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Floristic study on Sikash region of Siahkal district, Guilan Province, North Iran

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ABSTRACT
Identification of plant species in each region reflects the influence of various ecological factors. Sikash Forest, an area within Hyrcanian relict forests, with an area of approximately 744 hectares is located southwest of Siahkal in Northern Iran. In this study, the floristic composition and chorology of plant species of this region were investigated. Based on floristic studies from 2024 through 2025, 131 vascular plant species were identified, representing 104 genera and 49 families. Among them, 15 species (11.45%) were endemic to subendemic to Iran. The most species-rich families were Poaceae (13 species, 9.92%) and Asteraceae (9 species, 6.87%). They are followed by Rosaceae, Lamiaceae, Fabaceae, and Polypodiaceae, each with 8 species (6.1%). In terms of generic diversity, Poaceae and Asteraceae were the most diverse, with 13 and 9 genera, respectively. Regarding life form spectra, therophytes (22.77%) and hemicryptophytes (22.13%) represented the highest proportions. In terms of chorological types, Pluriregional elements (28.24%) were the most common ones of the region. Additionally, 61 species (45.46%), belonging to 33 families, were identified as medicinal plants. The present floristic study provides a valuable foundation for future ecological research, conservation planning, and sustainable management of Sikash Forest.

Keywords: Biodiversity, Chorotype, Hyrcanian Forest, Life form.
Article type: Research Article.

INTRODUCTION
Forests are among the most important biodiversity on Earth, and the conservation of forest biodiversity is essential for the productive value of forests, the health and vitality of forest ecosystems, as well as environmental and cultural processes (Thomson *et al.* 2001). The northern slopes of the Alborz Mountains range are covered with deciduous forests known as Hyrcanian Forests. These forests are sustained by the region's humid climate and substantial rainfall, with annual precipitation ranging from 700 to 1,200 mm, which dominates this part of Northern Iran. This region in Iran extends approximately 800 kilometers across four provinces: Guilan, Mazandaran, Golestan, and North Khorasan, covering an area of about 1.84 million hectares (Siadati *et al.* 2010). Hyrcanian forests are recognized as part of the Euro-Siberian (ES) phytogeographic region and represent a unique vegetation in Iran. These forests contain many deciduous trees, some of them are relicts of the Tertiary period, such as *Zelkova carpinifolia* (Pall.) K.Koch, *Parrotia persica* C.A.Mey., *Pterocarya fraxinifolia* (Poir.) Spach, *Quercus castaneifolia* C.A.Mey., and some semi-tropical Asian trees like *Albizia julibrissin* Durazz. These forests have three altitudinal vegetation zones (lowland, foothill, alpine) ranging from sea level to an altitude of 2,500 meters above sea level (m a.s.l.; Akhani *et al.* 2010). Floristic studies are important approaches in plant systematics that reveal the unknown aspects of vegetation in areas by identifying the quantitative and qualitative characteristics of the plant cover, serving as a sort of identification document for that region. One way to

understand the potential and actual capabilities of vegetation is to collect information about the plants in each area, which facilitates planning and selecting appropriate strategies for the conservation of ecosystems (Esmailzadeh *et al.* 2014). Since Iran is predominately located in arid and semi-arid zones, the existence of the humid Hyrcanian forests in Iran has attracted considerable interest among researchers. Consequently, numerous studies have been conducted over the past century in these forests regarding their floristic aspects (e.g. Siadati *et al.* 2010; Naqinezhad & Zarezadeh 2012; Bazdid Vahdati *et al.* 2014; Akhondnejad *et al.* 2016; Bakhshandeh Navroud *et al.* 2017; Porseyedian *et al.* 2021; Bidarlord *et al.* 2021; Ajamian *et al.* 2024). To date, no precise and focused study has been conducted to determine the floristic composition of Sikash region. The construction of mountain roads and tourist access enhance tourists' accessibility to the studied areas, along with deforestation, overgrazing and the conversion of forests into agricultural lands, have significantly disturbed the vegetation of the region. In addition, in recent years, the presence of exotic species has increased, reflecting human activities or other vectors responsible for introducing alien species to the area. Therefore, considering the mentioned issues and the ecological importance of this region, assessing and documenting its native flora is of significant importance.

MATERIALS AND METHODS

Study area

Sikash forest, covering an area of approximately 744 hectares, is located 16 kilometers southwest of Siahkal in Guilan Province, N Iran between 37° 03' 30" to 37° 04' 18" N and 49° 50' 00" to 49° 51' 20" E (Fig. 1). The study area is located on the northern slope of the Alborz Mountain and elevation ranges from 325 to 700 m a.s.l. (Alborz Sabz consulting engineers 2010).

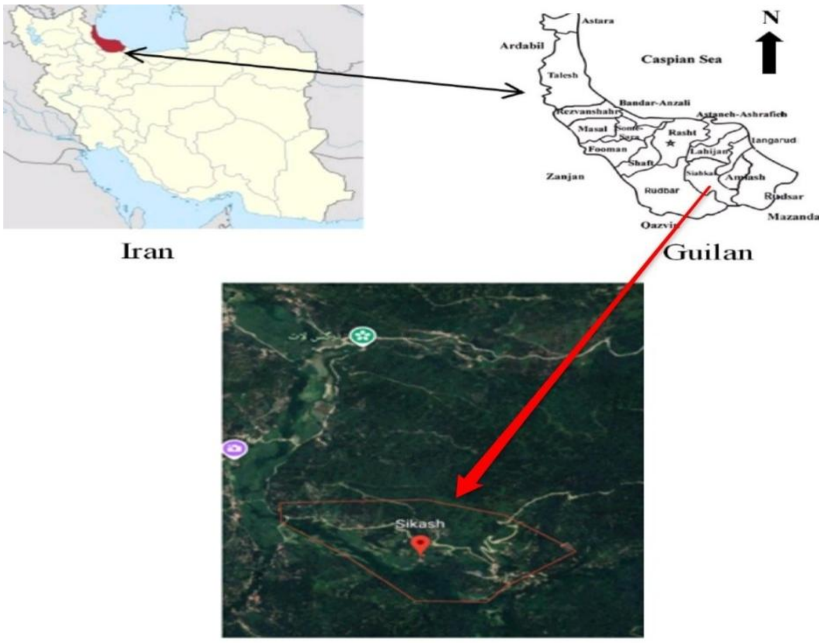

Fig. 1. Location of Sikash Forest in Guilan province, Iran (https://www.google.com/).

According to available data from the nearest climatological station to Sikash Forest (Lahijan climatological station, covering the 10-year period from 2014 to 2023), the region has a very humid climate. The maximum and minimum mean temperatures are 26.6 °C and 8.5 °C, respectively. The average total annual precipitation and average annual temperature are 1138.88 mm and 17.17 °C, respectively (Fig. 2). Based on Gossen's climate classification method, the area is categorized as cold semi-arid climate. However, according to the recent bioclimatic classification of Iran (Djamali *et al.* 2011), the climate of the area is considered to be temperate oceanic with semi-Mediterranean variant.

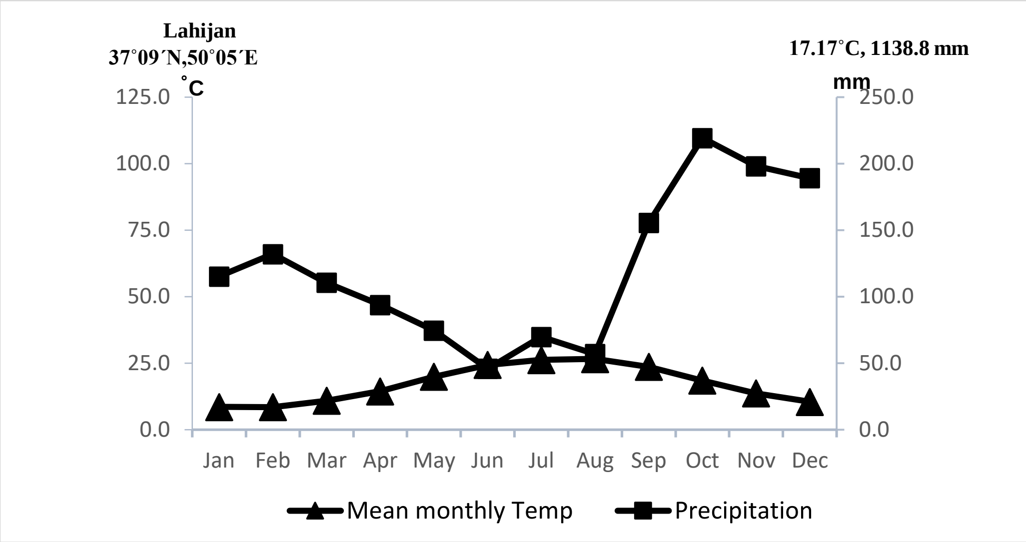

Fig. 2. Ombrothermic diagram drawn using climatological data from Lahijan meteorological station (2014–2023).

Data collection

Plant samples were collected from various parts of the study area during the growing seasons from March 2024 to March 2025. For each collection site, geographical coordinates (latitude, longitude, and altitude) and its habitat information were recorded. Additionally, photographs were taken for most of the collected plant species. After collecting and drying, the samples were transferred to the Guilan University Herbarium. Plant identification was performed using the current taxonomic references, including Flora Iranica, (Rechinger 1963–2015), Colored Flora of Iran (Ghahreman 1996–2022), Flora of Iran (Assadi *et al*. 1988–2023), Flora of Turkey (Davis 1965–1988), and Flora of Guilan (Mozaffarian 2018) and some other references (Bidarlord & Hamzeh'ee 2023). Moreover, seedless vascular plant species were identified using Khoshravesh *et al*. (2009). The classification of flowering plants was followed on APG IV system (2016). Type samples of the some identified species, taxonomic nomenclature, authoritative information and confidence level of the identified taxa were verified using botanical databases including International Plant Name Index (IPNI 2024); Plants of the World Online (POWO 2024), Global Biodiversity Information Facility (GBIF 2024), and World Flora Online (WFO 2025). The determination of the conservation status of species in Iran, where applicable, was based on the mentioned floras and the Red Data Book of Plants of Iran (Jalili & Jamzad 1999). Life form of species was determined according to Raunkiaer's classification system (Raunkiaer 1934). The geographical distribution of plant species (phytochorion) was determined based on the classification of vegetation regions (Zohary 1973; Takhtajan 1986), monographs and floras, particularly Flora Iranica (Rechinger 1963–2015), Flora of Turkey (Davis 1965–1988), Flora of Iran (Assadi *et al*. 1988–2023) and Plants of the World Online (POWO 2024).

RESULTS

A total of 131 taxa of vascular plants, belonging to 49 families and 104 genera, were recorded from Sikash Forest (Table 1). The images of some identified plants can be seen in Figs. 3 and 4. The flora comprised 18 species of seedless vascular plants and 113 species of angiosperms, of which 91 belonged to eudicots and 22 to monocots. Eudicots represented the most diverse group, encompassing 39 families, 77 genera and 91 species, while monocots are represented by 7 families, 17 genera and 22 species. Seedless vascular plants also exhibit notable diversity, with 18 recorded species belonging to four families and 10 genera. Among the families, Poaceae (13 species; 9.92%) and Asteraceae (9 species; 6.87%) are the most species-rich. These are followed by Rosaceae, Lamiaceae, Fabaceae, and Polypodiaceae, each comprising 8 species (6.1%). The most species- rich genus was *Trifolium* Tourn. ex L. with five species (3.81%), followed by *Dryopteris* Adans., *Carex* L., and *Veronica* L., each represented by four species (3.05%). Additionally, three genera were represented by three species, eight genera by two species, and 89 genera with one species. A list of species with conservation concern is provided in Table 2. Species not listed in Table 2 are considered as Not Evaluated (NE) for the flora of Iran.

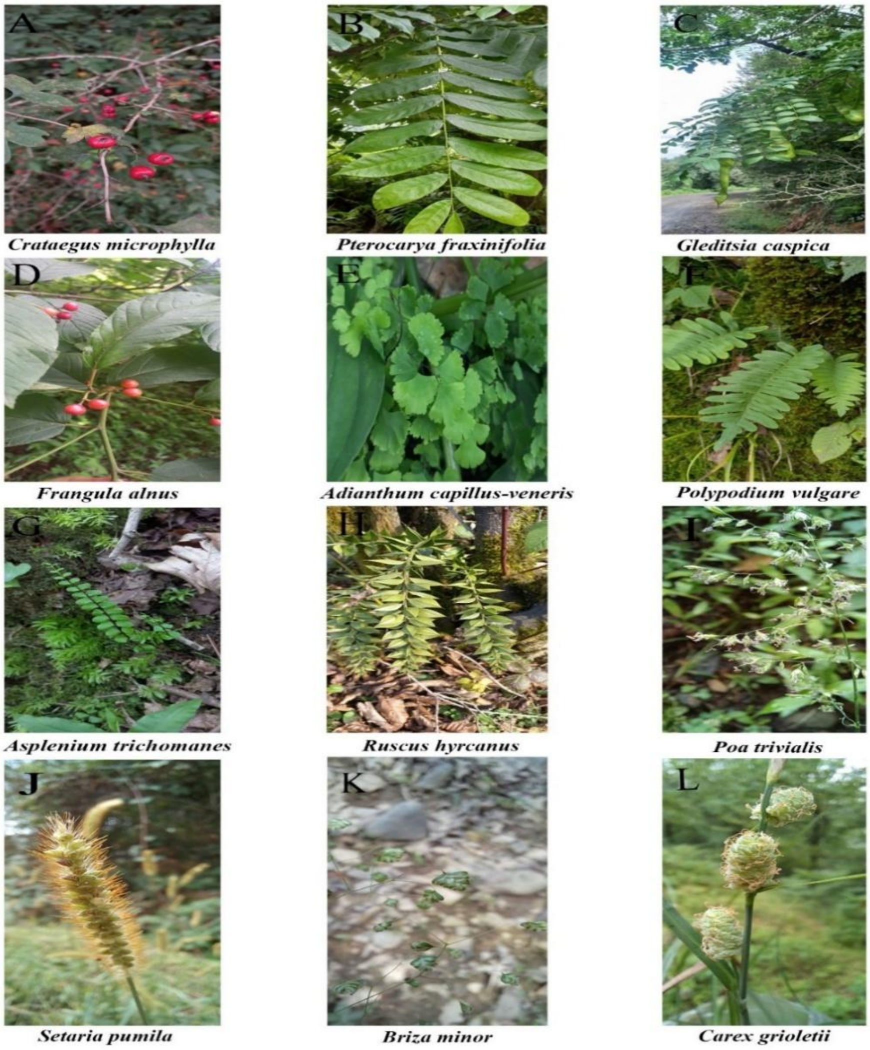

Fig. 3. Photos of some species identified in Sikash Forest.

In the present study, geophytes, with 42 species (32.06%) were the dominant life form, followed by therophytes (39 species, 29.77%), hemicryptophytes (29 species, 22.13%), phanerophytes (20 species, 15.26%) and chamaephytes (1 species, 0.76%). The proportion of different life forms were analyzed per biggest families of the region (Fig. 5). In terms of geographical distribution, the flora of the studied area is composed mostly of Pluriregional elements (37 species, 28.24%), followed by other phytochorions (Fig. 6). 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. Sikash Forest comprises about 15 species endemic-subendemic to Hyrcanian Province (Table 3).

Fig. 4. Photos of some species identified in Sikash Forest.

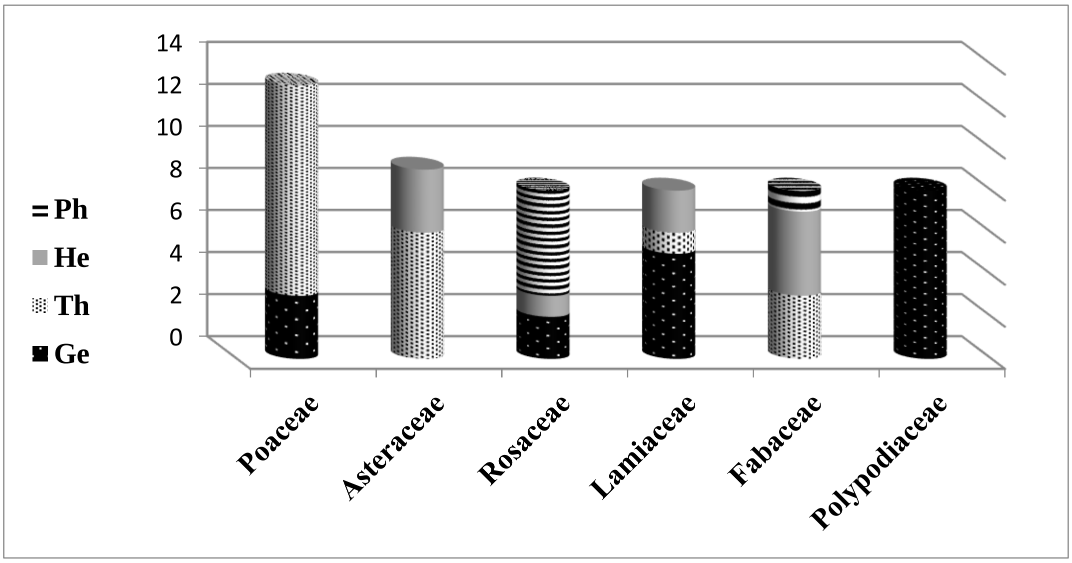

Fig. 5. Number of different life forms in the biggest families in Sikash Forest.

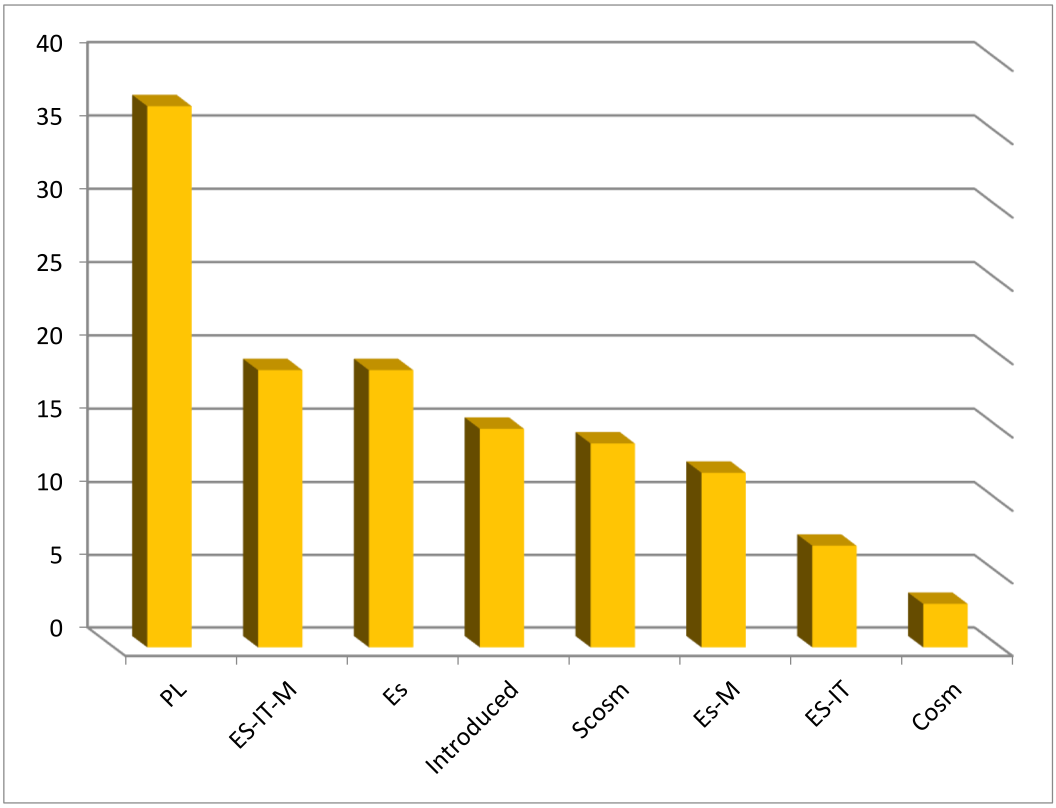

Fig. 6. Proportion of different chorotypes in the Sikash Forest. Abbreviation (ES = Euro-Siberian, PL= Pluriregional, M= Mediterranean, IT= Irano-turanian, SCosm= Semi-Cosmopolitan, Cosm= Cosmopolitan).

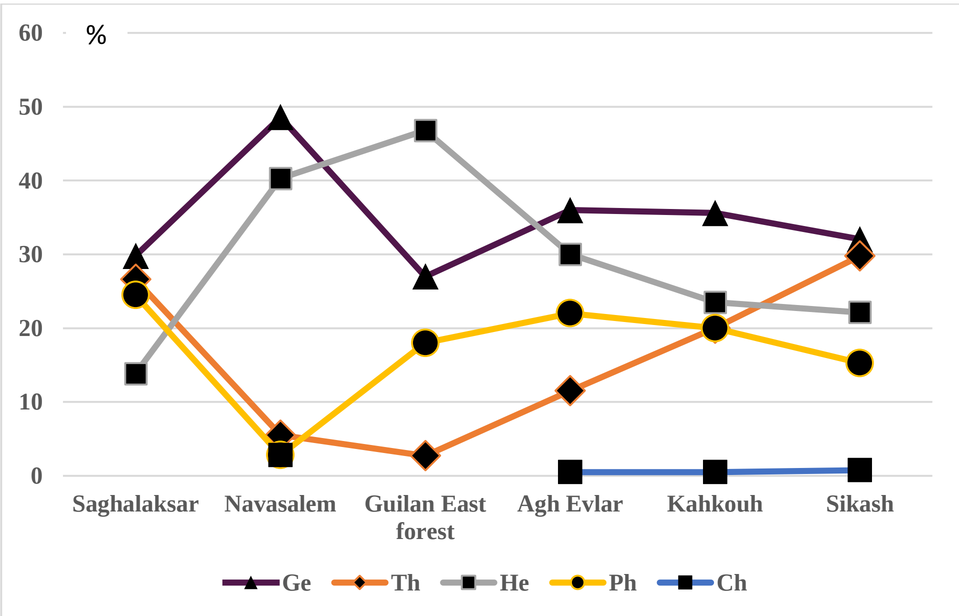

Fig. 7. Comparison of life forms in the Sikash Forest with other Hyrcanian Forest areas: Saqalaksar forest (Ajamian *et al.* 2024), Nav Asalem forest (Bakhshandeh Navroud *et al.* 2017), East Guilan forest (Gholizadeh *et al.* 2017), Agh Evlar forest areas (Porseyedian *et al.* 2021), Kahkouh (Barari 2018).

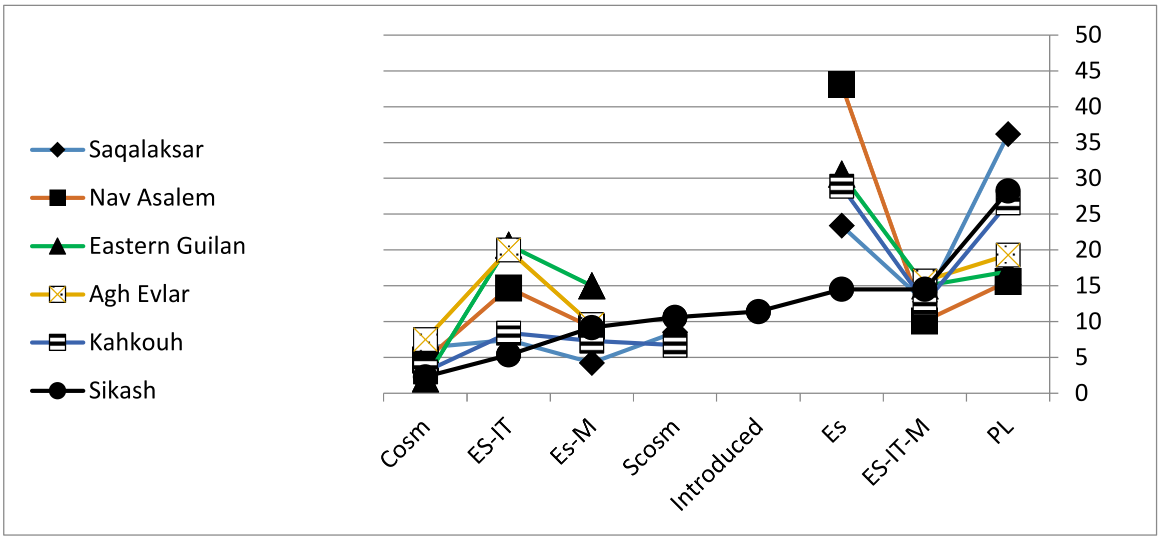

Fig. 8. Comparison of the phytogeography of the Sikash Forest area with other Hyrcanian forest regions. Saqalaksar Forest (Ajamian *et al.* 2024), Nav Asalem (Bakhshandeh Navrood *et al.* 2017), Eastern Guilan (Gholizadeh *et al.* 2017), Agh Evlar forest areas (Porseyedian *et al.* 2021), Kahkouh (Barari 2018). Abbreviations: PL: Pluriregional; ES-IT-M: Euro-Siberian, Irano-Turanian, Mediterranean; ES: Euro-Siberian; Scosm: Subcosmopolitan; ES-M: Euro-Siberian, Mediterranean; ES-IT: Euro-Siberian, Irano-Turanian; Cosm: Cosmopolitan.

Table 1. List of plant species in the area with their geographical distribution and life form.

No.		Life form	Chorotype	Herbarium Number*
	Seedless vascular plants			
Aspleniaceae				
1	*Asplenium adiantum-nigrum* L.	Ge	PL	9755
2	*A. scolopendrium* L.	Ge	PL	9756
3	*A. trichomanes* L.	Ge	Cosm	9757
4	*Athyrium filix-femina* (L.) Roth	Ge	PL	9758
5	*Blechnum spicant* (L.) Roth	Ge	PL	9759
6	*Cystopteris alpina* (Lam.) Desv.	Ge	ES-IT-M	9760
7	*C. fragilis* subsp. *fragilis* (L.) Bernh.	Ge	Cosm	9761
Dennstaedtiaceae				
8	*Pteridium aquilinum* (L.) Kuhn	Ge	PL	9762
Polypodiaceae				
9	*Dryopteris affinis* (Lowe) Fraser-Jenk	Ge	ES-M	9763
10	*D. caucasica* (A. Braun) Fraser-Jenk & Corley	Ge	ES-IT	9764
11	*D. filix-mas* (L.) Schott	Ge	PL	9765
12	*D. pallida* (Bory) Maire & Petitm	Ge	ES-IT-M	9766
13	*Polypodium vulgare* L.	Ge	PL	9767
14	*Polystichum braunii* (Spenn.) Fee	Ge	PL	9768
15	*P. lonchitis* (L.) Roth	Ge	PL	9769
16	*P. woronowii* Fomin	Ge	ES-IT	9770

Pteridaceae				
17	*Adianthum capillus-veneris* L.	Ge	Scosm	9771
18	*Pteris cretica* L.	Ge	PL	9772
	Monocots			
Asparagaceae				
19	*Ruscus hyrcanus* Woronow	Ph	ES (Suben)	9773
Commelinaceae				
20	*Commelina communis* var. *communis* L.	Th	IN	9774
Cyperaceae				
21	*Carex divulsa* Stokes	Ge	ES-IT-M	9775
22	*C. grioletii* Roem. ex Schkuhr	Ge	ES-IT-M	9776
23	*C. leersii* F.W.Schultz	Ge	ES-IT-M	9777
24	*C. pendula* Huds.	Ge	ES-M	9778
Iridaceae				
25	*Sisyrinchium micranthum* Cav.	Ge	IN	9779
Juncaceae				
26	*Luzula forsteri* (Sm.) DC.	He	ES-M	9780
Poaceae				
27	*Aira elegans* Willd. ex Roem. & Schult.	Th	ES-M	9781
28	*Briza minor* L.	Th	ES-M	9782
29	*Festuca myuros* L.	Th	PL	9783
30	*Lolium rigidum* Gaudin	Th	ES-IT-M	9784
31	*Milium vernale* M.Bieb.	Th	ES-IT-M	9785
32	*Oplismenus undulatifolius* (Ard.) P.Beauv.	Ge	PL	9786
33	*Paspalum distichum* L.	Ge	IN	9787
34	*Phleum paniculatum* Huds.	Th	ES-IT-M	9788
35	*Poa annua* L.	Th	Scosm	9789
36	*P. trivialis* L.	Ge	PL	9790
37	*Rostraria cristata* (L.) Tzvelev	Th	PL	9791
38	*Setaria pumila* (Poir.) Roem. & Schult.	Th	Scosm	9792
39	*Setaria viridis* (L.) P.Beauv.	Th	Scosm	9793
Smilacaceae				
40	*Smilax excelsa* L.	Ph	ES-M	9794
	Eudicots			
Apiaceae				
41	*Cyclospermum leptophyllum* (Pers.) Sprague ex Britton & P.Wilson	Th	IN	9795
42	*Pimpinella tragium* Vill.	He	ES-IT-M	9796

43	*Pimpinella* sp.	He		9797
Aquifoliaceae				
44	*Ilex spinigera* (Loes.) Loes.	Ph	ES (Suben)	9798
Araliaceae				
45	*Hedera pastuchovii* Woronow	Ph	ES (Suben)	9799
Asteraceae				
46	*Cirsium vulgare* (Savi) Ten.	He	PL	9800
47	*Eclipta prostrata* (L.) L.	Th	IN	9801
48	*Erigeron annuus* (L.) Desf	Th	IN	9802
49	*E. bonariensis* L.	Th	IN	9803
50	*Filago germanica* (L.) Huds.	Th	PL	9804
51	*Gamochaeta americana* Mill.	Th	IN	9805
52	*Soliva sessilis* Ruiz & Pav.	Th	IN	9806
53	*Sonchus asper* (L.) Hill	He	PL	9807
54	*Taraxacum* sp.	He		9808
Betulaceae				
55	*Alnus subcordata* C.A.Mey.	Ph	ES (Suben)	9809
56	*Carpinus betulus* L.	Ph	ES-M	9810
Brassicaceae				
57	*Capsella bursa-pastoris* (L.) Medik.	Th	Scosm	9811
58	*Cardamine hirsuta* L.	Th	PL	9812
59	*Noccaea perfoliata* (L.) Al-Shehbaz	Th	PL	9813
60	*Sisymbrium* sp.	Th		9814
Campanulaceae				
61	*Campanula rapunculus* subsp. *lambertiana* (A.DC.) Rech.f.	He	ES (Suben)	9815
Caryophyllaceae				
62	*Cerastium glomeratum* Thuill.	Th	PL	9816
63	*Stellaria media* (L.) Vill.	Th	Scosm	9817
Crassulaceae				
64	*Phedimus stoloniferus* (S.G.Gmel.) 't Hart	He	ES	9818
Ebenaceae				
65	*Diospyros lotus* L.	Ph	PL	9819
Euphorbiaceae				
66	*Acalypha australis* L.	Th	IN	9820
67	*Mercurialis perennis* L.	He	PL	9821
68	*Euphorbia amygdaloides* L.	He	ES-M	9822
69	*E. stricta* L.	Ge	ES-IT-M	9823

Fabaceae				
70	*Gleditsia caspica* Desf.	Ph	ES (Suben)	9824
71	*Lotus corniculatus* L.	He	PL	9825
72	*Trifolium arvense* L.	Th	PL	9826
73	*T. campestre* Schreb.	Th	PL	9827
74	*T. pratense* L.	He	PL	9828
75	*T. repens* L.	He	PL	9829
76	*T. resupinatum* L.	Th	ES-IT-M	9830
77	*Vicia sativa* L.	Th	Scosm	9831
Fagaceae				
78	*Fagus orientalis* Lipsky	Ph	ES	9832
79	*Quercus castaneifolia* C.A.Mey.	Ph	ES (Suben)	9833
Gentianaceae				
80	*Centaurium erythraea* Rafn	He	ES-IT-M	9834
Geraniaceae				
81	*Geranium dissectum* L.	Th	ES-IT-M	9835
82	*G. pusillum* L.	Th	ES-IT-M	9836
83	*G. rotundifolium* L.	Th	ES-IT-M	9837
Hamamelidaceae				
84	*Parrotia persica* C.A.Mey.	Ph	ES (Suben)	9838
Hypericaceae				
85	*Hypericum androsaemum* L.	Ch	ES-M	9839
86	*H. perforatum* L.	He	PL	9840
Juglandaceae				
87	*Pterocarya fraxinifolia* (Poir.) Spach	Ph	ES (Suben)	9841
Lamiaceae				
88	*Clinopodium vulgare* L.	Ge	PL	9842
89	*Lamium album* L.	He	PL	9843
90	*Mentha aquatica* L.	Ge	PL	9844
91	*Perilla frutescens* (L.) Britton	Th	IN	9845
92	*Prunella vulgaris* L.	Ge	Scosm	9846
93	*Salvia glutinosa* L.	He	ES-M	9847
94	*Scutellaria tournefortii* Benth	Ge	ES (Suben)	9848
95	*Teucrium hircanicum* L.	Ge	ES (Suben)	9849
Lythtraceae				
96	*Punica granatum* L.	Ph	ES-IT	9850
Malvaceae				

97	*Sida rhombifolia* L.	He	IN	9851
Moraceae				
98	*Ficus carica* L.	Ph	ES-IT-M	9852
Onagraceae				
99	*Circaea lutetiana* L.	Ge	PL	9853
Orobanchaceae				
100	*Rhynchocorys elephas* (L.) Griseb.	He	ES-M	9854
Oxalidaceae				
101	*Oxalis corniculata* L.	Th	IN	9855
Phytolaccaceae				
102	*Phytolacca americana* L.	He	IN	9856
Plantaginaceae				
103	*Plantago major* L.	He	Scosm	9857
104	*Veronica anagallis-aquatica* L.	He	Scosm	9858
105	*V. arvensis* L.	Th	ES-IT-M	9859
106	*V. persica* Poir.	Th	ES (Suben)	9860
107	*V. serpyllifolia* L.	He	Scosm	9861
Polygonaceae				
108	*Persicaria maculosa* Gray	Th	PL	9862
109	*Rumex conglomeratus* Murray	Ge	PL	9863
Primulaceae				
110	*Cyclamen coum* Mill.	Ge	ES	9864
111	*Lysimachia arvensis* (L.) U.Manns & Anderb.	Th	PL	9865
112	*Primula heterochroma* Stapf	He	ES (Suben)	9866
Ranunculaceae				
113	*Ranunculus kochii* Ledeb.	Ge	ES-IT	9867
Rhamnaceae				
114	*Frangula alnus* Mill.	Ph	PL	9868
Rosaceae				
115	*Crataegus microphylla* K.Koch	Ph	ES-IT	9869
116	*Fragaria vesca* L.	He	Scosm	9870
117	*Geum urbanum* L.	Ge	ES-IT-M	9871
118	*Mespilus germanica* (L.)	Ph	ES	9872
119	*Potentilla reptans* L.	Ge	PL	9873
120	*Prunus cerasifera* Ehrh.	Ph	ES-IT	9874
121	*Rubus hirtus* Waldst. & Kit.	Ph	ES-M	9875
122	*R. persicus* Boiss.	Ph	ES (Suben)	9876

Rubiaceae				
123	*Galium spurium* L.	Th	SCosm	9877
Scrophulariaceae				
124	*Scrophularia megalantha* Rech.f.	He	ES (En)	9878
125	*Verbascum* sp.	He		9879
Solanaceae				
126	*Datura stramonium* L.	Th	IN	9880
127	*Alkekengi officinarum* Moench	Ge	ES-IT	9881
Verbenaceae				
128	*Phyla nodiflora* (L.) Greene	Ge	Cosm	9882
129	*Verbena officinalis* L.	He	SCosm	9883
Viburnaceae				
130	*Sambucus ebulus* L.	Ge	ES-IT-M	9884
Violaceae				
131	*Viola* sp.	Ge		9885

Abbreviations: (PL) Pluriregional, (Cosm) Cosmopolitan, (ES-IT-M) Euro-Siberian/Iranian-Turanian/Mediterranean, (ES) Euro-Siberian, (SCosm) semi-cosmopolitan, (ES-M) Euro-Siberian/Mediterranean, (ES-IT) Euro-Siberian/Iranian-Turanian, (Cosm) cosmopolitan, (IN) Introduced, (Ge) Geophyte, (Ph) Phanerophyte, (Th) Therophyte, (He) Hemicryptophyte, (En) Endemic, (Suben) Subendemic.

* All samples have been deposited in Guilan University Herbarium.

Table 2. List of species of the region in terms of extinction status.

No.	Taxa	Extinction status	No.	Taxa	Extinction status
	Asteraceae			**Lythraceae**	
1	*Eclipta prostrata*	LC	**15**	*Punica granatum*	LC
	Betulaceae			Moraceae	
2	*Alnus subcordata*	LC	**16**	*Ficus carica*	LC
3	*Carpinus betulus*	LC		Plantaginaceae	
	Ebenaceae		**17**	*Plantago major*	LC
4	*Diospyros lotus*	LC	**18**	*Veronica anagallis-aquatica*	LC
	Fabaceae		**19**	*Veronica persica*	LC
5	*Trifolium campestre*	LC	**20**	*Veronica serpyllifolia*	LC
6	*Trifolium resupinatum*	LC		Poaceae	
	Fagaceae		**21**	*Aira elegans*	LC
7	*Quercus castaneifolia*	NT	**22**	*Briza minor*	LC
8	*Fagus orientalis*	LC	**23**	*Milium vernale*	LC
	Gentianaceae			Polygonaceae	
9	*Centaurium erythraea*	LC	**24**	*Persicaria maculosa*	LC
	Juglandaceae			Pteridaceae	
10	*Pterocarya fraxinifolia*	VU	**25**	*Pteris cretica*	LC
	Lamiaceae			Rhamnaceae	

11	*Mentha aquatica*	LC	**26**	*Frangula alnus*	LC
12	*Perilla frutescens*	LC		Rosaceae	
13	*Salvia glutinosa*	LC	**27**	*Crataegus microphylla*	LC
14	*Scutellaria tournefortii*	LC		Verbenaceae	
			28	*Phyla nodiflora*	LC

Abbreviations: (LC) Least Concern, (VU) Vulnerable, (NT) Near Threatened.

Table 3. The list of endemic and sub-endemic plants of Hyrcanian area in the Sikash Forest.

Taxa	Status	Distribution area
Betulaceae		
Alnus subcordata	Sub-endemic	Iran, Azerbaijan Republic
Campanulaceae		
Campanula rapunculus subsp. *Lambertiana*	Sub-endemic	Iran, Bulgaria, Crimea, Lebanon-Syria, Palestine, Turkey, Azerbaijan Republic
Fabaceae		
Gleditsia capsica	Sub-endemic	Iran, Azerbaijan Republic
Araliaceae		
Hedera pastuchovii	Sub-endemic	Iran, Iraq, Azerbaijan Republic, Georgia
Aquifoliaceae		
Ilex spinigera	Sub-endemic	Iran, Azerbaijan Republic, Georgia
Hamamelidaceae		
Parrotia persica	Sub-endemic	Iran, Azerbaijan Republic
Primulaceae		
Primula heterochroma	Sub-endemic	Iran, Azerbaijan Republic. Turkey, Georgia
Fagaceae		
Quercus castaneifolia	Sub-endemic	Iran, Azerbaijan Republic
Rosaceae		
Rubus hirtus	Sub-endemic	Iran, Azerbaijan Republic, Georgia
Rubus persicus	Sub-endemic	Iran, Azerbaijan Republic
Asparagaceae		
Ruscus Hyrcanus	Sub-endemic	Iran, Azerbaijan Republic, Crimea
Scrophulariaceae		
Scrophularia megalantha	Endemic	Iran

Lamiaceae		
Scutellaria tournefortii	Sub-endemic	Iran, Azerbaijan Republic, Turkey, Georgia
Teucrium hircanicum	Sub-endemic	Iran, Azerbaijan Republic, Turkey
Plantaginaceae		
Veronica persica	Sub-endemic	Iran, Azerbaijan Republic, Georgia

DISCUSSION

Floristic composition and vegetation structure

The flora of Sikash Forest has been studied and examined for the first time, leading to the identification of 131 vascular plant species belonging to 49 families and 104 genera. These findings highlight the significant biodiversity and suggest favorable ecological conditions, particularly in relation to forest cover and interspecific competition for resources such as light. In this study, three forest communities have been identified:

Gleditsia-Pterocarya forests: This community is dominated by deciduous trees *Gleditsia caspica* and *Pterocarya fraxinifolia*. A similar structure has been mentioned in Atakouh forest (Bazdid Vahdati *et al.* 2014). Some other additional woody species such as *Ficus carica*, *Punica granatum*, *Crataegus microphylla*, *Mespilus germanica*, and *Rubus hirtus* were observed in these communities. Notably, *Punica granatum* and *Mespilus germanica* have also been documented in the Atakouh studies (Bazdid Vahdati *et al.* 2014), while *Crataegus microphylla* has been recorded in the study of the lowland forests of Noor and Sisanghan in Mazandaran Province (Naqinezhad *et al.* 2012).

Carpinus-Quercus forests: The dominant tree species in this community are *Carpinus betulus* and *Quercus castaneifolia*, with *Parrotia persica* and *Diospyros lotus* occurring sporadically. *Parrotia persica* is primarily found in foothill and lowland areas at elevations of 250–400 m a.s.l. of Hyrcanian forests (Naqinezhad & Zarezadeh 2012). This vegetation unit is similar to the *Querco-Carpinetum betulii* community (Mossadegh 1981) from the *Parrotio-Carpionion* alliance and the *Zelkova-Parrotietea* class (Zohary 1973). In Sikash Forest, this community is between 400–550 m a.s.l, consistent with previously reported elevation ranges less than 400 m a.s.l (Mossadegh 1981). However, in other study up to 700 m a.s.l. was proposed for the *Querco-Carpinetum* community. The presence of this community in the lower Hyrcanian zones aligns with some previous studies (Mattaji & Babaikafaki 2006; Teimori *et al*. 2007; Borji *et al*. 2018).

Carpinus-Fagus forests: This forest community is dominated by *Carpinus betulus* and *Fagus orientalis* and occurs at elevations of 550–700 m a.s.l. *Alnus subcordata* was observed only sporadically at higher elevations within this plant community. *Carpinus betulus* is commonly distributed in the lower elevations of Hyrcanian forests and is a characteristic species in communities such as *Fageto-Carpinetum* (Tregubov 1967) and *Parrotio-Carpinetum* (Dorostkar & Noirfalise 1976; Mossadegh 1981). *Fagus orientalis* forms extensive communities in the mountainous parts of Hyrcanian forests (Gholizadeh *et al.* 2017), thriving in very humid and cold climates. These communities occur in the lower mid-elevation forests (up to 1700 m a.s.l.) and extend into higher altitudes (1700–2000 m a.s.l.) under colder conditions (Sagheb Talebi *et al.* 2014). The herbaceous layer is diverse, *Milium vernale* and *Mercurialis perennis* being among the most abundant understory species. These have been reported in similar communities, such as *Carpino-Fagetum orientalis* (Mattaji & Babaikafaki 2006; Moradi *et al.* 2016; Gholizadeh *et al.* 2017). In Turkey, a comparable *Carpinus betulus-Fagus orientalis* community has been described under the *Quercetea pubescentis* class (Ketenoglu *et al.* 2010). This plant community, corresponds to the *Fagetum* and *Fageti-Carpinetum* classification units (Zohary 1973) and aligns with some units of the *Kieseritzkii-Fagion orientalis* alliance (Gholizadeh *et al.* 2017). This vegetation type is consistent with the findings of other researchers documented across Hyrcanian forests (Teimori *et al.* 2007; Mattaji and Babaikafaki 2006; Bazdid Vahdati *et al.* 2014; Bidarlord *et al.* 2021).

Floristic patterns and dominant families

Among the plant families observed, Poaceae was the most represented. This is attributed to its adaptability to various habitats and resilience to environmental degradation (Mofidnezhad *et al.* 2022). The presence of Poaceae as the largest family has been reported in previous study in Nav Asalem (Bakhshandeh Navroud *et al*. 2017). Additionally, the other reason of high abundance of this family is the adaptation to stresses such as herbivory, allowing them to regrow despite the consumption of their apical meristems (Mofidnezhad *et al.* 2022). Another highly represented family in this area was Asteraceae, whose abundance is explained by its members' ability to thrive under unfavorable conditions such as poor soils and arid climates (Haghgoei & Pourbabaei 2011). The adaptive advantages of Asteraceae include high seed output due to their inflorescence structure, effective seed dispersal mechanisms, strong root systems, and production of secondary metabolites that deter herbivory. These features collectively enhance their persistence and competitiveness in disturbed environments.

Life form spectrum

The life spectrum of plants provides information about their adaptation to environmental conditions, leading to a classification based on habitat conditions (Raunkiaer 1934; Mueler-Dombois & Ellenberg 1974; Archibold 1995; Memariani *et al.* 2016). It also describes how plants adapt morphologically to climatic factors (Kent & Coker 1995). Each plant species has a distinct biological spectrum, which contributes to the overall structure of the plant communities (Mobayen 1985). In the assessment of life forms, geophytes were the most dominant, represented by 42 species (32.06%), followed by therophytes with 39 species (29.77%), hemicryptophytes with 29 species (22.13%), phanerophytes with 20 species (15.26%), and chamaephytes with only one species (0.76%). The high proportion of geophytes in the study area is mainly due to long wet period during the growing season and the relatively high annual precipitation (Danin & Orshan 1990). These findings are consistent with the results of floristic studies in other forest areas of Hyrcanian Province (e.g. Ghahreman *et al.* 2006; Razavi 2008; Bazdid Vahdati *et al.* 2014). Although geophytes are most abundant, therophytes also comprise a significant portion of the flora. A relatively high percentage of this life form compared to geophytes may indicate a relatively strong degradation in this area. Due to moisture availability and anthropogenic activities, therophytes are widespread throughout the region, especially around the dam. Their presence suggests an adaptation to dry habitats by completing their annual life cycle (Memariani *et al.* 2016). Although therophytes are commonly found in desert areas (Archibold 1995), they are also prevalent in lowland areas, where anthropogenic activities and overgrazing have caused ecological disturbance (Ghahremaninejad *et al.* 2011; Bazdid Vahdati *et al.* 2014). Hemicryptophytes are the next predominant life after therophytes. A significant percentage of hemicryptophytes and phanerophytes indicates suitable climatic conditions for the growth habitats in temperate regions (Esmailzadeh *et al.* 2014). In some studies, the prevalence of hemicryptophytes has been attributed to their adaptation to climatic fluctuations (especially temperature and humidity), soil conditions, and resilience to cold. This life form enables plants to withstand cold and drought and to grow rapidly at the beginning of the growing season (Pairanj *et al.* 2011). Phanerophytes are the predominant life form after hemicryptophytes. The abundance of phanerophytes could be due to the Mediterranean microclimate and topographic features of the region (Duran 2002). The successful establishment of phanerophytes depends on suitable vegetation conditions and protection of their habitats from degradation (Vaseghi *et al.* 2008). In Noor Forest Park, phanerophytes, accounted for 33% of the total life form spectrum, representing the most dominant group in that area (Yousefvand *et al.* 2017). A comparison of the growth forms of plants in the Sikash region of Siahkal with some other forests in Northern Iran is shown in Fig. 7. In the study area, geophytes exhibit a high frequency of occurrence, a pattern also observed in Nav Asalem forest (Bakhshandeh Navroud *et al*. 2017). Furthermore, a low proportion of chamaephytes has been reported in Sikash Forest, consistent with findings from Kahkouh (Barari 2018) and Agh Evlar (Porseyedian *et al.* 2021) forests. The abundance of hemicryptophytes in Sikash exceeds that of the Saqalaksar forest (Ajamian *et al.* 2024) but is comparable to levels observed in Kahkouh and Agh Evlar (Barari 2018; Porseyedian *et al.* 2021). In terms of phanerophyte presence, the studied forest appears to be relatively richer than Nav Asalem (Bakhshandeh Navroud *et al*. 2017). Notably, therophytes show the highest frequency in Sikash Forest, representing a greater proportion than reported by any of the compared Hyrcanian forests in Fig. 7.

Chorotype spectrum

In terms of geographical distribution, the flora of the studied area is mainly composed of Pluriregional elements (PL, 37 species, 28.24%), followed by Euro-Siberian- Irano-turanian- Mediterranean (ES-IT-M) and ES (19 species, 14.5%), introduced (IN, 15 species, 11.4%), subcosmopolitan (SCosm, 14 species, 10.6%), ES-M (12 species, 9.16%), ES-IT (7 species, 5.34%) and cosmopolitan (Cosm, 3 species, 2.29%). 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 elements 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). Introduced species are among the major threats to biodiversity. These species have negative impacts on the environment as well as economic conditions. Their negative effects extend to agricultural lands, aquatic ecosystems, wildlife, and forest. In the study area, several alien species have also been reported, such as *Acalypha australis*, *Commelina communis*, *Sida rhombifolia*. The phytogeographic elements were compared with those of other Caspian lowland forests (Bakhshandeh Navroud *et al.* 2017; Gholizadeh et al. 2017; Barari 2018; Porseyedian *et al.* 2020; Ajamian *et al.* 2024). Two peaks can be observed in the phytochorions spectrum, one in the Pluriregional and the other in the Euro-Siberian elements (Fig. 8). The highest proportion of Pluriregional elements was found in Saqalaksar, while the lowest in the forests of Izdeh-e Noor. This is due to the fact that the faces of former site are more affected by anthropogenic activities. These results are also consistent with the studies of Ghahremaninejad *et al.* (2011). In addition, Nav Asalem possesses the highest proportion of Euro-Siberian elements. Our results suggest that the Nav Asalem forest exhibits the highest correspondence to a common Euro-Siberian Forest due to the large number of Euro-Siberian elements.

CONCLUSION

Plant vegetation roles as a key indicator for assessing the ecological factors of regio and reflects the biological responses shaped through the evolutionary processes of plant life (Mofidnezhad *et al*. 2022). North Iran, due to its favorable climatic condition-including moderate temperatures, consistent precipitation, and proximity to the sea, supports a high level of plant species diversity. In the area, the presence of species belonging to the Poaceae family is of particular significance for soil conservation. Conversely, the occurrence of species from the Asteraceae family is indicative of vegetation degradation and anthropogenic disturbances. The result of the study reveals that the region exhibits a considerable degree of species richness. Moreover, exist of therophyte plants is associated with environmental disturbances. The touristic nature of the area, along with ongoing human interventions, has increased these ecological impacts. In order to ensure more effective management of this area, several measures can be proposed: the restoration and cultivation of native species suited to the local conditions, the development of ecotourism initiatives, and the implementation of strategies to maintain a balance between forest conservation and tourism management.

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