Plant diversity patterns along altitudinal gradient in understory communities of Darkesh region, Bojnord, Iran

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Abstract. The ecotone region of Darkesh with an area of 22,500 hectares is located in the Irano-Turanian xeric-continental bioclimatic zone of Khorassan-Kopet Dagh. To investigate the plant diversity patterns of understory communities along three elevation classes of 1100-1600, 1600-2100, and 2100-2600 m, 187 plots were sampled randomly and abundance and cover of species were recorded using 4-m^2 plots. Beta diversity and Hill indices were calculated by using R and PAST software. A total of 252 species were recorded including 31 perennial grasses. The most abundant grasses were *Poa nemoralis*, *Poa bulbosa*, *Bromus sterilis*, *Brachypodium sylvaticum*, and *Dactylis glomerata* subsp. *glomerata*. *Poa nemoralis* was an important dominant grass under *Quercus* community. From the standpoint of species richness, Hill indices were highest under woods stories along the elevation of 1100-1600 m. Understories of oak forest and alpine communities had almost the same indices and were in the second rank compared to woods communities. Based on the β diversity index, the wood understory had the highest indices followed by *Quercus* and alpine communities. By increasing the elevations, the diversity of understory communities also decreased.

Introduction

More than 50% of global biodiversity hotspots are in the mountains with high species diversity and endemism (Munson and Sher 2015; Noroozi *et al*. 2018). Many mountainous regions are being affected by recent climate changes such as higher temperatures or lower rainfalls which alter the quantity and quality of vegetation. Furthermore, mountain soils are highly dynamic which affect plant communities by altering species components (Cowles *et al*. 2016). Therefore, these regions are considered significant for biodiversity conservation at global, national, and local scales (Noroozi et al. 2019).

The Irano-Turanian Floristic Region consists of a vast territory in southwestern and central Asia in the Holarctic, connecting to the Mediterranean, Euro-Siberian, and Saharo-Sindian regions. The region has a high level of plant speciation and endemism, especially in genera including *Astragalus*, *Cousinia*, *Acantholimon*, *Acanthophyllum*, and *Allium* (Takhtajan 1986; Zohary 1973). Several biogeographic units have been distinguished within this region including the Khorassan-Kopet Dagh (KK) Floristic Province located in northeastern Iran and southern Turkmenistan. This area is mainly mountainous and is a transition zone connecting different provinces of the Irano-Turanian Region and the Hyrcanian montane forests of the Euro-Siberian Region. Different mountain ranges make up the KK Floristic Province that show high biodiversity and endemism (Memariani et al. 2016a; Memariani 2020). The Darkesh area is located in the western part of KK Floristic Province. Providing floristic composition and comparing plant biodiversity of understory communities in three vegetation types (shrubland, oak forest, and alpine) along the altitudinal gradient are our main objectives.

Study Site and Methods

Darkesh area is located in the western Aladagh mountains in the western part of the KK Floristic Province (Fig. 1). The average annual precipitation is about 350 mm mainly falls in late autumn and early spring. The vegetation of the study area has three types of shrubland, oak forest, and alpine with rich grasses in the understories community. By stratified-random sampling, we estimated abundance and canopy cover percentages using Braun-Blanquet scale in 187 plots (2m×2m) in the full stage of grasses along 1100 to

2400 m elevations.

All vascular plant species in sample plots were collected and identified using the relevant literature and floras (Rechinger 1963-2015; Assadi et al. 1988-2018; Memariani et al. 2016c). Hill indices and β diversity were calculated by using R and PAST software for understory using 4-m^2 plots.

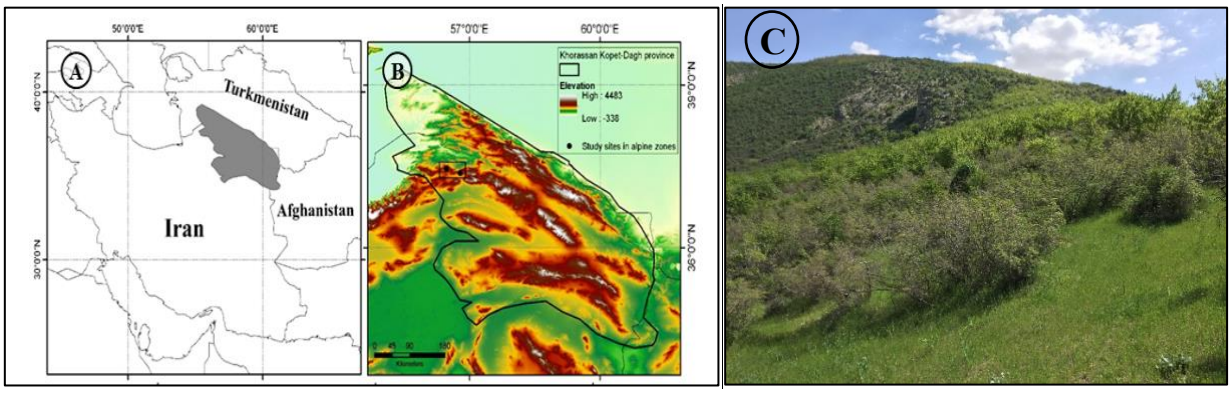

Figure 1. Maps of the study area: A: Location of Khorassan-Kopet Dagh (KK) Floristic Province; B: Topographic map C: And a typical vegetation of study area.

Results and Discussion

Based on the floristic study, 252 species were recorded belonging to 83 genera and 44 families. The richest families are Poaceae, Asteraceae, and Lamiaceae. Hemicryptophytes and therophytes were the dominant life-form in this area and grasses with 31 species were dominant in understories. (Fig. 2 and Table 1). *Poa nemoralis* was an important dominant grass under the oak community. *Piptatherum ferganense* has been introduced as a new grass for the study area (Memariani *et al*. 2022).

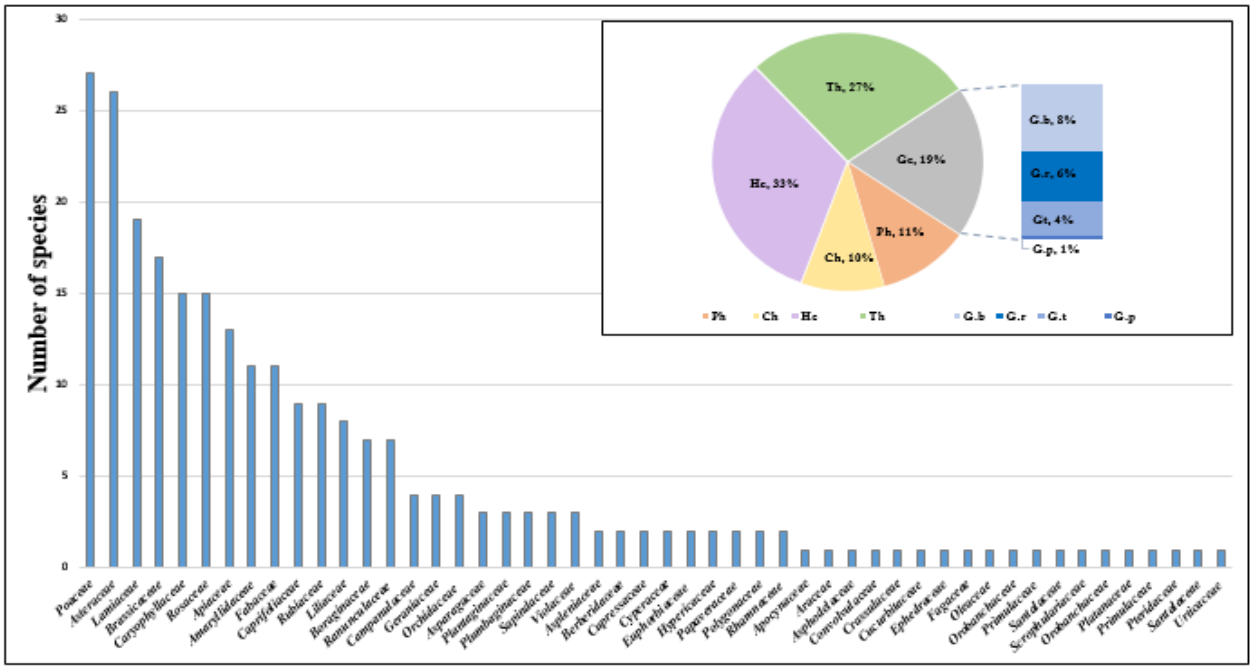

Figure 2. The number of species in plant families and the life-form spectrum: Ch: chamaephytes, G.b: bulbous geophytes, G.t: tuberous geophytes, G.r: rhizomatous geophytes, G.p: parasitic geophytes, He: hemicryptophytes, Ph: phanerophytes, and Th: therophytes.

Table.1. The graminoids in study area.

No.	Family	Species	Life-form	No.	Family	Species	Life-form
1	Cyperaceae	*Carex halleriana*	G.r	17	Poaceae	*Poa nemoralis*	He
2	Cyperaceae	*Carex leersii (=Carex cuprina)*	G.r	18	Poaceae	*Poa versicolor*	He
3	Poaceae	*Brachypodium sylvaticum*	He	19	Poaceae	*Stipa caucasica*	He
4	Poaceae	*Bromus briziformis*	He	20	Poaceae	*Stipa lessingiana*	He
5	Poaceae	*Bromus danthoniae*	He	21	Poaceae	*Arrhenatherum elatius subsp. elatius*	He
6	Poaceae	*Bromus kopetdaghensis*	He	22	Poaceae	*Avena sterilis*	Th
7	Poaceae	*Dactylis glomerata* subsp. *glomerata*	He	23	Poaceae	*Bromus sterilis*	Th
8	Poaceae	*Elymus hispidus*	He	24	Poaceae	*Bromus tectorum*	Th
9	Poaceae	*Elymus longearistatus*	He	25	Poaceae	*Echinaria capitata*	Th
10	Poaceae	*Elymus repens*	He	26	Poaceae	*Hordeum murinum*	Th
11	Poaceae	*Festuca valesiaca*	He	27	Poaceae	*Milium vernale*	Th
12	Poaceae	*Hordelymus europaeus*	He	28	Poaceae	*Phleum paniculatum*	Th
13	Poaceae	*Koeleria macrantha*	He	29	Poaceae	*Taeniatherum caput-medusae*	Th
14	Poaceae	*Melica persica*	He	30	Poaceae	*Aegilops tauschii*	Th
15	Poaceae	*Piptatherum ferganense*	He	31	Poaceae	*Aegilops triuncialis*	Th
16	Poaceae	*Poa densa*	He				

Based on the Hill indices and the species diversity profile, the understory of shrubland (1100 to 1600) has the highest value followed by oak forest (1600-2100) and alpine (2100-2600) understories (Fig. 3).

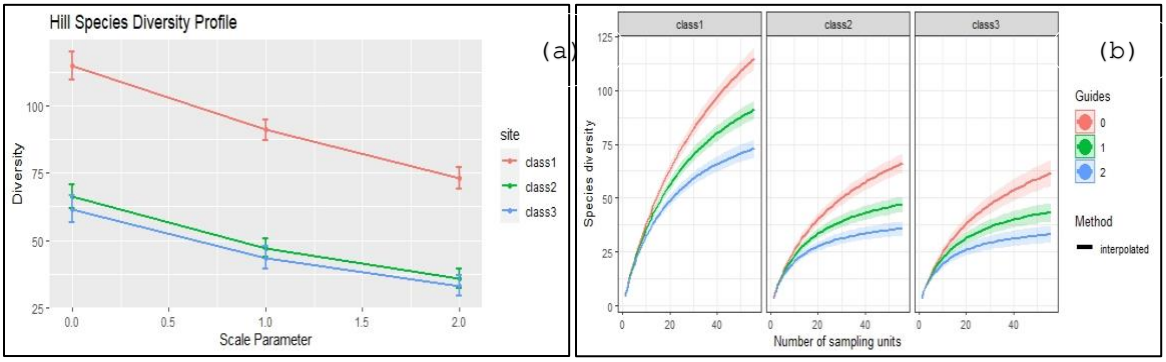

Figure 3. Hill indices (N0, N1, N2) (a) and Hill species diversity profile (b) along the altitudinal gradient with class intervals of 500 m.

Most of the beta diversity indices in the shrubland understory (1100 to 1600), have the highest values, followed by oak forest (1600-2100) and alpine (2100-2600) understories (Table 2).

Table 2. Beta diversity indices in interval classes of 500 m in the study area.

Altitude classes	Whittaker	Harrison	Cody	Routledge	Wilson-Shmida	Mourelle	Harrison 2	Williams
1100-1600	11.117	0.11702	893	0.81744	55.776	0.58712	0.065107	0.86082
1600-2100	7.2747	0.12763	379.5	0.65975	29.348	0.51488	0.071846	0.80374
2100-2600	5.6684	0.17714	211	0.5941	18.039	0.56371	0.11213	0.78205

The study area with three vegetation types (shrubland, oak forest, and alpine) is one of the hotspots of plant biodiversity in the Irano-Turanian region. In general, the values of diversity indices show a decreasing trend along the altitude gradient due to heterogeneity of vegetation which in turn is due to complex topography, diverse habitats, and the long evolutionary history of this area. Considering the existence of a high species diversity and the vulnerability of most understory plant species, especially young oak seedlings, due to

animal grazing and in order to protect valuable plant species and communities, especially young oak seedlings in this region, it is recommended that a protective corridor should be created along the gradient of 1500 meters. This strategy is necessary to protect this unique habitat.

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