

Study on floristic and plant species diversity in the Lebanon oak (*Quercus libani*) site, Chenareh, Marivan, Kordestan Province, western Iran

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Abstract. Pourbabaie H, Navgran SZ. 2011. Study on floristic and plant species diversity of the Lebanon oak site (*Quercus libani*) in Chenareh, Marivan, Kordestan Province, western Iran. *Nusantara Bioscience* 3: 15-22. In order to study floristic and plant species diversity, approximately 450 ha of oak forests were selected in Chenareh, Marivan of Kordestan province in western Iran. Inventory was selectively carried out in 50 m elevation range in the different aspects. Vegetation was surveyed in the four layers including: tree (dbh >5 cm), regeneration (dbh <5 cm), shrub and herb. Diversity and richness indices were used to analyze data in the different vegetation layers. Results indicated that 82 plant species found in the studied site, comprise of 9 tree, 3 shrub and 70 herbaceous. The mean diversities and richness measures were found to be the highest in southwestern and lowest in southeastern and northern aspects for the tree layer. Whereas for the regeneration layer, the mean diversity measures were found the highest in northeastern (i.e., 1-D and H') and southern (i.e., N₂ and N₁) and lowest in southwestern (i.e., 1-D, H' and N₁) and southeastern (i.e., N₂). The mean diversities were found the highest in northern (i.e. N₂ and H') and northwestern (i.e. 1-D and N₁) and lowest in northeastern aspect in the shrub layer. The mean diversities were also found the highest in western and lowest in northeastern aspect in the herbaceous layer. Moreover, Mean richness and diversity were found the highest in 1500 m asl and lowest in 1750 and 1800 m asl in the tree and shrub layers. Mean richness and diversity were found the highest in 1500 m asl and lowest in 1750 m asl in the regeneration layer. Also, the mean diversities were found the highest in elevation 1700 m asl and lowest in elevation 1800 m asl in the herbaceous layer.

Keywords: floristic, plant diversity, aspect, elevation, western Iran.

Abstrak. Studi keanekaragaman floristik dan jenis tumbuhan pada situs Lebanon ek (*Quercus libani*) di Chenareh, Marivan, Provinsi Kordestan, Iran barat. *Nusantara Bioscience* 3: 15-22. Dalam rangka meneliti floristik dan jenis tumbuhan, sekitar 450 ha hutan kayu ek dipilih di Chenareh, Marivan, Provinsi Kordestan di Iran barat. Inventarisasi dilakukan secara selektif pada kisaran elevasi 50 m dengan aspek yang berbeda-beda. Vegetasi disurvei dalam empat lapisan termasuk: pohon (dbh > 5 cm), regenerasi (dbh < 5 cm), semak dan herbal. Indeks keanekaragaman dan kekayaan digunakan untuk menganalisis data dalam lapisan vegetasi yang berbeda. Hasil penelitian menunjukkan bahwa 82 jenis tumbuhan ditemukan di lokasi penelitian, terdiri dari 9 pohon, 3 semak dan 70 herba. Pada pengukuran lapisan pohon mean keanekaragaman dan kekayaan ditemukan bahwa yang tertinggi di barat daya dan yang terendah di tenggara dan utara. Pada pengukuran lapisan regenerasi mean keanekaragaman ditemukan yang tertinggi di timur laut (yaitu, 1-D dan H') dan selatan (yaitu, N₂ dan N₁) dan yang terendah di barat daya (yaitu, 1-D, H' dan N₁) dan tenggara (yaitu, N₂). Pada lapisan semak keanekaragaman ditemukan mean tertinggi di utara (N₂ yaitu dan H') dan barat laut (yaitu 1-D dan N₁) dan terendah di timur laut. Pada keanekaragaman lapisan herba ditemukan mean tertinggi di barat dan terendah di timur laut. Selain itu, mean kekayaan dan keanekaragaman lapisan pohon dan semak ditemukan tertinggi pada ketinggian 1500 m dpl dan terendah pada 1750 dan 1800 m dpl. Mean kekayaan dan keragaman lapisan regenerasi ditemukan tertinggi pada ketinggian 1500 m dpl dan terendah pada 1750 m dpl. Juga, ditemukan mean keragaman lapisan herba tertinggi ditemukan pada ketinggian 1700 m dpl dan terendah pada 1800 m dpl.

Kata kunci: flora, keanekaragaman tanaman, aspek, ketinggian, Iran barat.

INTRODUCTION

The Zagros forests of western Iran extend from Piranshahr city in western Azarbayejan province in the Zagros and Bakhtiary mountains to around the Jahroum and Fasa cities in the Fars province. These forests cover approximately 5 million ha area, and because of dominance of species of oak genus, these forests are called as western oak forests (Mohadjer 2005). The western oak forests have remarkable significance in regard to ecological services including water and soil conservation. Therefore, these forests play an important role in preventing soil erosion.

About 40% of surface waters of our country run from Zagros mountains basin in which seven rivers exist with fresh water. In the other hand, these forests produce by-products through their woody species, and also maintain sustainable agriculture in the lowlands.

In general, forest communities in these forests from lowland to highland as follows: *Amygdaletum scopariae*, *Pistacio-Amygdaletum*, *Quercetum persicae* (*Q.brantiae*), *Juniperetum polycarpae*. *Juniperetum* community has a large extent from Khorasan to Azarbayejan, Zagros, Bandar Abbas and Baluchestan (Sabeti 1994). In the *Pistacio-Amygdaletum* community, *Amygdalus* species

affect on the natural regeneration of *Pistacia* species, that is, the seedlings of *Pistacia* species would be protected under the spiny bushes of *Amygdalus* species.

The Zagros mountains are divided into two parts: northern and southern. The northern Zagros consists of the growing site of *Quercus infectoria* Oliv. and also *Q. libani* Oliv. and *Q. persica* J. & sp. (*Q. brantii* Lindl.) species are found in this part. However, the southern Zagros is included *Q. persica* site which it extended to Fars province (i.e., 29° 5' N). The northern Zagros is wetter and cooler than the southern one. The dispersion areas of Lebanon oak (*Q. libani*) are mostly restricted to central and eastern mountains of Taurus and Amanous of Anatolia in Turkey, the mountains of northeastern of Iraq and northwestern of Syria and western part of Iran (i.e., Kordestan province) (Browicz 1994). In addition, this species is found over 1000 m asl elevation and the best conditions range from 1200 to 1600 even to 1800 m asl to growing it, and also this species is found higher than 2000 m asl elevation in Ahir dagi and Herakol dagi mountains in southern Anatolia, Turkey. Western borderline of this species is located in the Goniah province in Anatolia and northern borderline restricted to latitude 40°N in Erzincon province in Turkey (Davis 1982). In flora of Iraq, the distribution area of this species was cited in central regions of Iraq forests, north of Syria, Palestinian, Turkey, and Iran on hillsides on the metamorphic and igneous rocks and loam soils, and elevation ranges from 1800 to 2000 (occasionally 2100) m asl (Townsend and Guest 1980). In Iran, the distribution of this species is restricted to highlands of Sardasht in Kordestan and Euromiah provinces, and horizontal distribution is from north of Sardasht to south of Marivan in Kordestan province and vertical distribution is from 1400 to 2150 m asl elevation (Fattahi 1994). This species is situated in latitude from 25° to 36° N and longitude from 45° to 46° E and is grown cold humid, cold subhumid or humid climates. The pure type of this species

is found in highlands and the mixed one mostly found associated with *Q. infectoria* and *Q. brantii* species. This species is in relation to soil and climatic conditions. The forests of this species are found as high and coppice forms, and the species covers 106316 ha area in western Iran of which 83844 is located in the Kurdistan province (Fattahi 1994).

There are numerous studies in relation to floristic composition all over the world (e.g., Anel 2001; Nebel et al. 2001; Ipor et al. 2002; Blanckaert et al. 2004; Wardell-Johnson et al. 2004; Ramírez et al. 2007; Cayuela et al. 2008; Gole et al. 2008; Macía 2008; El-Ghanim et al. , 2010; Figueroa et al. , 2011). In addition, plant species diversity has been assessed in forest ecosystems in recent decades (e.g., Brockway 1998; Pitkänen 1998; Khera et al. 2001; Ashton and Macintosh 2002; Aubert et al. 2003; Nagaike 2003; Jobidon et al. 2004; Chiarucci and Bonini 2005; Pant and Samant 2007; Aparicio et al. 2008; Macía 2008; Pe rez-Ramos 2008; Hayat et al. , 2010). Whereas there is fewer studies about plant species diversity in Zagros forest ecosystems (Mirzaei et al. 2008; Pourbabaei et al. 2010).

The aim of this study was to determine floristic composition and plant species diversity in the Lebanon oak site in Kordestan province of Iran.

MATERIALS AND METHODS

Study area

The study area is located in Marivan city of Kordestan province in western Iran, and Chenareh is situated 25 km from northwestern Marivan city (35° 29' to 35° 45' N latitude, 46° 14' to 46° 29' W longitude). Mean annual precipitation is 909.5 mm, ranging from 590.8 to 1422.2 mm (Figure 1).

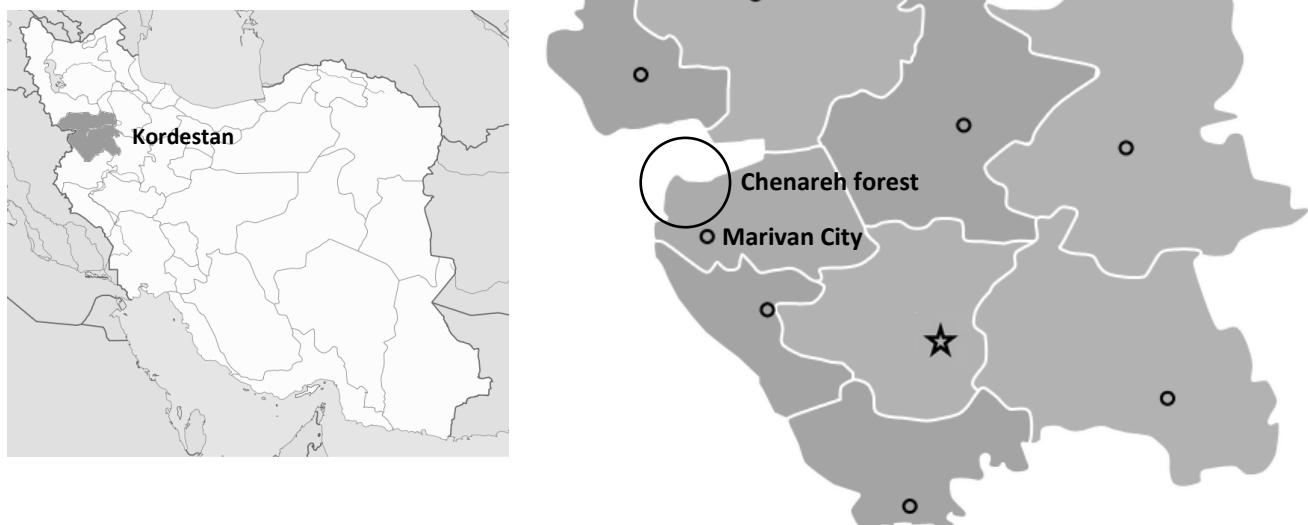


Figure 1. Study site maps Chenareh's forests (blank circle) in Marivan District, Kordestan Province, IR Iran.

Mean annual temperature is 13.3°C, and the length of dry season is 4 month (based on embrothermic curve) from June to August. Type of climate is sub-humid with cold winters on the basis of Emberger's formula (Department of Forestry 2002). Edaphically, soils consist of developed brown (calciferous and eutroph), deep and semi-deep, and young soils consisting of lithosol and colluvium which often are less deepness and shallow. *Quercus brantii* community are predominantly found on calcico brown soils, and *Q.libani* community often found on eutroph brown soils.

The research was conducted in 450 ha of Chenareh's forests where included Lebanon oak and altitude ranges from 1500 to 1800 m asl. These forests are located steep areas, and slope is more than 50% in the most area. Main aspects of these forests are northern and southern. These forests have been under anthropogenic disturbances in the past, therefore they are considered as manipulated forests now.

Sampling

At first, oak site was quantified on the map with 1:50000 scale with surveying forests. Inventory was selectively carried out in 50 m elevation range from 1500 m to 1800 m asl in the different aspects in the basis of distribution of Lebanon oak population. Sampling plot area was 1000 m² in size and circular (Zobeiri 1994). In total, 42 sampling plots were made. At each plot, diameter at 1.3 m (DBH) of tree ≥ 5 cm was measured and identified (high and coppice origin), and crown diameters (i.e., large and small) of regeneration with DBH < 5 cm were measured. For shrub species, the number of individuals was recorded and identified. To collect herbaceous data, nested plot sampling was performed at center the plot (Muller-Dombois 1974), and minimal area ranged from 32 to 1000 m² in the basis of different altitudes. Cover percentage was visually estimated, as accurately as possible, for each herbaceous species in the nested plots, and type of species was identified in the Herbarium of Faculty of Natural Resources, University of Guilan.

Data analysis

Species richness (total number of species present) and evenness (the manner in which abundance is distributed among species) are the two principal components of diversity. Species richness is frequently characterized by the number of species present (S), Margalef species richness (R₁) and Menhinick species richness (R₂) (Ludwig and Reynolds 1988). In this study, Smith and Wilson's evenness index (E_{var}) was applied to calculate evenness measures (Krebs 1999). Diversity indices combine species richness and evenness components into a single numeric value. The most commonly used indices of diversity, Simpson (1-D) and Shannon-Wiener (H') were used in this study (Magurran 2004). Moreover, Hill's N₂ and McArthur's N₁ were calculated on the basis of these indices (Krebs 1999). Vegetation data were analyzed in four layers (i.e., tree, regeneration, shrub, and herb) using richness, evenness and diversity indices. In tree layer, DBH was converted to basal area (m²) for each individual tree and summed for each species, and then substituted for the

number of individuals in the diversity formula. Furthermore, crown cover area (m²) was computed for each regeneration species and applied the formula. Data analyses were performed using Ecological Methodology and SPSS 13.0 software (Krebs 1999; Kinnear 2001).

RESULTS AND DISCUSSION

Floristic composition

A total of 82 plant species were found in the studied area, of which 12 woody species (9 trees, 3 shrubs) and 70 herbaceous species existed (Table 1) while 4 trees, 3 shrubs, one bush, and 78 herbaceous species were identified in Ilam forests of Zagros (Pourbabaei et al. 2010). Therefore, it is concluded that tree richness is high in the studied area. Also, it can be deduced from Table 1 that Rosaceae and Fagaceae families play an important role in among woody species. Moreover, Asteraceae and Poaceae families were most abundant amongst herbaceous species. In addition, results were revealed that the Asteraceae family was dominant in Ilam forests of Zagros (Pourbabaei et al. 2010).

The number of plant species was considered in the studied area when compare with northern Zagros mountains since there is 165 woody species (tree and shrub) in Zagros and 182 bush and herbaceous species only in northern Zagros (Jazirehi and Rostaghi 2003). The highest richness of woody species belong to Fagaceae and Rosaceae and the highest richness of herbaceous species belong to Asteraceae and Poaceae families in the studied area, these results were confirmed in the Zagros zone (Jazirehi and Rostaghi 2003).

Plant diversity based on different aspects

Plant species diversity of four growth layers was obtained in terms of different aspects. The highest and lowest population of Lebanon oak was found in eastern (32%) and northwestern (24%) aspect, respectively. Figure 1 displays mean tree (high and coppice forms) diversity in the basis of different aspects.

The mean diversities were highest in southwestern and lowest in southeastern and northern aspects in the tree layer. The ANOVA test indicated that there were no significant differences amongst mean diversity measures in the different aspects ($P > 0.05$). Figure 3. displays mean tree richness, Margalef (R₁) and Menhinick (R₂) and evenness measures in the different aspects.

The mean richness, R₁ and R₂ measures were highest in southwestern, and lowest in southeastern and northern aspects, respectively. The mean E_{var} was the highest in southeastern and lowest in northeastern aspect. The Kruskal-Wallis test showed that there were no significant differences amongst mean richness values in the different aspects. Whereas, the ANOVA test indicated that there were significant differences amongst mean R₁ and R₂ in the different aspects ($P < 0.05$), and Tukey test showed that there was significant difference between southwestern and southeastern aspects in view of mean R₁. Also, there was significant difference between southwestern and other aspects except southern in view of mean R₂.

Table 1. Plant species list based on growth layers

| Layer | Species |
|------------|---|
| Tree | <i>Acer monspessulanum</i> L. (Aceraceae), <i>Amygdalus communis</i> L. (Rosaceae), <i>Cerasus mahaleb</i> L. (Rosaceae), <i>Crataegus pontica</i> C.Koch. (Rosaceae), <i>Pistacia atlantica</i> (Anacardiaceae), <i>Pyrus syriaca</i> Boiss. (Rosaceae), <i>Quercus brantii</i> Lindl. (Fagaceae), <i>Q.infectoria</i> Oliv. (Fagaceae), <i>Q.libani</i> Oliv. (Fagaceae). |
| Shrub | <i>Cerasus microcarpa</i> (C.A.Mey) Boiss. (Rosaceae), <i>Cotoneaster nummularia</i> Fisch & Mey. (Rosaceae), <i>Lonicera nummularifolia</i> Jaub & Spach. (Caprifoliaceae). |
| Herbaceous | <i>Acanthus dioscoridus</i> L. (Acanthaceae), <i>Achillea filipendula</i> L. (Asteraceae), <i>A.millefolium</i> L. (Asteraceae), <i>Aegilops triuncialis</i> L. (Poaceae), <i>A.triuncialis</i> L. (Poaceae), <i>Alopecurus myosuroides</i> Ovcz. (Poaceae), <i>Antemisia tinctoria</i> L. (Asteraceae), <i>Astragalus curvirstris</i> Boiss. (Papilionaceae), <i>A. michauxianus</i> Boiss. (Papilionaceae), <i>A. (tragacantha)</i> sp. (Papilionaceae), <i>Aristolochia bottae</i> Jaub & Spach. (Aristolochiaceae), <i>Boissiera squarrosa</i> Hochst. (Poaceae), <i>Bromus tectorum</i> L. (Poaceae), <i>Buchingera axillaris</i> Boiss. (Cruciferae), <i>Bunium elegans</i> (Fenzl.) Freyn. (Umbelliferae), <i>Callipeltis cucularia</i> Stev. (Rubiaceae), <i>Centaurea virgata</i> Lam. (Asteraceae), <i>Cephalaria syriaca</i> (L.)Schrad. (Dipsaceae), <i>Chaerophyllum macropodium</i> Boiss. (Umbelliferae), <i>Cornilla varia</i> L. (Papilionaceae), <i>Dactylis glomerata</i> L. (Poaceae), <i>Dianthus tabrizianus</i> Adams. (Caryophyllaceae), <i>Echinops orientalis</i> Trauth. (Asteraceae), <i>E.ritrodes</i> Bunge. (Asteraceae), <i>Eremopoa persica</i> (Trin.) Roshev (Poaceae), <i>Eryngium thyrsoides</i> F.Delaroche. (Umbelliferae), <i>Euphorbia macroclada</i> Boiss (Euphorbiaceae), <i>Ferula orientalis</i> L. (Umbelliferae), <i>Fibijia macrocarpa</i> Boiss. (Cruciferae), <i>Galium aparine</i> L. (Rubiaceae), <i>Grammosciadium platycarpum</i> Boiss. (Umbelliferae), <i>Gundelia tournefortii</i> L. (Asteraceae), <i>Helianthemum ledifolium</i> (L.) Miller. (Cistaceae), <i>Heterantherium piliferum</i> (Banks & Soland) (Poaceae), <i>Hordeum bulbosum</i> L. (Poaceae), <i>Hypericum scabrum</i> L. (Hypericaceae), <i>Inula britannica</i> L. (Asteraceae), <i>Lamium album</i> L. (Labiatae), <i>Marrubium vulgare</i> L. (Labiatae), <i>Mesostemma kotschyannum</i> Wed. (Caryophyllaceae), <i>Milium pedicellare</i> Bornm. (Poaceae), <i>Onopordon kurdicum</i> Bornm& Beauv (Asteraceae), <i>Onosma elwendicum</i> L. (Boraginaceae), <i>O. microcarpa</i> DC. (Boraginaceae), <i>Phlomis olivieri</i> Benth. (Labiatae), <i>P.rigida</i> Labill. (Labiatae), <i>Picnomon acarna</i> L. (Asteraceae), <i>Poa bulbosa</i> L. (Poaceae), <i>Potentilla kurdica</i> Boiss & Hohen. (Rosaceae), <i>Prangos ferulaceae</i> L. (Umbelliferae), <i>Rhaponticum insigne</i> Boiss. (Asteraceae), <i>Rhabdoscidium aucheri</i> Boiss. (Umbelliferae), <i>Salvia bracteata</i> Banks & Soland. (Labiatae), <i>Sanguisorba minor</i> Scop. (Rosaceae), <i>Scabiosa calocephala</i> Boiss.(Dipsacaceae), <i>S. leucactis</i> Patzak. (Dipsacaceae), <i>Scutellaria pinnatifida</i> A.Hamilt. (Labiatae), <i>Serratula grandifolia</i> Boiss. (Asteraceae), <i>Smyrniolum aucheri</i> Boiss. (Umbelliferae), <i>Stachys inflata</i> Benth. (Labiatae), <i>Taeniatherum crinitum</i> (Schreb.)Nevski (Poaceae), <i>Teucrium polium</i> L. (Labiatae), <i>Trifolium campestre</i> Schreb. (Papilionaceae), <i>T.pratens</i> L. (Papilionaceae), <i>Turginia latifolia</i> L. (Umbelliferae), <i>Valerianella dactylophylla</i> Boiss & Hohen. (Valerianaceae), <i>Veronica kurdica</i> Benth. (Scrophulariaceae), <i>Vicia variabilis</i> Freyn & Sint. (Papilionaceae), <i>Xeranthemum inaeptum</i> Boiss. (Asteraceae), <i>Zoega leptaurea</i> L. (Asteraceae). |

The mean diversity measures were highest in northeastern (i.e., 1-D and H') and southern (i.e., N₂ and N₁) and lowest in southwestern (i.e., 1-D, H' and N₁) and southeastern (i.e., N₂) in the regeneration layer (Figure 4). The ANOVA test showed that there were significant differences amongst mean 1-D measures in the different aspects, but no significant differences amongst other diversity indices. In addition, Tukey test showed that there was significant difference between northeastern and southwestern aspects.

The mean richness, R₁ and R₂ measures were highest in northern, southern and lowest in southwestern and southeastern aspects, and mean E_{var} was the highest in southwestern and lowest in northern aspect (Figure 5). There were significant differences amongst mean richness, R₁ and R₂ measures. Tukey test showed that there was significant difference between northern and southwestern aspect in view of richness.

The mean diversities were highest in northern (i.e., N₂ and H') and northwestern (i.e. 1-D and N₁) and lowest in northeastern aspect in the shrub layer (Figure 6). The ANOVA test showed that there were no significant differences amongst mean diversities measures in the different aspects.

The mean richness and R₁ measures were highest in northern, while R₂ was the highest in eastern aspect. The mean richness was lowest in other aspects and also the mean of R₁ and R₂ were found the lowest in northwestern

aspect, and the E_{var} were found the highest in northwestern and lowest in northeastern (Figure 7). There were no significant differences amongst mean richness, R₁, R₂ and E_{var} measures in the different aspects.

The mean diversities were highest in western and lowest in northeastern aspect in the herbaceous layer (Figure 8). The ANOVA test showed that there were significant differences amongst mean diversities measures in the different aspects. The differences among means were detected using Tukey's test which is characterized by different letters on the histogram of Figure 8.

The mean richness and E_{var} measures were highest in western and lowest in northern aspect in the herbaceous layer and there were significant differences amongst mean measures in different aspects (Figure 9).

The Lebanon oak was found in all aspects, but it had the most abundant in eastern and the least in northwestern aspect since it requires plenty of sunlight in eastern aspect (Maroufi 2000). This species is preferred northern and eastern aspects and ecological needs of *Q.libani* is higher than *Q.infectoria* and *Q.brantii* (Jazirehi and Rostaghi 2003).

The tree species diversity was found the highest in southwestern and lowest in southeastern and northern aspects, because richness and richness indices had the highest and lowest values the mentioned aspects, and evenness had the highest and lowest values in southeastern and northeastern aspects, respectively.

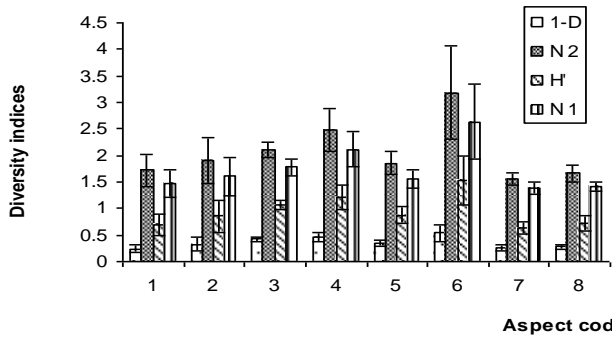


Figure 1. Mean diversity measures and their standard errors based on different aspects in the tree layer (1. northern, 2. northeastern, 3. northwestern, 4. eastern, 5. southern, 6. southwestern, 7. southeastern, 8. western).

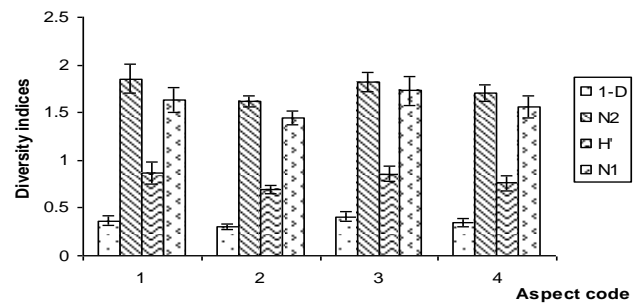


Figure 6. Mean diversity measures and their standard errors based on different aspects of the shrub layer.

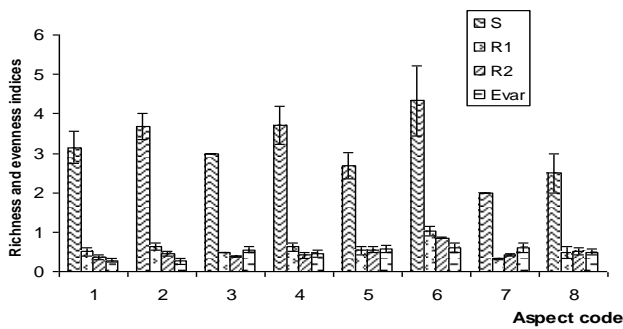


Figure 3. Mean richness, R_1 , R_2 and E_{var} measures and their standard errors based on different aspects in the tree layer.

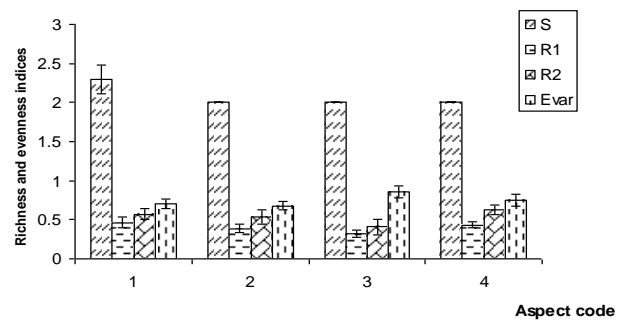


Figure 7. Mean richness, R_1 , R_2 and E_{var} measures and their standard errors based on different aspects in the shrub layer.

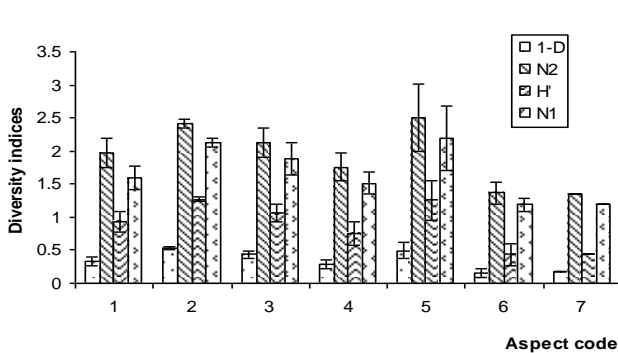


Figure 4. Mean diversity measures and their standard errors based on different aspects of the regeneration layer.

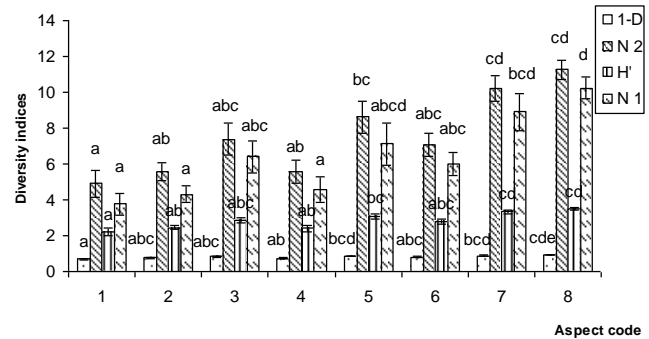


Figure 8. Mean diversity measures and their standard errors based on different aspects in the herbaceous layer (The same letters on the histogram indicate that there are no significant differences amongst mean values).

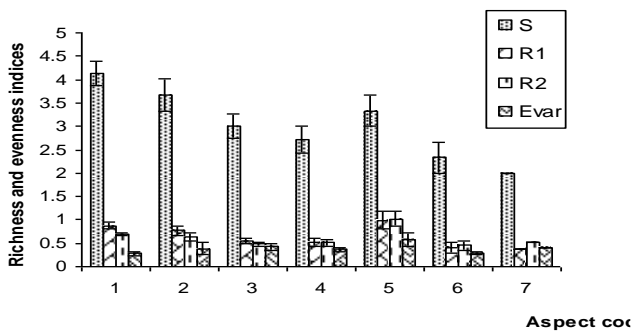


Figure 5. Mean richness, R_1 , R_2 and E_{var} measures and their standard errors based on different aspects in the regeneration layer.

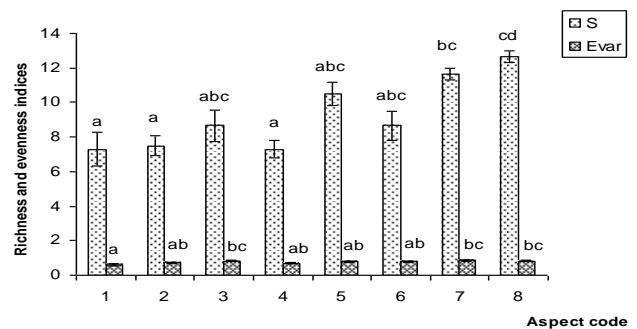


Figure 9. Mean richness and E_{var} measures and their standard errors based on different aspects in the herbaceous layer.

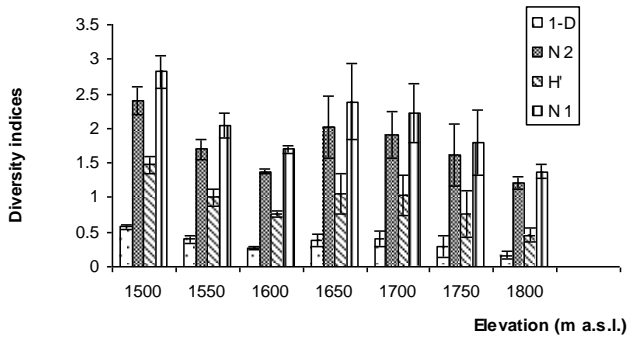


Figure 10. Mean diversity measures and their standard errors based on elevation classes in the tree layer.

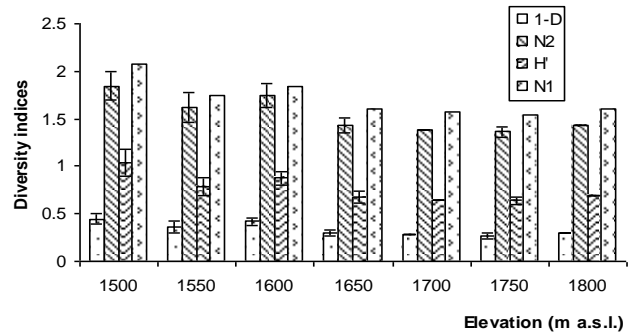


Figure 14. Mean diversity measures and their standard errors based on elevation classes in the shrub layer.

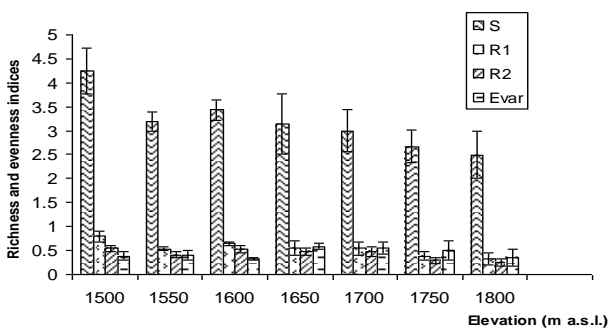


Figure 11. Mean richness, R_1 , R_2 and E_{var} measures and their standard errors based on elevation classes in the tree layer.

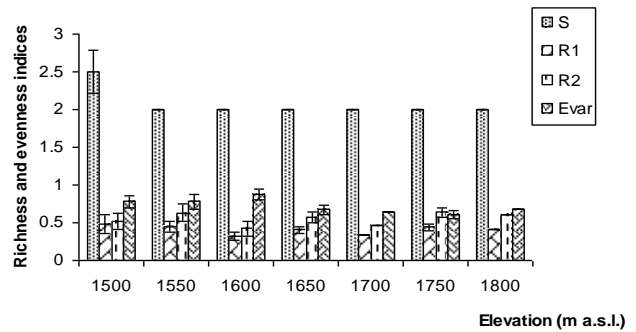


Figure 15. Mean richness, R_1 , R_2 and E_{var} measures and their standard errors based on elevation classes in the shrub layer.

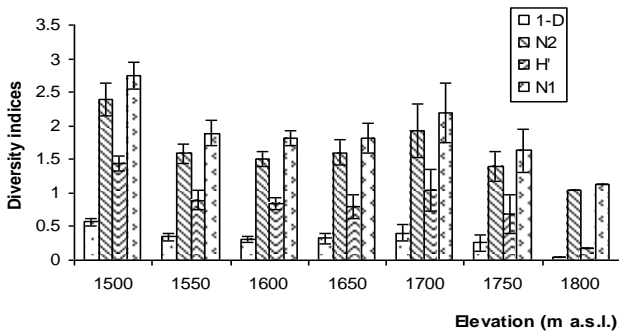


Figure 12. Mean diversity measures and their standard errors based on elevation classes in the regeneration layer.

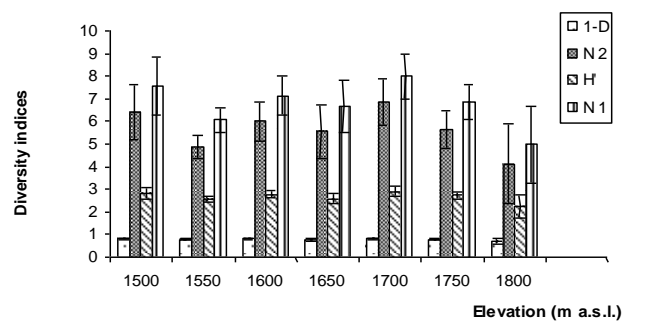


Figure 16. Mean diversity measures and their standard errors based on elevation classes in the herbaceous layer.

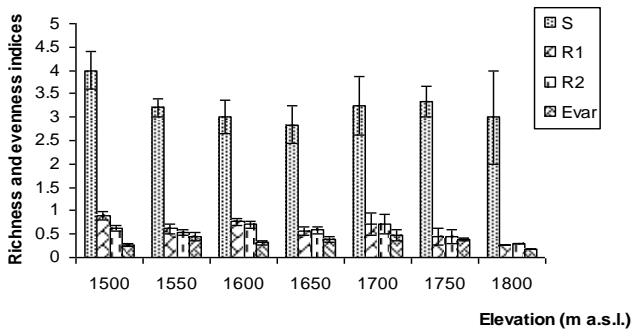


Figure 13. Mean richness, R_1 , R_2 and E_{var} measures and their standard errors based on elevation classes in the regeneration layer.

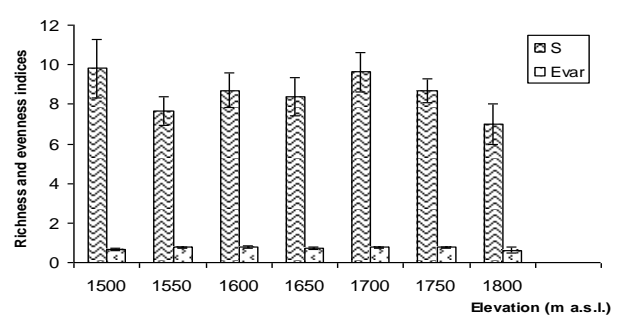


Figure 17. Mean richness and E_{var} measures and their standard errors based on elevation classes in the herbaceous layer.

These results are to be confirmed with obtained results from Zagros forests in Ilam (Mirzaei et al. 2008; Pourbabaei et al. 2010). The Lebanon oak trees have been overexploited in southwestern aspect and as a result, population of other species such as *Amygdalus communis* and *Crataegus pontica* have increased in this aspect and also caused to increase tree species diversity.

The regeneration diversity of woody species was found the highest in northeastern (i.e., 1-D and H') and southern (i.e., N₁ and N₂) and the lowest in southwestern (i.e., 1-D and H') and southeastern (i.e., N₂). The highest value of richness, R₁ and R₂ were found in northern and southern aspects and the lowest in southwestern and southeastern aspects. The highest value of evenness was found in southwestern and the lowest in northern aspect.

The shrub diversity was found the highest in northern (i.e., H' and N₂) and northwestern (i.e., 1-D and N₁) and the lowest in northeastern aspect. The highest value of richness and R₁ was found in northern and R₂ in eastern aspect. The lowest value of richness was found in other aspects, and R₁ and R₂ in northwestern aspect. The highest value of evenness was found in northwestern and the lowest in northeastern.

The herbaceous diversity was highest in western and the lowest in northeastern aspect. The highest value of richness and evenness were found in western and the lowest was in northern aspect. The number of tree individuals per hectare and its crown cover was low in western aspect and as a result, the herbaceous diversity was the highest in this aspect. The population of tree species was more in northeastern aspect, and crown coverage was 60 to 80 percent, and as a result, the herbaceous diversity was lower in this aspect.

Plant diversity based on elevation classes

The elevation distribution of Lebanon oak species stretches from 1500 to 1800 m asl in the studied area. The highest and lowest Lebanon oak population was found from 1600 to 1750 m asl (18%) and from 1500 to 1600 m asl (8%), respectively. The mean diversities were found the highest in elevation 1500 m asl and lowest in elevation 1800 m asl in the tree layer (Figure 10). There were no significant differences amongst mean diversity measures in the different elevations ($P > 0.05$). These results are to be confirmed with gained results of Zagros forests in Ilam (Mizaei et al. 2008).

The mean richness, R₁ and R₂ measures were found the highest and lowest in elevation 1500 and 1800 m asl, respectively in the tree layer, while the highest and lowest of mean E_{var} was found in elevation 1650 and 1600 m asl, respectively (Figure 11). There were no significant differences amongst mean these parameters in the different elevations.

The mean diversities were found the highest in elevation 1500 m asl and lowest in elevation 1800 m asl in the regeneration layer (Figure 12). The mean richness and R₁ measures were found the highest in elevation 1500 m asl, and the highest value of R₂ was in elevation 1700 m asl and these parameters were lowest in elevation 1650 and 1800 m asl, respectively in the regeneration layer. The highest and lowest of E_{var} were found in elevation 1700 and 1800 m asl, respectively (Figure 13). There were no

significant differences amongst mean diversity, richness and evenness measures in elevation classes in the regeneration layer.

The mean diversities were found the highest in elevation 1500 m asl and lowest in elevation 1750 m asl in the shrub layer (Figure 14). The mean richness and R₁ measures were also found the highest in elevation 1500 m asl, and the highest value of R₂ was in elevation 1750 m asl and these parameters were lowest in elevation 1600 m asl in the shrub layer. The highest and lowest of E_{var} were found in elevation 1600 and 1750 m asl, respectively (Figure 15). There were no significant differences amongst mean diversity, richness and evenness measures in elevation classes in the shrub layer.

The mean diversities were found the highest in elevation 1700 m asl and lowest in elevation 1800 m asl in the herbaceous layer (Figure 16). The mean richness was found the highest in elevation 1500 m asl, and lowest in elevation 1800 m asl, and the highest and lowest of E_{var} were found in elevation 1600 and 1800 m asl, respectively, in this layer (Figure 17). There were no significant differences amongst mean diversity, richness and evenness measures in elevation classes in the herbaceous layer.

The most population of Lebanon oak was found from 1600 to 1750 m asl elevation. Maroufi (2000) indicated that this tree was distributed upper 1400 m asl elevation and it formed pure stands in elevation from 1600 to 1700 m asl. The *Quercus brantii*, *Q. infectoria* and *Q. libani* species were observed with each other in elevation from 1500 to 1600 m asl, and in elevation of 1600 to 1650 m asl *Q. infectoria* and *Q. libani* species found with together, and from 1650 to 1800 m asl just *Q. libani* was found (Tabatabaei and Geisarani 1992). The *Q. libani* species is distributed from 1500 to 2100 m asl and the best elevational range of this species was characterized from 1600 to 1800 m asl (Jazirehi and Rostaghi 2003).

The herbaceous species of *Vicia variabilis* Fren & Sint. has more population in sites where *Q. libani* population is plentiful. With increasing elevation up to 1700 m asl, *V. variabilis* population is also increased. The *Q. libani* forms pure stands in higher elevations (1650 to 1800 m asl) and population of *Mesostemma kotschyianum* is increased in comparing with *V. variabilis* since ecological needs of *Mesostemma kotschyianum* lower than is *Vicia variabilis*. The herbaceous coverage is to be increased in western and eastern aspects due to decreasing crown cover of oak species, and *Turginia latifolia* L. species is formed the most coverage percent since it has less ecological needs and it also is a thorny species.

CONCLUSION

The Zagros are divided into two parts: northern and southern. Northern Zagros is determined in the basis of distribution of *Quercus infectoria* Oliv. and *Q. libani* Oliv. Southern Zagros is also determined based on distribution of *Quercus brantii* Lindl. The Lebanon oak was found in all aspects, but it had the most population in eastern aspect and also this species was preferred northern aspect due to high

ecological needs. The most population of Lebanon oak was found from 1600 to 1750 m asl elevation because of suitable humidity and edaphically conditions. In fact, elevational distribution of Lebanon oak is as spindle shape, that is, population of this species is increasing when the elevation is increasing and the population is decreasing in higher elevation. The disturbance is approximately high in elevation of 1500 m asl, as a result, herbaceous and other woody species have been dominated and Lebanon oak decreased. Therefore, in order to rehabilitate the northern Zagros, it is recommended that plantation of Lebanon oak is greatly conducted in the mentioned aspects and elevations. Regarding that plant species, diversity and richness are considerable in studied area, it is better than this site is considered as genetic reservoir.

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