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Floristic, life form and chorological studies of the Saqalaksar forest, Rasht, Northern Iran

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ABSTRACT
Saqalaksar forest is a relict of Caspian plain forests with an area of 200 ha in northern Iran and an altitude of 60 to 150 m a.s.l. This study was conducted to determine the floristic composition, life form and chorology of all plants of the region. Based on the results, 94 vascular plant species belonging to 80 genera and 46 families were identified in the study area. The most numerous families were Rosaceae (10 species), Fabaceae (8 species), Poaceae (7 species) as well as Asteraceae and Lamiaceae (6 species each). The classification according to the life spectrum showed that geophytes with 28 species (29.79 %) and therophytes with 25 species (26.60 %) had the highest proportion of life forms in the region. Similarly, the results of the chronological studies showed that the largest proportion of the flora consisted of pluri-regional elements (34 species, 36.17 %). As the forests investigated in this study are considered remnants of the Caspian Plain forests, urgent conservation measures are needed to protect these very important, vulnerable and threatened ecosystems.

Keywords: Plant, Flora, Guilan Province, Lowland forest, Chorological studies.
Article type: Research Article.

INTRODUCTION
The floristic survey documents all plant species in a given geographical area, provides an essential tool for biodiversity assessment and monitoring (Barans 1969; Chiarucci & Bonini 2005; Ataei *et al.* 2021; Kudryavtsev *et al.* 2021; Mirhashemi *et al.* 2021; Aghajani *et al.* 2023; Muratovna *et al.* 2024) and shows unknown angles of the vegetation of the area (Yousefi 2009). The study of the flora of each area is very important to provide basic information on the ecological capacity of that area, to assess the effectiveness of management in the area and to protect threatened and vulnerable species (Stanford & Robinson 2005; Najafi Tire Shabankar 2008). In addition, plant geography and floristic surveys of each region show the region's position in the International Union for Conservation of Nature (IUCN 2020). Forests are a valuable asset for countries. The existence of forests in the countries creates an enormous wealth that encompasses all aspects. The Hyrcanian region, stretch in an arc along the southern shore of the Caspian Sea, is located in the provinces of Guilan, Mazandaran and Golestan in Northern Iran. They are the most important remnants of Arcto-Tertiary forests (Scharnweber *et al.* 2007) located in the Euro-Siberian geographical vegetation zone (Zohary 1973; Léonard 1988; Akhani 1998) and in steppe forest ecotones. Unlike arid and semi-arid landscapes in most central and southern regions of Iran (Naqinezhad *et al.* 2008), Hyrcanian forests receive large amount of water vapor from evaporation of the Caspian Sea. As these water vapours meet a large barrier such as the Alborz Mountains and form dense clouds, heavy rainfall in the northern part of the mountain range has given rise to dense forests, in contrast to the southern half (Knapp 2005). Hyrcanian forests comprise 15% of the total forests of Iran and 1.1% of the total area of the country (Sagheb-Talebi 2014), which is scattered from the sea level up to 2800 m and includes several types of plants (Tohidifar *et al.* 2016). So far, numerous studies have been carried out on the floristic composition and vegetation of Hyrcanian forests (e.g. Djazirei 1964-1965; Tregubov & Mobayen 1970; Zohary 1973; Dorostkar 1974; Assadollahi 1980; Rastin 1983;

Frey & Probst 1986; Klein 2001; Ghahreman *et al.* 2006; Hamzeh'ee *et al.* 2008; Naqinezhad *et al.* 2008; Atashgahi *et al.* 2009; Akhani *et al.* 2010; Bazdid vahdati *et al.* 2014; Naqinezhad *et al.* 2015; Bazdid vahdati *et al*. 2017; Poursiidian *et al*. 2022). However, there is no information on the vegetation of the Saqalaksar forest. The aim of this study was to determine the floristic composition, life forms and chorology of each taxon. The results will also provide (i) an overview of the biodiversity of plant species, (ii) a checklist of all vascular plants found in the study area, (iii) a comparison of the present study with recorded data from other forest areas in the Hyrcanian region, and (iv) the identification of threats to the conservation of the vegetation.

MATERIALS AND METHODS

Study Area

The dense forest of Saqalaksar is located beside the ecotourism village of Saqalaksar, on the southeastern border of Rasht City and northeast of Shaft City (Guilan Province). It is noteworthy that the Saqalaksar earth dam has created a natural and tourist-friendly area on the edge of the dense forest. The study area covers an area of 200 ha between latitudes 37°8′33″-37°9′25″ N and longitudes 49°31′48″-49°32′46″ E and includes both aquatic and terrestrial habitats. The minimum and maximum elevation of the study area varies between 60 and 150 m a.s.l., which is one of the few remnants of forest in lowland areas (Fig. 1).

Fig. 1. Location of the Saqalaksar area in Guilan Province, Iran (https://www.google.com/).

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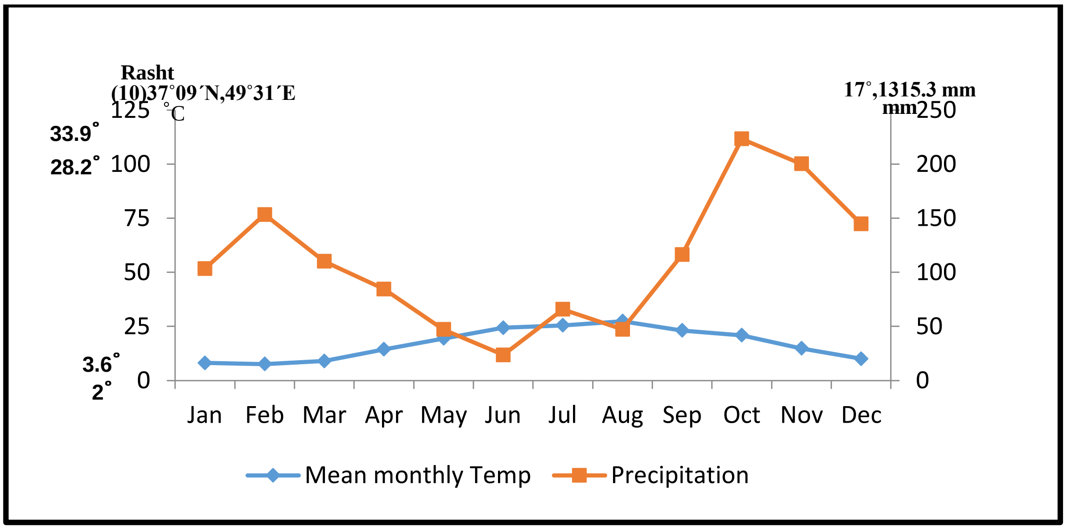

Fig. 2. Climatological diagram from Rasht station (2010-2020).

According to long-term statistics, climate is the general state of the climate prevailing in a particular place (Bailey 1999), so defining the climate zones of a region requires recognition of climate heterogeneity factors over time and space (Harding *et al.* 2011). Based on the De'Martonne and Emberger climate classification (De Martonne 1926; Emberger 1932), the Saqalaksar ecotourism region has a very humid climate, and according to a recent bioclimatic classification of Iran (Rivas-Martinez *et al.* 1997, 1999), the region is also known as a temperate oceanic climate (sub-Mediterranean type) or Tocsm (Djamali *et al.* 2011). The average rainfall and temperature during the last 10 years (2010-2020) were 1315.37 mm and 17.03 °C, respectively. The average minimum and maximum temperatures varied between 2.7 and 27.16 °C, respectively. The maximum rainfall is in late summer and autumn (September to December; Fig. 2), when July is the hottest month of the year.

Data collection

Data collection was performed during three seasons (spring, summer and autumn) of 2018 and 2019. The voucher specimens were deposited in the Herbarium of Guilan University, Rasht, Iran. The plant specimens were collected of 25 relevés with an area of 400 m^2 for forest and 25 m^2 for herbaceous habitat, based on Mueler-Dombois & Ellenbreg (1974) and Djazirei (1965) and minimal areas method (Cain 1938). Floristic data were collected using relevés of 25 with an area of 400 m^2 for forest and 25 m^2 for herbaceous habitat, based on Mueler-Dombois & Ellenbreg (1974) and Djazirei (1965). The specimens were identified by Rechinger (1963-2015), Assadi *et al.* (1988-2016), Davis (1965-1985), Ghahreman (1979-2005) and Tutin *et al.* (1964-1980). The classification of flowering plants was coordinated based on APG IV (2016) and the names of the authors of the taxon using IPNI (2020). Life form classification was identified based on the Raunkiaer classification system (Raunkiaer 1934). Detailed information about phanerophytes based on Pears (1985), (megaphanerophyte = more than 30 m height, mesophanerophytes = 8-30 m height, microphanerophytes = 2-8 m, nanophanerophytes = less than 2 m height, liana = no height limit). The distribution of the species was taken from surveys, monographs and floras, especially the Flora Iranica (Rechinger 1963-2015) and Flora of Turkey (Davis 1965-1985). The terminology and delimitation of the main phytochoria followed the concepts used by Zohary (1973) and Takhtajan (1986). The abbreviations used are ES (plants distributed in the Euro-Siberian region), PL (Pluriregional, Plants distributed in three phytogeographical regions), M (plant distributed in the Mediterranean region), IT (plant distributed in the Irano-Turanian region), COS (Cosmopolitan, refers to a plant with a worldwide distribution), SCOS (Sub cosmopolitan, a plant distributed on most continents but not all).

RESULTS AND DISCUSSION

Flora

As a result of our fieldwork, the vascular flora of Saqalaksar forest contains a total of 94 taxa from 46 families and 80 genera (Appendix 1). Angiosperms include Eudicots with 72 species, 61genera and 34 families, followed by monocots with 17 species, 15 genera and 8 families. While Monilophytes (Pteridophytes) represent 5 species, 4 genera and 4 families (Table 1). In terms of the number of genera, the richest families were Rosaceae and Poaceae (7 genera), Asteraceae (6 genera), Fabaceae and Lamiaceae (5 genera; Fig. 3). The genus with the highest number of species was *Trifolium* with 4 species, *Carex* and *Rubus* each with 3 species, *Asplenium, Crataegus, Geranium, Mentha, Ranunculus, Solanum* and *Viola* with 2 representatives each, and the remaining 70 genera with 1 species. The floristic composition of the region indicated the predominance of angiosperms and the ratio of Eudicots (76.60%) to Monocots (18.08%) = 4: 1, which is typical for the flora of Iran and Central Asia (Kamakhina 1994; Memariani *et al.* 2016). Pteridophytes (5 species, 5.32%), were the least diverse group in the region. The richest families of vascular plants in terms of number of species were Rosaceae with 10 species, Fabaceae with 8 species, Poaceae with 7 species, Asteraceae and Lamiaceae with 6 species (Fig. 3). The presence of Rosaceae as the largest family has been reported in previous studies in lowland and mountain forests (Fallah *et al.* 2009; Siadati *et al.* 2010; Ghahremaninejad *et al.* 2011). The abundance of Rosaceae species can be due to geographical conditions, their impacts on the region and the Hyrcanian climate (Razavi & Abbasi 2009), while presence of Poaceae indicates the role of habitat diversity as well as developed soils in the species richness of grasses and Asteraceae, which consist mainly of xerophytic species (Memariani *et al.* 2016). In this study, the results indicated high plant diversity in a limited area. Moreover, comparison of these results with some previous studies in Hyrcanian lowland forest such as Gisum (Ravanbakhsh & Amini 2012), Sedtrik Rudbar (Haghgooy &

Pourbabaei 2012) and Bibi Yanloo Astara (Salahi *et al.* 2018), show similarities in the floristic composition (Table 3).

Table 1. Number of families, genera and species of main plant groups of Saqalaksar.

Plant Groups	Families	Genera	Species
Eudicots	34	61	72
Monocots	8	15	17
Monilophytes	4	4	5
Total	46	80	94

Table 2. Number of families, genera and species according to APG IV (2016).

				Family	Genus	Species
Angiosperms	Monocots	Commelinids	Poales	3	9	11
		Alismatales		3	3	3
		Asparagales		1	2	2
		Liliales		1	1	1
	Ceratophyllales			1	1	1
	Eudicots	Ranunculales		1	1	2
		Fabids	Fabales	1	5	8
			Rosales	3	9	12
			Fagales	3	4	4
			Oxalidales	1	1	1
			Malpighiales	3	4	5
		Malvids	Geraniales	1	1	2
			Myrtales	1	1	1
			Malvales	1	1	1
			Sapindales	2	2	2
		Superrosids	Saxifragales	1	1	1
		Superasterids	Caryophyllales	2	3	3
		Asterids	Ericales	1	3	3
		Campanulids	Aquioliales	1	1	1
			Asterales	1	6	6
			Apiales	2	3	3
			Dipsacales	1	1	1
		Lamiids	Solanales	2	3	4
			Lamiales	3	8	9
			Gentianales	2	2	2
			Total	42	76	89

Table 3. Comparison of floristic richness of Saqalaksar forest with Gisoum (Ravanbakhsh & Amini 2012), Sadetarik Rudbar (Haghgooy & Pourbabaei 2012) and Bibi Yanlou Astara (Salahi *et al.* 2018).

Number of plants	Saqalaksar	Sadetarik Rudbar	Bibi Yanlou	Gisoum
Number of species	94	90	92	76
Number of genera	80	81	79	66
Number of Family	46	46	48	45

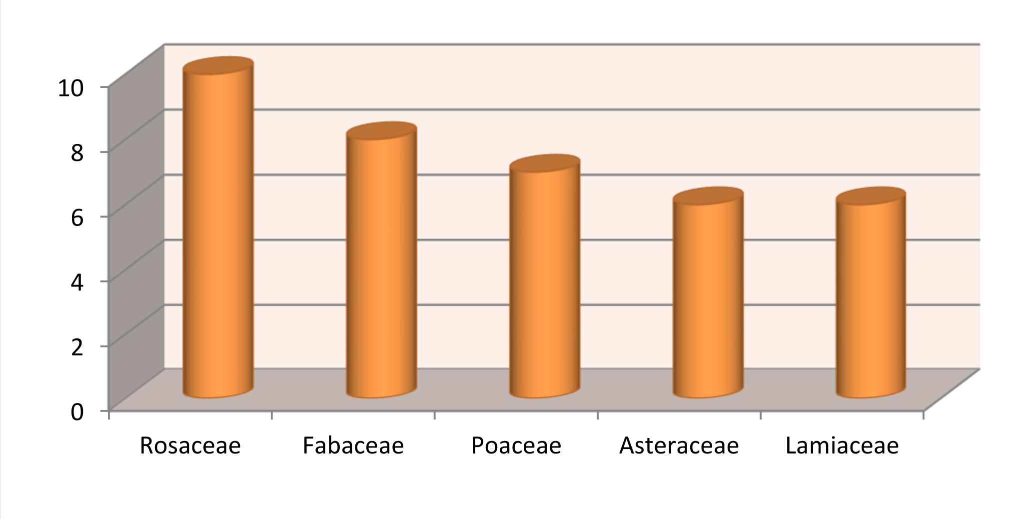

Fig. 3. The richest families in terms of species.

Table 3. Comparison of floristic richness of Saqalaksar forest with Gisoum (Ravanbakhsh & Amini 2012), Sadetarik Rudbar (Haghgooy & Pourbabaei 2012) and Bibi Yanlou Astara (Salahi *et al.* 2018).

Number of plants	Saqalaksar	Sadetarik Rudbar	Bibi Yanlou	Gisoum
Number of species	94	90	92	76
Number of genera	80	81	79	66
Number of Family	46	46	48	45

Life form spectrum

The life spectrum of plants provides information about their adaptation to environmental conditions, which leads to a classification based on habitat conditions (Archibold 1995; Memariani *et al.* 2016). It can also describe how plants adapt morphologically to climatic factors (Kent & Coker 1995; Asri 2011). Each plant species has a different biological spectrum, which forms the basic structure of the plant communities (Mobayen 1985). In the assessment of life forms, geophytes dominated by 28 species (29.79%), followed by therophytes by 25 species (26.60%), phanerophytes by 23 species (24.47%), hemicryptophytes by 13 species (13.82%), hydrophytes by 3 species (3.20%) and helophytes by 2 species (2.12%; Fig. 4). A precise classification of the phanerophytes also shows that microphanerophytes are represented by 10 species (10.62 %), megaphanerophytes by 5 species (5.30 %), nanophanerophytes by 4 species (4.25 %), lianas by 3 species (3.20 %) and mesophanerophytes by 1 species (1.1 %). The high proportion of geophytes in the study area is mainly due to the long wet period during the growing season and the relatively high annual precipitation (Danin & Orshan 1990). This is consistent with the results of floristic studies in other forest areas of Hyrcanian province (e.g. Akbarinia *et al.* 2004; Ghahreman *et al.* 2006; Razavi 2008; Bazdid Vahdati *et al.* 2014). While therophytes are second only to geophytes in the study area, a high percentage of this life form compared to geophytes indicates a relatively strong degradation in this area. Due to moisture and anthropogenic activities, they grow everywhere in the region, especially around the dam. They seem to have been adapted to dry habitats by completing their annual life cycle (Memariani *et al.* 2016). Although therophytes are found in large numbers in desert areas (Archibold 1995), a high percentage of this life form is also found in lowland areas, as most areas are damaged by anthropogenic activities and overgrazing (Naqinezhad *et al.* 2010-2011; Ghahremaninejad *et al.* 2011; Bazdid Vahdati *et al.* 2014). Regarding the relationship between Rosaceae and their destructive factors in the region, it is noted that the edible fruits of Rosaceae can attract other factors such as humans and animals to the region and consequently cause soil erosion and displacement. Therefore, they can create favourable conditions for the growth of therophytes in the region. Phanerophytes are the predominant life form after therophytes. The abundance of phanerophytes could be due to the Mediterranean microclimate and topographic features of the region (Duran 2002). For the establishment of phanerophytes, it is necessary to provide the resources and vegetation conditions of the region and to prevent and protect them from destruction in the region (Vaseghi *et al.* 2008). In Noor Forest Park, phanrophytes were introduced by 33 % of the largest life form spectrum in the area (Yousefvand *et al.* 2017). The percentage of life forms varies from climate to climate, and the spectrum extracted from each region reflects the climate (Raunkiaer 1934; Mueler-Dombois & Ellenberg 1974). In temperate regions, the predominant species are hemicryptophytes (Raunkiaer 1934), however, due to degradation in the region, therophytes have a high proportion, which is consistent with previous studies (Grime 2001; Bazdid vahdati *et al*. 2014). Hydrophytes are adapted to life in water and are found in areas such as ponds, rivers, streams, lakes, wetlands and other aquatic environments. They develop certain characteristics (adaptations) to ensure their survival in the aquatic environment. Of the three hydrophytes identified, *Ceratophyllum demersum*, *Lemna minor* and *Stuckenia pectinata* were fully submerged and anchored to the substrate. *L. minor*, on the other hand, is free-floating and has a strand of root (Tansley 1949; Penfound 1952; Spence 1964; Sculthorpe 1967). *Ludwigia palustris* (L.) Elliott and *Alisma gramineum* Lej. are two helophytes that occur in this area. They are aquatic macrophytes (Penfound 1952) that root in shallow water and rise above the water surface (Sender & Grabowski 2016). In general, helophytes occur in the transition zone between aquatic and terrestrial environments (Hernández & Rangel 2009; Tavakoli *et al*. 2014). For example, the amphibious nature and high morphological ductility of *Ludwigia* allow it to withstand a wide range of environmental conditions and efficiently colonize aquatic environments (especially rivers, ditches and canals, natural lakes, ponds, wetlands and artificial lakes; Thouvenot *et al.* 2013). In addition, the comparison between the life forms in the forest of Saqalaksar and other forests in Northern Iran is also shown in Fig. 5 (Ghahremaninejad *et al.* 2011; Bazid Vahdati *et al.* 2014; Akhondnejad *et al.* 2016). A high proportion of geophytes can be found in Saqalaksar, Ata-Kuh (Southeastern of lahijan, Gilan province) and Izdeh-e Noor (Noor, Mazandaran province). These concentrations appear to be the most similar to the natural structure and flora of the forests of the Hyrcanian Plain (Zohary 1973; Rastin 1983). Therophytes are present in Semeskandeh and Dasht-e Naz (South of Sari, Mazandaran province) (Ghahremaninejad *et al.* 2011). The therophytes in Semeskandeh and Dasht-e Naz show the peak of occurrence (Ghahremaninejad *et al.* 2011) and the high percentage of therophytes in these two localities is probably due to some reasons, disturbance and human activities. These results are also consistent with the studies of Grime (2001).

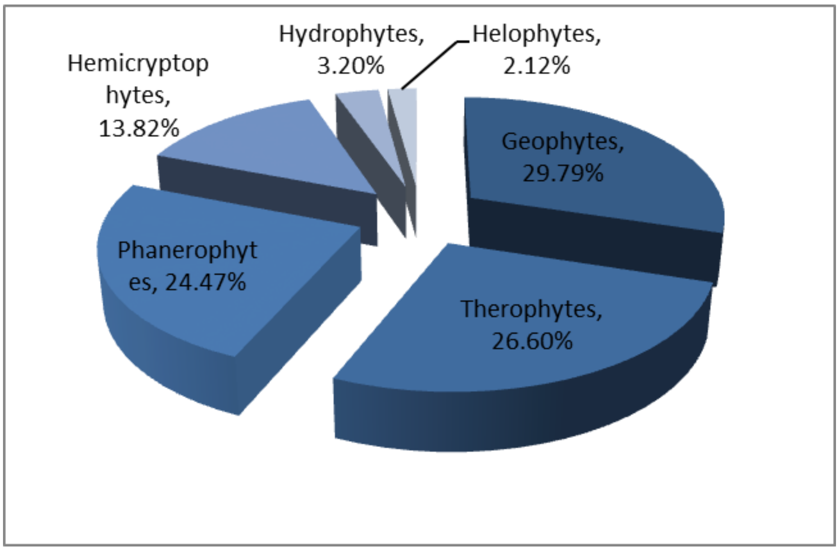

Fig. 4. Life form spectrum of plants studied in Saqalaksar forest.

Chorotype spectrum

In terms of geographical distribution, the flora of the studied area is mainly composed of PL elements (34 species, 36.17%), followed by ES (22 species, 23.40%), ES-M-IT (12 species, 12.76%), SCOS (8 species, 8.51%), ES-IT (7 species, 7.44%), COS (6 species, 6.37%), ES-M (4 species, 4.25%) and M elements (1 species, 1.1%) respectively (Fig. 6). Each plant species has a unique ecological range and tolerates a certain degree of ecological change. Therefore, floristic research and study of the geographical distribution of plant species in these areas serve to better understand the potential of the environment and also to manage and protect genetic resources (Naqinezhad *et al.* 2015). Based on the information available, the pluriregional element exhibited the largest geographical distribution. In the classification, geographic distribution refers to pluriregional elements that occur in more than four regions. Plants that have spread in two or more geographical areas, account for about 19% of the flora of Iran (Zohary 1973). According to Naqinezhad *et al.* (2006), water stations (e.g. the areas around the earth dam) with high humidity provide the necessary conditions for the establishment of pluriregional elements. In addition, some researchers confirmed the occurrence of pluriregional elements affected by both water resources and destructive human activities (Gahreman *et al.* 2006; Naqinezhad *et al.* 2008). In explaining the pluriregional elements, it is assumed that they mainly rely on secondary habitats with particular soil conditions such as swamps, marshes, sand dunes and rocks (Mehrabian *et al.* 2009).

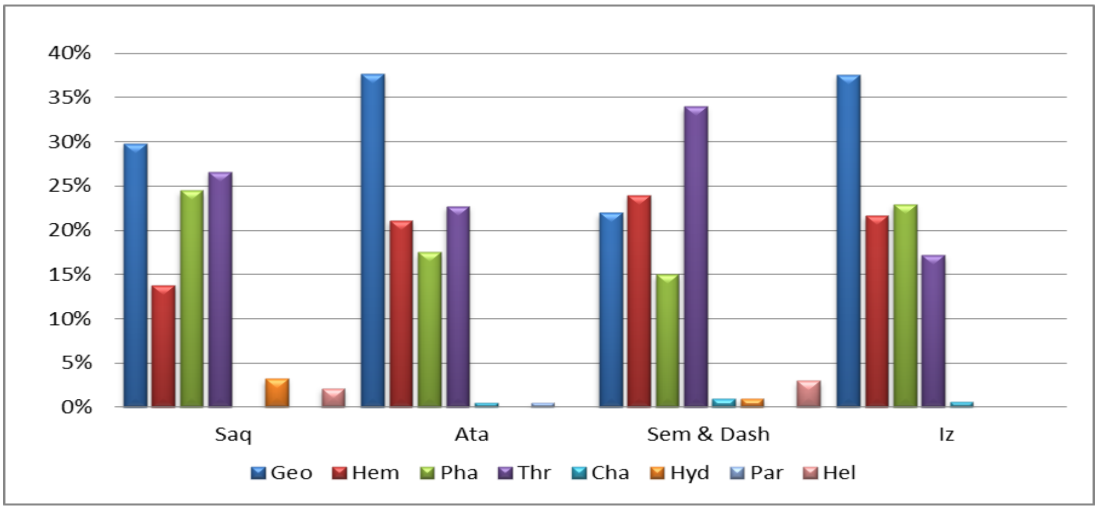

Fig. 5. Variation of each life form over the sites Ata-Kuh forest (Bazdid vahdati *et al.* 2014); Semeskandeh and Dasht-e Naz forests (Ghahremaninejad *et al.* 2011); Iz = Izdeh-e Noor forest (Akhondnejad *et al.* 2016). Abbreviations: (Cha = Chamaephyte, Geo = Geophyte, Hel = Helophyte, Hem = Hemicryptophyte, Hyd= Hydrophyte, Pha = Phanerophyte, Par = Parasite, Thr = Therophyte).

Euro-Siberian elements were the predominant chorotype after PL, demonstrating the association of this forest with European-Siberian forests (Ghahreman *et al.* 2006; Siadati *et al.* 2010). The phytogeographic elements were compared with those of other Caspian lowland forests (Ghahremaninejad *et al.* 2011; Bazdid Vahdati *et al.* 2014; Akhondnejad *et al*. 2016; Fig. 7). Two peaks can be observed in the phytochoria spectrum, one in the pluriregional and the other in the Euro-Siberian elements. Phytogeographic elements such as PL and ES exhibit high variation between sites, while ES-M-IT, ES-M, COS, SCOS, M, IT-M-PON and M-IT do not display much variation between sites. The highest proportion of pluriregional elements was found in Saqalaksar, while the lowest proportion in the forests of Izdeh-e Noor. This is due to the fact that the faces of this site are more affected by anthropogenic activities. These results are also consistent with the studies of Ghahremaninejad *et al.* (2011). In addition, Ata-Kuh has the highest proportion of Euro-Siberian elements. Our results suggest that the Ata-Kuh forest has the highest correspondence to a common Euro-Siberian forest due to the large number of Euro-Siberian elements.

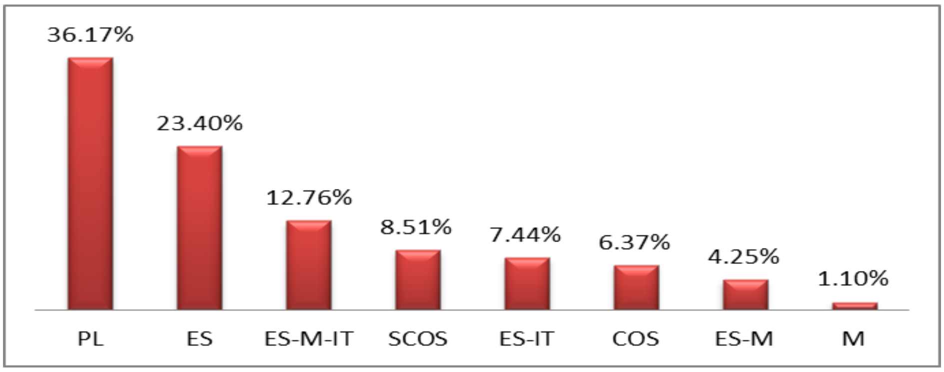

Fig. 6. Proportion of different phytochoria elements of plants in Saqalaksar forest. Abbreviations (ES= Euro-Siberian, PL= Pluriregional, M= Mediterranean, IT= Irano-Turanian, COS= Cosmopolitan, SCOS= Subcosmopolitan).

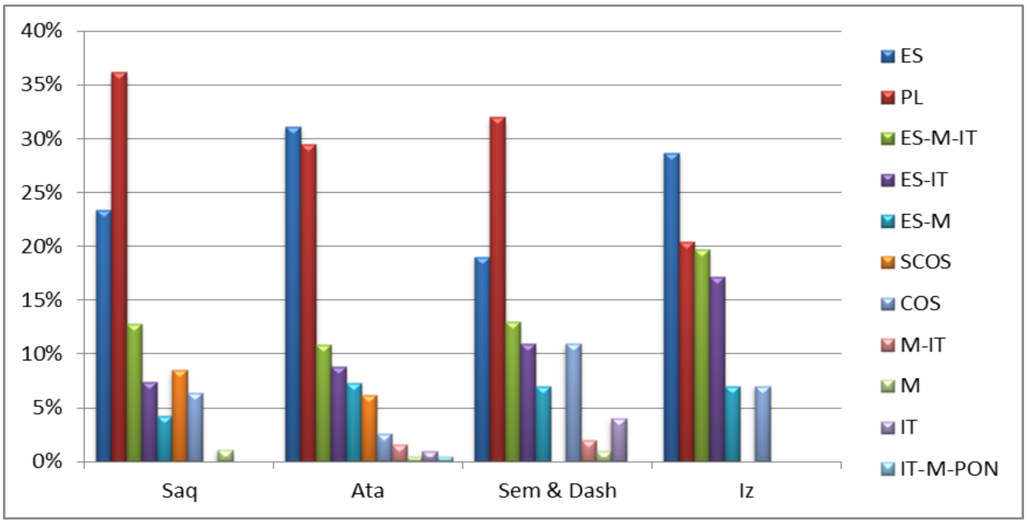

Fig. 7. Variation of each phytochoria over the sites. Abbreviations: Saq= Saqalaksar, Ata = Ata-kuh, Sem & Dash = Semeskandeh and Dashte-Naz, Iz = Izdeh-e Noor, ES = Euro-Siberian, PL= Pluriregional, M = Mediterranean, IT = Irano-Turanian, COS = Cosmopolitan, SCOS = Subcosmopolitan.

Hyrcanian endemics

These are species occur exclusively in the Hyrcanian geographical area. From a floristic point of view, the occurrence of 44% of all plant species in Iran (3234 out of 7300 species) on only 6% of Iranian surface area (Akhani *et al.* 2010) is very significant. The endemic species of each region are considered the most important species of that region, since their unique occurrence creates a rare diversity compared to other regions where they are more common, indicating the special ecological conditions and genetic diversity of the region. The Saqalaksar forest comprises about 11 species endemic/subendemic to the Hyrcanian province. Among them, *Gleditsia caspica, Quercus castaneifolia, Parrotia persica, Acer velutinum* comprise the best known Hyrcanian endemic trees (Akhani *et al.* 2010; Alavi *et al.* 2020), while *Ilex spinigera, Hedera pastuchovii* and *Ruscus hyrcanus* are evergreen species that grow in most of these forests (Rastin 1983).

CONCLUSION

The study of the vegetation in the region shows a great ecological diversity, including aquatic and terrestrial habitats, most of which are forested areas. Most of this biodiversity is only found in a small part of the dam. This demonstrates the importance of vegetation in marginal areas and prevents further destruction and conservation of the remaining elements. As a number of species are only located in one releves, the focus can be placed on protecting and managing the vegetation in this area. In addition, unregulated tourism activities can cause serious damage to the vegetation. Therefore, the threat category of the plant species should be considered according to the IUCN categories and criteria.

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Appendix 1

Floristic list of the Saqalaksar forest.

Symbols and abbreviation used:

1. Life cycle

A = Annual, B = Biennial, P = Perennial

2. Life forms

G = Geophyte, Hel = Helophytes, Hem = Hemicryptophyte, Hyd = Hydrophyte, Pha = Phanerophyte [PH-M = megaphanerophyte, PH-m = mesophanerophyte, PH-mi = microphanerophyte, PH-n = nanophanerophyte, PH-li = Liana], T = Therophyte.

3. Chorotype

COS = Cosmopolitan, ES= Euro-Siberian (Hyr = Hyrcanian, E-Hyr = Euxino-Hyrcanian, E = Endemic), IT = Irano-Turanian, M = Mediterranean, PL = Pluriregional, SCOS = Subcosmopolitan

Hb. No.= Herbarium number