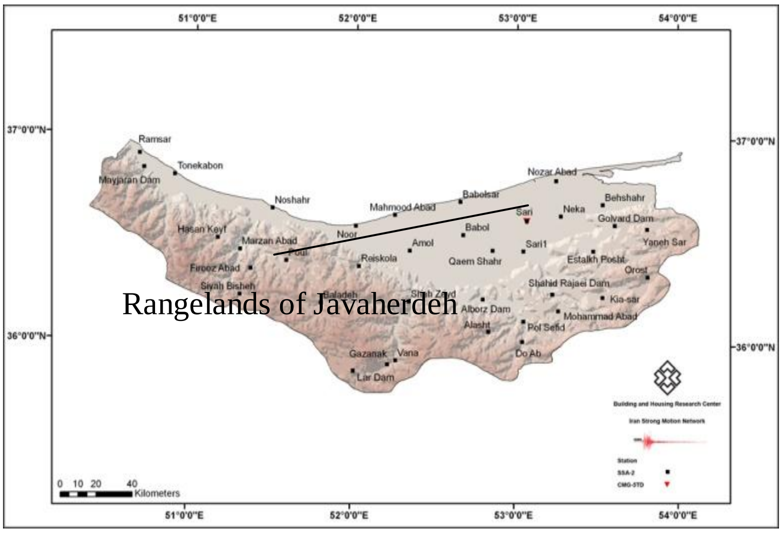


Fig. 1. Position of the study area in the Province and town

## Research Approach

First of all, using a topographical map in scale of 1:25000 and field monitoring, the territory of study area was determined and the landform units were derived. To evaluate the function of riparian area safety and to consider the V shape of the area, we prepare a cross section of the area and the neighborhood region to determine the diversity and species richness (Schade *et al.*, 2001). Then, a floristic list was prepared and completed through collecting and identifying them by color Flora and Flora of Iranica (Ghahraman, 2000).

Table 1. Names of some of species in the area investigated coming through floristic list

| Number | Species name | Family | Biological type |
|---|---|---|---|
| 1 | *Achillea millefolium* | Compositae | Ch |
| 2 | *Cardamine pratensis* | Cruciferae | Tr |
| 3 | *Carex ovalis* | Cyperaceae | - |
| 4 | *Agropyron intermedium* | Gramineae | Ch |
| 5 | *Chenopodium album* | Chenopodiaceae | Tr |
| 6 | *Alchemilla persica* | Rosaceae | Ch |
| 7 | *Dactylis glomerata* | Gramineae | Ch |
| 8 | *Echinops robustus* | Compositae | Ch |
| 9 | *Alopecurus sp* | Gramineae | Ch |
| 10 | *Euphorbia helioscopia* | Euphorbiaceae | Ch |
| 11 | *Anchusa iranica* | Boraginaceae | Ch |
| 12 | *Anthemis cotula* | Compositae | Ch |
| 13 | *Arctium lappa* | Compositae | Ch |
| 14 | *Artemisia aucheri* | Compositae | Ch |
| 15 | *Plantago major* | Plantaginaceae | Cr |
| 16 | *Astragalus sp* | Fabaceae | Ch |
| 17 | *Avena barbata* | Gramineae | Tr |
| 18 | *Malva neglecta* | Malvaceae | Tr |
| 19 | *Onobrychis cornuta* | Fabaceae | Ch |
| 20 | *Poa annua* | Gramineae | Tr |
| 21 | *Poa bulbosa* | Gramineae | Cr |
| 22 | *Bromus persica* | Gramineae | Ch |
| 23 | *Bromus tectorum* | Gramineae | Tr |
| 24 | *Poterium sanguisorba* | Rosaceae | Ch |
| 25 | *Capsella bursa-pastoris* | Cruciferae | Tr |

The sampling method in riparian and adjacent areas has been done randomly (Body & Svejcar, 2004; Clary, 1995) using transect-plot method (Robins *et al.*, 2001; Jouri, 2010; 73, Sabetpour *et al.*, 2002) and the determination of plot size was done by Minimum Area method (Cain, 1932) and the plot number also was obtained by statistical method (Pielou, 1975). Three different transects from 20 to 50 meters were used in the study area (Robins *et al.*, 2001). The plots must be randomly settled along with the big diameter of the investigated area (Smith and Wilson, 1996). Sampling was done in the mid of flowering period in each stand area individually. The vegetation traits, frequency and the amount of species were recorded for each plot to infer the biological diversities' indices (Table 2). Calculating the biological indicators was done through PAST v.2.7 software. In order to find out the relationship between biological indices and the rangeland conditions, multivariate statistics was used via stepwise regression method using SPSS v.17 software (Afshani *et al.*, 2009). In this research, the rangeland conditions and biological indicators were recognized as dependent and independent variables, respectively.

Table 2. Formula of diversity, richness, and evenness and dominance indexes (adapted of Ejtehadi *et al.*, 2009)

| The Changes range | Formula | Component | Index |
|---|---|---|---|
| 0-1 | $H' \equiv -\sum_{i=۱}^{s} p_i Ln\ p_i$ | Shannon-Wiener | |
| 0-1 | $D = \sum_{i=1}^{s} P_i^{s}$ | Simpson | |
| 0-1 | $d = N_{max} / N$ | Berger-Parker | |
| 0-1 | $(ax), \frac{(ax)^{۲}}{۲}, \frac{(ax)^{۳}}{۳}, \ldots, \frac{(ax)^{n}}{n}, \ldots$ | Fisher alpha | |
| $0-\infty$ | $D_{mg} = \frac{S-۱}{InN}$ | Margalef | |
| $0-\infty$ | $D_{Mn} = \frac{S}{\sqrt{N}}$ | Menhinick | |
| 0-1 | $\hat{D}_{Max} = \frac{1}{s}$ | Simpson | Evenness |
| 0-1 | $C = \sum\left(\frac{ni}{N}\right)^2$ | Simpson | Dominance |

**Results**

According to the gained results, 66 species were recognized that all were belong to 19 families and 56 genera. The families of Gramineae and Compositae had the most frequency (12.1% & 23.2%) and the families of Boraginaceae and Hypolepidaceae with 2% compose the species coverage of the study area (Fig. 2). Therefore, in Gramineae family, *Bromus tomentellus* shows the most abundance (18.75%) and *Digitaria* sp. with the least amount (1%) as the area flora. The results of classifying biological type in Raunkiaer method in the area showed that Hemicryptophyte (70.73%), Therophyte (20.33%), Geophyte (8.13%) plants had the most amounts of biological forms in the area (Fig. 3).

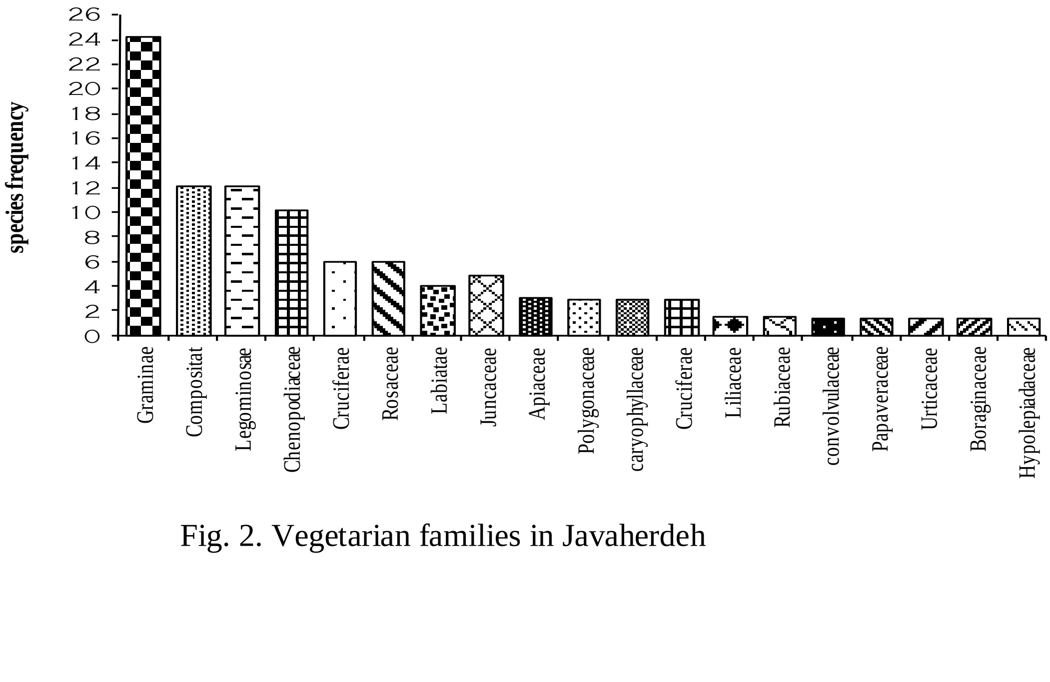


Fig. 2. Vegetarian families in Javaherdeh

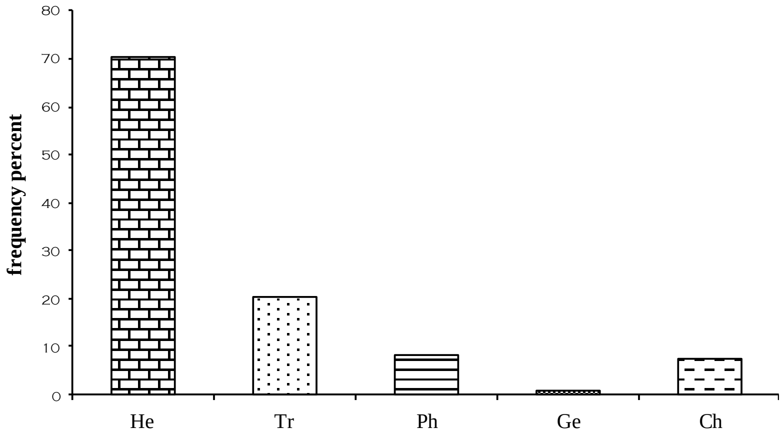


Fig. 3. The biological type in Javaherdeh

In order to signify the exploring of biological diversity indices in both riparian and adjacent areas, T-test was used. The result showed that the richness index of Margalef was the only significant index in the both areas (Table 4).

Furthermore, in each region, the biological indices were individually analyzed along with rangeland conditions. The results of multivariate regression analysis in riparian area showed that both Margalef and Menhinick indices (from species richness class) had significant relationship with the rangeland conditions (Table 5).

Table 4. The amount of bio-diversity indices in both areas: riparian and adjacent

| Zone | Average ± (standard division) | T statistic | Component | Index |
|---|---|---|---|---|
| Riparian | 2.095 ± 0.356 | 0.767 | Shannon-Wiener | Diversity |
| Adjacent | 2.174 ± 0.389 | 0.766 | | |
| Riparian | 0.837 ± 0.076 | -1.348 | Simpson | |
| Adjacent | 0.847 ± 0.084 | -1.346 | | |
| Riparian | 2.839 ± 0.862 | -0.767 | Berger-Parker | |
| Adjacent | 3.161 ± 1.159 | -0.766 | | |
| Riparian | 0.255 ± 0.113 | -1.987 | Fisher-alpha | |
| Adjacent | 0.245 ± 0.118 | -1.982 | | |
| Riparian | 2.21 ± 0.577 | -1.820 * | Margalef | Richness |
| Adjacent | 2.23 ± 0.706 | -1.815 * | | |
| Riparian | 0.870 ± 0.206 | -0.602 | Menhinick | |
| Adjacent | 0.942 ± 0.258 | -0.601 | | |
| Riparian | 0.866 ± 0.869 | -2.038 | Simpson | Evenness |
| Adjacent | 0.875 ± 0.098 | -2.031 | | |
| Riparian | 0.162 ± 0.076 | 0.568 | Simpson | Dominance |
| Adjacent | 0.153 ± 0.084 | 0.568 | | |

* = significant at 5%. level

Table 5. Multivariate regression in riparian area on basis of stepwise method

| Index | Coefficient of Correlation R | Coefficient of determination $R^2$ | F-statistic | Sig. |
|---|---|---|---|---|
| Margalef | 0.252 | 0.064 | 5.584 | 0.000 |
| Menhinick | 0.428 | 0.182 | 9.080 | 0.001 |

The regression equation (1) of both variables considering the rangeland conditions is as follows:

$Y=60.973-59.052X_1+26.969X_2$ (1)

In addition, the results show that the amount of Margalef index in defining rangeland condition's score changes is more observable than the others (regression model 2).

$Y=8.19X_1 -0.66X_2$

The above equation shows that the most changes are related to Margalef richness (positive), and then it follows the Menhinick one (negative).

The regression results out of river adjacent area show that the studied indices of Shannon and Fisher-alpha (diversity indices) and Menhinick richness in contrast to the others show sorts of significant relation to rangeland score (Table 6).

Table 6. Multi variable regression in river adjacent area

| Index | Coefficient of Correlation R | Coefficient of determination $R^2$ | F-statistic | Sig |
|---|---|---|---|---|
| Shannon | 0.414 | 0.171 | 5.265 | 0.001 |
| Fisher alpha | 0.547 | 0.200 | 11.127 | 0.000 |
| Menhinick | 0.550 | 0.202 | 8.222 | 0.000 |

While the regression equation of this analysis was as follows:
$Y=2.118-0.145X_1 +0.16X_2 -0.55X_3$

The standard model shows that the amount of Fisher-alpha index (directly & positively) and Menhinick richness (inverse) had the most and Shannon index (inverse) the least role in defining the rangeland changes (below regression model):

$Y=-0.54X_1 -1.38X_2 +1.84X_3$

**Discussion and Conclusion**

Reserving the biodiversity as a natural heritage can be challenged mostly today by politicians and scientist as well as preserving the flora species diversity as the only productive creatures besides being the bio-bed for the other organisms can be regarded as the most important ones in contrast to the other biodiversity components. To calm all these debates, we must analyze the bio indices. Regarding that, the area flora in altitude of 1800 to 3000 m was remarkable (Fig. 2), but comparing the bio-indices analysis shows that the Menhinick and Margalef indicators had the most correlation to the rangeland condition's score. Having a high degree of just one genus species (*Bromus)* in an area shows that the utilize factors (livestock & human) had interfered somehow in unifying the area flora. The field observations note that riparian area had been severely affected by free livestock grazing such as sheep, goat, cow or sometimes horses. Furthermore, it is not so overstated that the wetlands such as the riparian area in possession of wet and succulent species can attract many livestock in contrast to the other areas. Therefore, the existence of palatable and semi-palatable species would be severely affected by different kinds of livestock and animals in the area because of their different feed requirements so that according to the observation, these species can be found refuge in spiny shrubs among the rocks and the steep slops. So, it is not an imagination that species richness in both areas could be related mostly to rangeland conditions more than the other bio-indices which for sure can be along with the gained results by West (1993) and Lorio *et al.* (2002). Furthermore, through analyzing bio-indices in the adjacent areas (off the water margin), we have got that the diversity indicators have already shown the most amount of changes in the rangeland conditions. Being away from the riverbank and water resources causes less appearance of livestock at these areas, so lots of different flora species are seen here. Diversity species index therefore can be more significant than the others can (Table 6). In addition, in some steps when the animals are mostly attended, the species richness can be accounted for different changes in status that this part according to field monitoring is clearly obvious. Then, the gained results are completely in accordance with the results coming out of Robines *et al.* (2001) and Jouri (2010). Considering the results coming of analyzing, the rangeland conditions and studying bio-indices draw an acceptable view in account for the health of rangeland ecosystem that can be used in defining the ecologic management of the rangeland. Therefore, using bio-indices can be regarded as a suitable ecological indicator in analyzing the rangeland ecosystems that is in agreement with the results in Odum (1969), Jouri *et al.* (2008) and Mahdavi *et al.* (2005) studies.

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