FLORISTIC DIVERSITY IN NORTH-EASTERN BAKHTIARI PROVINCE ON THE CENTRAL ZAGROS MT RANGE OF IRAN

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Abstract. The present study dealt with the plant species diversity of north-eastern Bakhtiari province located in central Zagros Mt. chain of Iran; one of the diversity-rich areas in the middle east. Three nesting datasets were compiled in this study, corresponding to one, eight and twenty-two local floras across the region. Results showed that a total of 1512 species of flowering plants are distributed in 22 local floras (dataset 3), belonging to 517 genera and 96 families. Dataset 2 corresponding to flora of north-eastern Bakhtiari province, comprised of 714 species belonging to 323 genera and 60 families, of which 60 species were exclusively identified from Babazaki mountain area. Babazaki flora (dataset 1) was characterized by 84 medicinal and 59 endemic plants (to Iran) and sixty percent of the species native to Irano-Turanian phytochorion. Floristic characteristics and relations between the local floras of dataset 2 are presented. Multivariate analysis of 22 local floras in dataset 3 based on occurrence data resulted in four coherent groups. Floristic specifications of groups are presented. This study represents a considerable update on the previous knowledge and a contribution to the diversity and distribution of taxa in the central Zagros Mt chain of Iran.
Keywords: *Babazaki, Middle-East, multivariate analysis, occurrence data, plant*

Introduction

The basic information used in conservation biology for identifying and monitoring the distribution of species, is provided through ecological and taxonomic works. Species near extinction and areas with high diversity, that should be considered for conservation are indicated in such studies. Heywood (2004) stated that Taxonomists should ask themselves just how they reacted to the alarming situation regarding the continuing loss of biodiversity which was widely reported. It requires the inventory of plant diversity and floristic studies to be continued (Heywood, 2004). Documenting the distribution of plant species at regional scale is needed for predicting ongoing changes in contemporary ecosystems. However, diversity inventories do not show how complete the local floras or plant communities are (Pärtel et al., 2013). Compilation of local floras and groups of them into nested datasets may provide clearer view of diversity and distribution of species at different scales. This may also help reveal the dark diversity (Pärtel et al., 2011; Lewis et al., 2016), which is used for calculating the community completeness indices (Pärtel et al., 2013).

Multivariate analyses could be used for grouping of species distributed over areas and/or environmental variables. The rationale behind this type of analysis is that they may exploit relations between the species that are present in the data. These techniques could be used to construct a "species map" in which species that frequently co-occur are grouped close together; species that hardly co-occur are depicted far apart (Van Der Maaten et al., 2012). Clustering of species distributions could also be used for identifying floristic elements in regional floras (Finnie et al., 2007). Those analyses put biological species as objects of the analysis rather than variables. Data reduction methods could also

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be used for grouping of areas, sites, and communities, etc., as objects, considering species as variables. The rational is that, species are identifiable independent biological identities, that could serve as independent variables of an analysis, providing reliable occurrence data. The local flora method is based on the concept that detailed information from a limited number of sites could provide more reliable knowledge of regional flora, compared to occasional irregular samplings (Tolmatchev, 1931). Study of local floras could provide opportunities to study gradients of floristic variables, such as, differences in taxonomical features of local floras (Khitun et al., 2016). This approach which has been used in a limited number of diversity-oriented studies (Talbot et al., 2007; Khitun et al., 2016; Veiskarami and Sharifi-Tehrani, 2017), is followed in this study on the central Zagros region of Iran.

Central Zagros region, is a diversity-rich area in the middle east (Heywood, 2004), located in Zagros mountain chain stretched from northwest to southwest of Iran (Djamali et al., 2009). Western slopes are faced to and affected from the Mediterranean climate, and the Eastern slopes boarder Iran's inland dry deserts, mainly comprised of Irano-Turanian vegetations. Northern Zagros neighboring Caucasus and consisting of Euro-Siberian vegetations, and Southern parts, neighboring Sahara-Sindian vegetations, also prevalent in Northern Arabian Peninsula. Although a relatively large proportion of species in Central parts of the Zagros are endemics of Irano-Turanian floristic region, due to diverse geological, geographical, topological and climatic conditions, the regional flora of Central Zagros is complex in terms of species composition and distribution. Plant species diversity and distribution of species across local flora has been studies in this region, through several investigations, yet flora of the region is not fully acknowledged. Contemporary flora of this region is evolving rapidly due to the changing climate and intense human activities, especially grazing and agricultural activities. To date, a number of local floras in the Bakhtiari Province at the heart of Central Zagros range, have been investigated (*Tables 1, 2*) and many areas remain to be studied. This study is concerned with the diversity of plant species in north-eastern Bakhriari province. Some local floras of this region are investigated by the authors in recent years. In this study, flora of Babazaki mountain area characterized by its relatively rich flora with high percentage of medicinal and endemic species, located near the Tang-e-Sayad National Park in Bakhtiari province, is being added to our previous datasets. This study was also aimed to compile a floristic checklist of local floras, to assess similarities and differences between sites, and to analyze the floristic structure of north-eastern part of the Bakhtiari province in the central Zagros region of Iran, which is shaped and altered throughout time by changing climate and topography.

Materials and Methods

Three nested floristic datasets comprising one, eight, and twenty-two local floras, are compiled in this study. The first dataset, consists of a checklist of the Babazaki mountain and the lands towards southern parts of the Saman region, acquired through our recent field survey. Babazaki local flora is located between 50.878 and 51.064 eastern longitudes and 32.431 and 32.287 northern latitudes, in north-east of Bakhtiari province of Iran (*Fig. 1*). It covers an area of 12052 ha. Altitude ranges from 2120 to 2810 m a.s.l. (average: 2350 m). Mean temperature ranges from -0.4 °C (minimum in Jan) to 25.74 °C (maximum in July) with an annual average of 12.98 °C, according to meteorological data acquired from Iranian meteorological organization. The average sum of annual

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precipitation is 218.51 mm (data from three meteorological stations adjacent to the study area). Climate type of the study area for dataset 1 was 'semi-arid' based on Amberger (*Eq.1*), and Thornth-Waite's (*Eq.2*) coefficients, separately calculated for three adjacent synoptic stations: Saman (Q_2= 32.43, IPE= 32.8), Shahrekord (Q_2= 27.77, IPE= 38), and Farrokhshahr (Q_2=23.58, IPE= 20.4). Ombrothermic charts (*Fig. 2*) show that drought period span between May and October.

$$Q_2 = 2000\ P / (M^2 - m^2) \qquad \text{(Eq.1)}$$

$$IPE = 10\sum ((0.1645\ P) / (T + 12.2))^{10/9} \qquad \text{(Eq.2)}$$

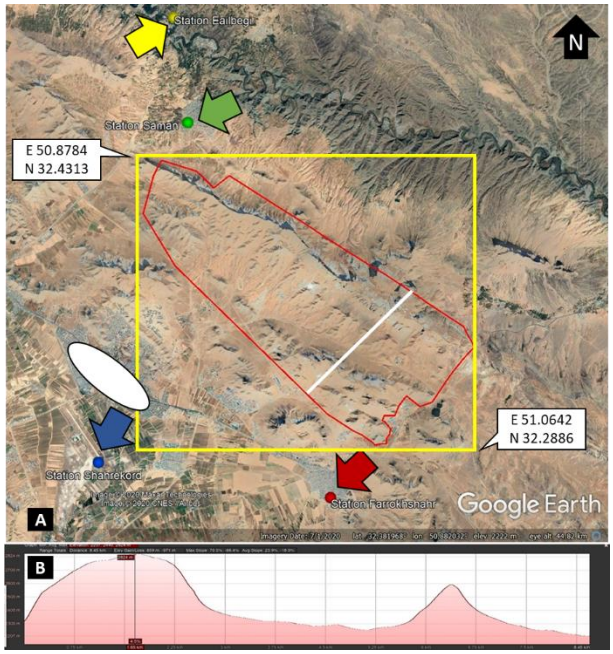

Figure 1. *Map showing study area of the first dataset (Babazaki flora). A: white boxes: Coordinates of circumferential rectangle, white elliptic: city of Shahrekord, black arrow: north direction, colored arrows: four meteorological stations (green: Saman station, blue: Shahrekord-airport station, red: Farrokhshahr station, yellow: newly stablished Eilbegi station), red line: circumferential polygon around the study area, B: altitudinal profile along the white line in Fig. 1A*

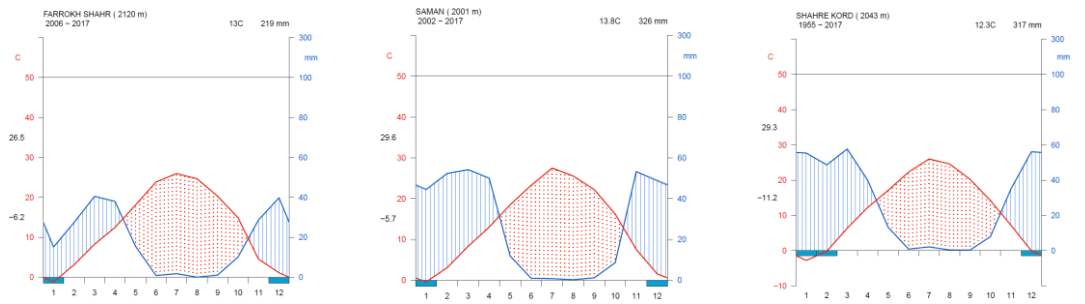

Figure 2. *Ombrothermic charts drawn based on meteorological data of three adjacent synoptic stations to the Dataset 1 study area. Left: Station Farrokhshahr, Mid: Station Saman, Right: Station Shahrekord. Meteorological data obtained from Iranian national meteorological organization (www.irimo.ir)*

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Species occurring in Babazaki flora (dataset 1) were recorded by collecting specimens during grow seasons of 2018-2019, using random sampling method. Taxonomic determinations performed using available literature i.e. Flora Iranica (Rechinger, 1963-2012), Flora of Iran (Assadi, 1989-2016), Flora of Turkey (Davis, 1965-1985), and Flora Europaea (Tutin et al., 1968-1980). Vouchers are deposited in the Herbarium of the Shahrekord University (SKU). For dataset 2, comprising eight local floras (including dataset 1), checklists of two local floras (Jahanbin and Sheet Mt areas) were prepared by the author through field surveys during 2015-2016, and checklists of five remaining local floras are compiled from literature (*Table 1*). Eight local floras (*Table 1*, *Fig. 3*) adjacent to (and including) Babazaki flora in north-eastern Bakhtiari province were compiled into dataset 2 and used for comparing between adjacent local flora to elucidate dark diversity. The third dataset in which datasets 1 and 2 were nested, comprised of twenty-two local floras in the central Zagros region (*Table 2*, *Fig. 3*); it was compiled for determining floristic structure of the region through multivariate analysis.

Table 1. *Local floras compiled into the second dataset*

ID	Coordinates	Alt. (m)	Area (ha)	Prec (mm)	Alpha		1	2	3	4	5	6	7
211	N 32.05 E 50.983	2720	27000	304	235	**1**							
213	N 32.281 E 50.831	2045	2045	-	55	**2**	224						
228	N 32.375 E 50.873	2120-2660	1070	349	211	**3**	272	214					
229	N 32.575 E 50.656	2100-3165	22164	435	314	**4**	273	301	319				
232	N 32.174 E 50.755	2150-3300	12187	324	271	**5**	318	254	266	339			
264	N 32.265 E 50.994	2142-2890	6402	-	95	**6**	172	112	218	279	266		
380	N 32.433 E 50.583	2100-2900	3151	441	158	**7**	223	161	221	260	269	147	
534	N 32.35 E 50.95	2125-2824	12052	276	257	**8**	284	266	262	363	328	260	261

ID: identification number of the local flora in floristic database, Alt.: Altitude of the site from sea level, Prec = Sum of annual precipitation, Alpha= alpha diversity (=species richness), numbers 1-8: local floras; components of the second dataset. Seven right-most columns of the table showing beta diversity measures

Dataset 2 encompasses an area between 50.583 and 50.994 eastern longitudes and 32.050 and 32.575 northern latitudes (*Fig. 3, up*), covering an area of 132800 ha. Altitude of local floras within dataset 2 ranges from 2045 to 3300 m a.s.l. Mean temperature ranges from -0.8 °C to 25.74 °C and the average sum of annual precipitation ranges from 218 to 441 mm. Dataset 3 encompasses an area between 50.083 and 51.188 eastern longitudes and 31.472 and 32.994 northern latitudes (*Fig. 3, down*), covering an area of 1261920 ha. Altitude of local floras within dataset 3 ranges from 834 to 4135 m a.s.l. Mean temperature ranges from -19 °C to 39.8 °C and the average sum of annual precipitation ranges from 188 to 505.9 mm.

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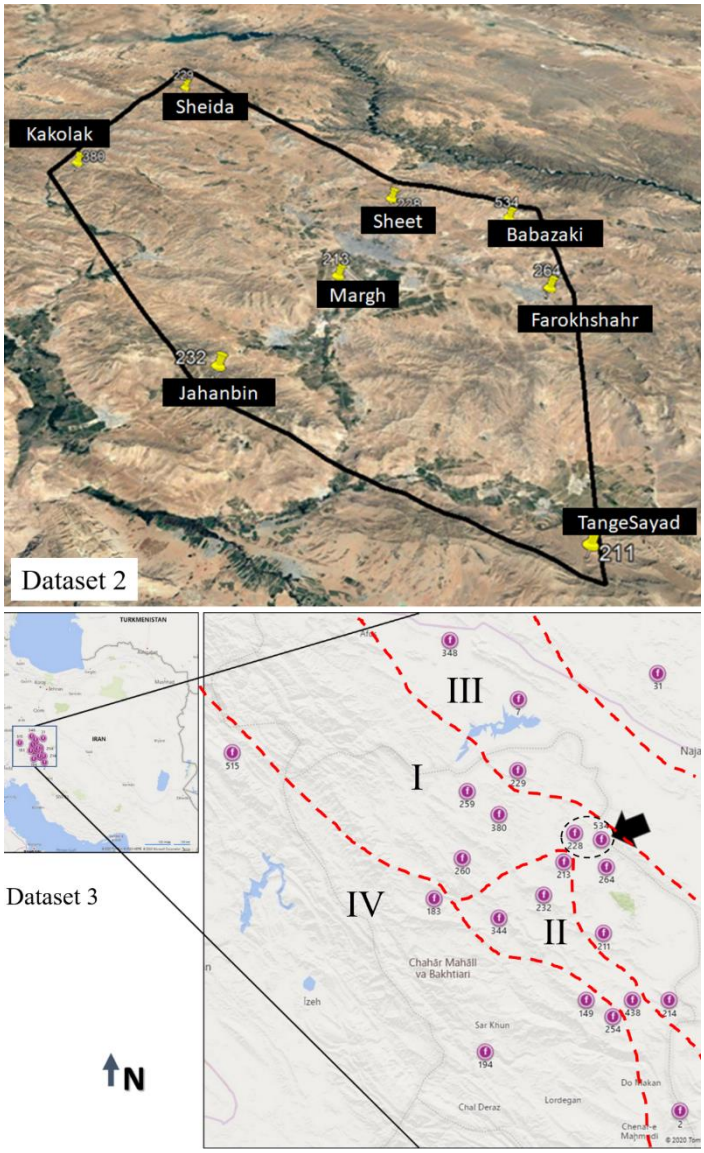

Figure 3. *Up: Map showing location of seven local floras (dataset 2) adjacent to Babazaki. Down: map showing location of 22 local flora (the third dataset), selected for multivariate analysis. Marked areas correspond to four groups (K=4) resulted in multivariate analysis (see text and Fig. 6)*

Datasets were prepared using a developing floristic database (Sharifi-Tehrani and Rahiminejad-Ranjbar, 2013), in which occurrence data considered at the species level (Van Der Maaten et al., 2012).

Species names were checked using International Plant Names Index (IPNI) and The Plant List (TPL) online taxonomic databases through the CheckName program (Sharifi-Tehrani, 2014) which uses software API codes to connect to online databases. Geographical distribution, endemism and conservation status of species were determined according to Red Data Book of Iran (Jalili and Jamzad, 1999), and available relevant literature (Rechinger, 1963-2012; Zohary, 1973). Life forms determined based on direct observation of specimens (for three surveyed local floras), according to Raunkiaer's classification (1934).

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Table 2. *Twenty-two local floras; checklists of them compiled into the third dataset and used for multivariate analysis*

	ID	Publ.	Area (ha)	Alpha	Flora (Abbreviation used in Fig. 6)
1	534	this paper	12052	257	Babazaki Flora (4MB_bbzk)
2	214	Tahmasebi, 2014b	Na	79	Ghorogh Boroujen (4MB_Brojen)
3	260	Kafash-Saei et al., 2014a	6905	69	Darreh Sir (4MB_DarrehSir)
4	264	Kafash-Saei et al., 2014b	6402	95	Farrokhshahr (4MB_Farrokh)
5	183	Shirmardi et al., 2014a	9816	487	Gheysari (4MB_Gheisar)
6	194	Shirmardi et al., 2014b	40231	392	Helen (4MB_HelenPA)
7	232	Jalali et al., 2016	12187	271	Jahanbin (4MB_Jhnbn)
8	380	Naghipoor-Borj, 2016	3151.5	158	Kakolak (4MB_Kakolak)
9	149	Shahrokhi, 2005	50800	514	Kallar (4MB_Kallar)
10	259	Pairanj et al., 2011	576	276	Karsanak (4MB_Karsnk3)
11	213	Tahmasebi, 2014a	Na	55	Margh Shahrekord (4MB_Margh)
12	228	Dehghani et al., 2015	1070	211	Sheet Mt. (4MB_MtSheet)
13	515	Gholami et al., 2018	213300	343	RobatKouh Bazoft (4MB_RobatKuh)
14	254	Assadi et al., 2009	54010	433	SabzKouh (4MB_Sabzkouh)
15	344	Hasanzadeh et al., 2017	13943	267	Saldaran (4MB_Saldrn)
16	229	Vahabi et al., 2018	22164	314	Sheida (4MB_Sheida)
17	211	Heydari-Ghahfarrokhi et al., 2012	27000	235	TangeSayad PA (4MB_TangSayad)
18	438	Iranmanesh et al., 2017	2870	137	Bakhtiari Wetlands (4MB_Wetlands)
19	7	Yousofi et al., 2011	10000	339	Chadegan (Isf_Chadegan)
20	348	unpublished	97645	364	Fereydan/Daran (Isf_Daran)
21	31	Yousofi, 2006	50000	143	Ghameshloo (Isf_Ghameshloo)
22	2	Parishani, 2005	40000	614	Vanak-Semirom (Isf_Vanak)

ID: identification number of the local flora in floristic database. Publ.: Publication. Alpha: Alpha diversity (= species richness). Most of the checklists are published in native language. Na: not available

Presence (1) or absence (0) of each species were entered into a data matrix comprising 22 rows and 1512 columns (species). Data matrix was used for calculating alpha, beta, and gamma diversity measures, for comparing local floras, and for multivariate floristic analyses. Required data matrices were prepared and formatted by using the "Alamut floristic database" (Sharifi-Tehrani and Rahiminejad-Ranjbar, 2013). Data was analyzed using Dice (*Eq.3*) and SMC (*Eq.4*) coefficients for qualitative data, in which a= co-occurrence of species, b= species present in one flora, c= species present in another flora, m= number of matches, and n= number of non-matches.

$$SDice = 2a / (2a + b + c) \quad \text{(Eq.3)}$$

$$SM = m / n \quad \text{(Eq.4)}$$

PCO and clustering analyses were conducted using NTSYSpc (Rohlf, 2000) and SplitTree (Huson and Bryant, 2006) software packages. Best fit for number of clusters in the multivariate analyses was inferred by exploratory data analysis in CLUTO software package (Karypis, 2003) which computes the maximum internal similarities inside each group by minimizing the similarity between groups.

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Results

Results of this study are based on three nesting datasets. The first dataset which is presented for the first time in this study (*Table 3*), comprises of species checklist of Babazaki flora. There are 257 plant species growing in this local flora belonging to 177 genera and 45 families. Species to family, genera to family and species to genus ratios are 5.71, 3.93, and 1.45, respectively. Checklist of plant species in this area was interesting as it revealed that a high percentage (82%; 212 spp) of plant species growing in this site are not previously evaluated for conservation status (NE category). Sixteen percent (40 species) are in LR (lower risk) category and three species (*Astragalus cyclophyllon* Beck, *Astragalus griseus* Boiss., and *Ziziphora clinopodioides* Lam.) are vulnerable species (VU). Babazaki flora consists of 84 medicinal, 59 endemics (to Iran), and 47 range species growing in relatively scarce water conditions. Climate type (semi-arid) of this area prefers for hemicryptophyte (48%) and therophyte (32%) life forms (*Fig. 4*). Sixty percent of the plant species growing in this site, are native elements of Irano-Turanian chorotype (*Fig. 4*). Checklist of the plant species growing in this site along with their properties (being medicinal, range, or endemic), life forms and chorotypes are presented in *Table 3*. The largest families of the region in terms of species richness are Asteraceae (17%), Brassicaceae (11%), and Apiaceae and Lamiaceae (7% each). The sequence of large families in terms of generic richness is: Asteraceae (16%), Lamiaceae (11%) and Brassicaceae (10%). The largest species-rich genera in this flora are *Astragalus* (14 spp), *Nepeta* (6 spp), and *Allium*, *Centaurea* and *Salvia* (5 spp each). Most of the genera in this flora are represented with few species, which could also be inferred from species to genera ratio (sp/gen=1.45). There are sixty species growing in Babazaki flora, which are not reported from adjacent local floras in dataset 2.

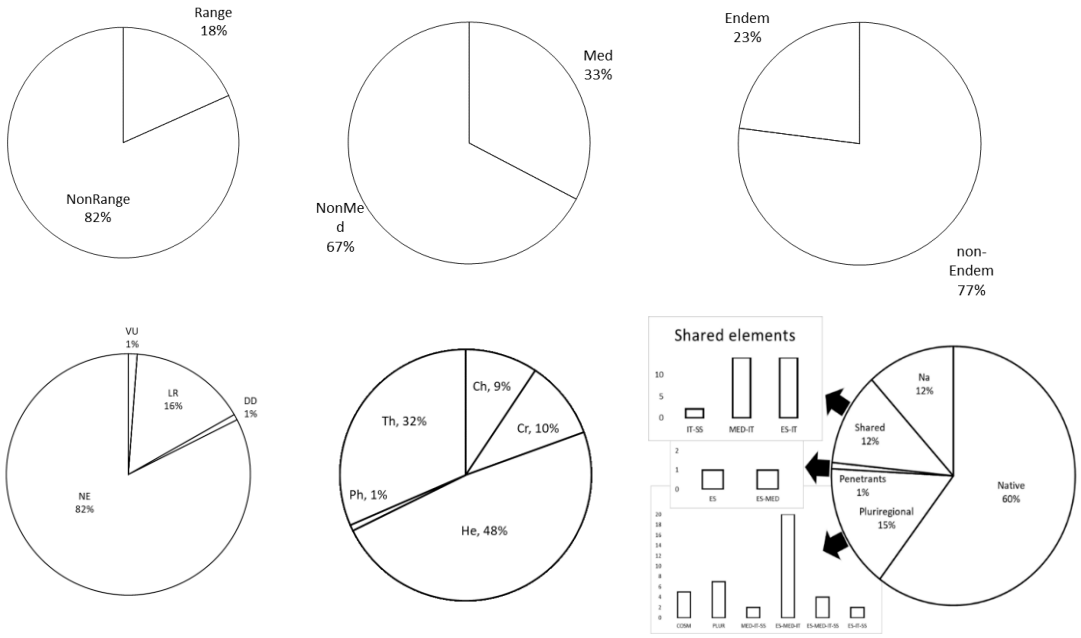

Figure 4. *Percentage of range (upper left), medicinal (up middle), and endemic species (upper right), and each IUCN category (lower left), life forms (low mid), and percentage of plant species belonging to each chorotype, in Flora of Babazaki. He: hemicriptophyte, Cr: cryptophyte, Ch: chamaeophyte, Th: therophyte, Ph: phanerophyte, Vu: vulnerable, LR: lower risk, DD: data deficient, NE: not evaluated*

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Table 3. *Checklist of 257 plant species growing in Babazaki flora (dataset 1, id: 534), consisting 59 endemic and 84 medicinal species. Plant families are listed according to LAPGIII and modifications by APGIV. Species names are listed alphabetically*

Group & Family	Scientific Name	Characteristics
Monocots		
Liliales		
Colchicaceae	*Colchicum wendelboi* K.Perss.	LEM [IT] [Cr]
Liliaceae	*Fritillaria gibbosa* Boiss.	[IT] [Cr]
Liliaceae	*Fritillaria pinardii* Boiss.	[IT] [Cr]
Liliaceae	*Gagea reticulata* Schult.f.	[Plur] [Th]
Liliaceae	*Ornithogalum orthophyllum* Ten.	M [IT] [Cr]
Liliaceae	*Tulipa biflora* Pall.	[ES, IT] [Cr]
Liliaceae	*Tulipa systola* Stapf	[IT] [Cr]
Asparagales		
Ixioliriaceae	*Ixiolirion tataricum* (Pall.) Herb. & Traub	M [ES, Med, IT] [Th]
Iridaceae	*Iris barnumiae* Baker & Foster	LE [IT] [Cr]
Iridaceae	*Iris songarica* Schrenk	M [IT] [Th]
Iridaceae	*Iris* sp.	[Cr]
Asphodelaceae	*Eremurus* sp.	[Cr]
Amaryllidaceae	*Allium akaka* S.G.Gmel. ex Schult. & Schult.f.	EM [IT] [Cr]
Amaryllidaceae	*Allium ampeloprasum* L.	M [Med, IT] [Cr]
Amaryllidaceae	*Allium scabriscapum* Boiss.	M [IT] [Cr]
Amaryllidaceae	*Allium* sp.	[Cr]
Amaryllidaceae	*Allium tripedale* Trautv.	[IT] [Cr]
Asparagaceae	*Bellevalia glauca* (Lindl.) Kunth	M [IT] [Cr]
Asparagaceae	*Muscari neglectum* Guss. ex Ten.	M [ES, Med, IT] [Th]
Asparagaceae	*Pseudomuscari inconstrictum* (Rech.f.) Garbari	[ES, Med, IT] [Cr]
Poales		
Juncaceae	*Juncus inflexus* L.	[Plur] [Th]
Poaceae	*Boissiera squarrosa* (Sol.) Nevski	[IT] [Th]
Poaceae	*Bromus danthoniae* Trin. ex C.A.Mey.	[IT] [Th]
Poaceae	*Bromus gracillimus* Bunge	[IT] [Th]
Poaceae	*Bromus tectorum* L.	[Plur] [Th]
Poaceae	*Bromus tomentellus* Boiss.	[ES, IT] [He]
Poaceae	*Eremopoa persica* (Trin.) Roshev.	[Med, IT] [Th]
Poaceae	*Heteranthelium piliferum* Hochst. ex Jaub. & Spach	[Med, IT] [Th]
Poaceae	*Hordeum murinum* L.	[Med, IT] [Th]
Poaceae	*Melica persica* Kunth	[IT] [He]
Poaceae	*Piptatherum holciforme* Roem. & Schult.	[IT] [He]
Poaceae	*Poa bulbosa* L.	[ES, IT] [Cr]
Poaceae	*Psathyrostachys fragilis* (Boiss.) Nevski	[IT] [He]
Poaceae	*Stipa arabica* Trin. & Rupr.	[IT] [He]
Poaceae	*Taeniatherum caput-medusae* (L.) Nevski	[Med, IT] [Th]
Basal Eudicots		
Ranunculales		
Papaveraceae	*Corydalis* sp.	[Cr]
Papaveraceae	*Corydalis verticillaris* DC.	LEM [IT] [Cr]
Papaveraceae	*Fumaria asepala* Boiss.	M [Med, IT] [Th]
Papaveraceae	*Glaucium corniculatum* Curtis	M [Med, IT] [Th]
Papaveraceae	*Glaucium oxylobum* Boiss. & Buhse	M [IT] [He]
Papaveraceae	*Hypecoum pendulum* L.	M [ES, IT] [Th]
Papaveraceae	*Papaver dubium* L.	M [Plur] [Th]
Papaveraceae	*Roemeria hybrida* (L.) DC.	M [Med, IT, SS] [Th]
Papaveraceae	*Roemeria refracta* DC.	M [ES, IT] [Th]
Berberidaceae	*Bongardia chrysogonum* Boiss.	M [IT] [Th]
Berberidaceae	*Leontice armeniaca* Boiv.	[IT] [Cr]
Ranunculaceae	*Adonis aestivalis* L.	M [IT] [Th]

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Ranunculaceae	*Anemone biflora* DC.	M [IT] [Th]
Ranunculaceae	*Ceratocephala falcata* (L.) Pers.	M [ES, Med, IT] [Th]
Ranunculaceae	*Consolida orientalis* (J. Gay) Schrodinger	M [ES, Med, IT] [Th]
Ranunculaceae	*Delphinium pallidiflorum* Freyn	[IT] [Cr]
Ranunculaceae	*Ranunculus kotschyi* Boiss.	LEM [IT] [He]
Ranunculaceae	*Ranunculus* sp.	[Th]
Ranunculaceae	*Thalictrum isopyroides* C.A. Mey.	M [IT] [He]
Super Rosids		
Saxifragales		
Crassulaceae	*Pseudosedum multicaule* (Boiss. & Buhse) Boriss.	[IT] [He]
Crassulaceae	*Rosularia elymaitica* A.Berger	LE [IT] [He]
Crassulaceae	*Rosularia sempervivum* (M. Bieb.) A. Berger	[IT] [He]
Rosids		
Fabales		
Fabaceae	*Alhagi maurorum* Medik.	M [IT] [He]
Fabaceae	*Astragalus babakhanloui* Maassoumi & Podlech	LE [IT] [He]
Fabaceae	*Astragalus campylanthus* Boiss.	LE [IT] [Ch]
Fabaceae	*Astragalus campylorhynchus* Fisch. & C.A.Mey.	[IT] [Th]
Fabaceae	*Astragalus cephalanthus* DC.	LEM [IT] [Ch]
Fabaceae	*Astragalus chahartaghensis* Maassoumi & Podlech	LE [IT] [He]
Fabaceae	*Astragalus cyclophyllon* Beck	VEM [IT] [He]
Fabaceae	*Astragalus fragiferus* Bunge	LE [IT] [Ch]
Fabaceae	*Astragalus grammecalyx* Boiss. & Hohen.	[IT] [He]
Fabaceae	*Astragalus griseus* Boiss.	VE [IT] [He]
Fabaceae	*Astragalus holopsilus* Bunge	LE [IT] [He]
Fabaceae	*Astragalus macropelmatus* Bunge	[IT] [Th]
Fabaceae	*Astragalus ovinus* Boiss.	M [IT] [He]
Fabaceae	*Astragalus rhodosemius* Boiss. & Hausskn.	E [IT] [Ch]
Fabaceae	*Astragalus* sp.	[Ch]
Fabaceae	*Hedysarum grandiflorum* Pall.	[ES, IT] [He]
Fabaceae	*Vicia* sp.	[Th]
Rosales		
Rosaceae	*Amygdalus lycioides* Spach	LEM [IT] [Ph]
Rhamnaceae	*Rhamnus persica* Boiss.	LEM [IT] [Ph]
Urticaceae	*Parietaria judaica* L.	M [ES, Med, IT] [He]
Malpighiales		
Euphorbiaceae	*Euphorbia bungei* Boiss.	[IT] [He]
Euphorbiaceae	*Euphorbia* sp.	[He]
Linaceae	*Linum album* Kotschy ex Boiss.	LEM [IT] [He]
Linaceae	*Linum austriacum* L.	[ES, IT] [He]
Geraniales		
Geraniaceae	*Erodium cicutarium* (L.) L'Hér.	M [ES, Med, IT] [Th]
Geraniaceae	*Geranium lucidum* L.	M [ES, Med] [Th]
Geraniaceae	*Geranium tuberosum* L.	M [ES, Med, IT] [Cr]
Sapindales		
Biebersteiniaceae	*Biebersteinia multifida* DC.	M [Med, IT] [Th]
Nitrariaceae	*Peganum harmala* L.	M [ES, Med, IT] [He]
Rutaceae	*Haplophyllum acutifolium* (DC.) G. Don	[IT] [He]
Rutaceae	*Haplophyllum rechingeri* C.C.Towns.	EM [IT] [He]
Malvales		
Malvaceae	*Alcea koelzii* I.Riedl	EM [IT] [He]
Malvaceae	*Malva neglecta* Wallr	M [Plur] [He]
Brassicales		
Resedaceae	*Reseda lutea* L.	M [ES, Med, IT] [He]
Cleomaceae	*Cleome coluteoides* Boiss.	M [IT] [He]
Brassicaceae	*Aethionema carneum* B.Fedtsch.	M [IT] [Th]
Brassicaceae	*Aethionema virgatum* (Boiss.) Hedge	[IT] [Th]
Brassicaceae	*Alyssum linifolium* Stephan ex Willd.	M [Med, IT] [Th]

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Brassicaceae	*Arabis caucasica* Willd.	[ES, Med, IT] [He]
Brassicaceae	*Arabis nova* Vill.	[ES, Med, IT] [Th]
Brassicaceae	*Aubrieta parviflora* Boiss.	[IT] [Ch]
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	M [Cosm] [Th]
Brassicaceae	*Cardamine* sp.	[Th]
Brassicaceae	*Conringia clavata* Boiss.	[IT] [Th]
Brassicaceae	*Descurainia sophia* (L.) Webb ex Prantl	M [ES, Med, IT] [Th]
Brassicaceae	*Draba rosularis* Chodat & Wilczek	[IT] [He]
Brassicaceae	*Eruca vesicaria* (L.) Cav.	[ES, Med, IT] [Th]
Brassicaceae	*Erysimum repandum* L.	M [IT] [He]
Brassicaceae	*Fibigia suffruticosa* (Vent.) Sweet	M [IT] [He]
Brassicaceae	*Fibigia umbellata* (Boiss.) Boiss.	EM [IT] [He]
Brassicaceae	*Hesperis persica* Boiss.	[IT] [He]
Brassicaceae	*Isatis cappadocica* Desv.	M [IT] [He]
Brassicaceae	*Isatis* sp.	[He]
Brassicaceae	*Lepidium draba* L.	M [Cosm] [Th]
Brassicaceae	*Malcolmia* sp.	[Th]
Brassicaceae	*Matthiola farinosa* Bunge ex Boiss.	[IT] [He]
Brassicaceae	*Matthiola ovatifolia* Boiss.	LEM [IT] [He]
Brassicaceae	*Pseudocamelina glaucophylla* N.Busch	LE [IT] [He]
Brassicaceae	*Sameraria elegans* Boiss.	LE [IT] [Th]
Brassicaceae	*Sameraria* sp.	[Th]
Super Asterids		
Santalales		
Santalaceae	*Thesium kotschyanum* Boiss.	[IT] [Cr]
Caryophyllales		
Plumbaginaceae	*Acantholimon senganense* Bunge	E [IT] [Ch]
Polygonaceae	*Atraphaxis spinosa* L.	M [ES, IT] [Ch]
Polygonaceae	*Polygonum aridum* Boiss. & Hausskn. ex Boiss.	LEM [IT] [Ch]
Polygonaceae	*Polygonum aviculare* L.	M [Cosm] [Th]
Polygonaceae	*Rheum ribes* L.	M [IT] [Th]
Polygonaceae	*Rumex* sp.	[IT] [Cr]
Caryophyllaceae	*Acanthophyllum crassifolium* Boiss.	LEM [IT] [Ch]
Caryophyllaceae	*Acanthophyllum mucronatum* C.A.Mey.	M [IT] [Ch]
Caryophyllaceae	*Acanthophyllum* sp.	[Ch]
Caryophyllaceae	*Bufonia* sp.	[He]
Caryophyllaceae	*Cerastium dichotomum* L.	[ES, Med, IT, SS] [Th]
Caryophyllaceae	*Dianthus macranthoides* Hausskn. ex Bornm.	LEM [IT] [Ch]
Caryophyllaceae	*Dianthus orientalis* Adams	ERM [IT] [He]
Caryophyllaceae	*Gypsophila* sp.	[He]
Caryophyllaceae	*Mesostemma kotschyanum* (Fenzl ex Boiss.) Vved.	[IT] [He]
Caryophyllaceae	*Paronychia caespitosa* Stapf	LE [IT] [He]
Caryophyllaceae	*Silene longipetala* Vent.	[IT] [He]
Caryophyllaceae	*Silene* sp.	[He]
Caryophyllaceae	*Stellaria media* (L.) Vill.	M [ES, Med, IT, SS] [Th]
Caryophyllaceae	*Vaccaria* sp.	[Th]
Amaranthaceae	*Camphorosma monspeliaca* L.	M [ES, IT] [Ch]
Asterids		
Ericales		
Primulaceae	*Androsace maxima* L.	[ES, Med, IT, SS] [Th]
Gentianales		
Rubiaceae	*Asperula glomerata* (M.Bieb.) Griseb.	M [IT] [He]
Rubiaceae	*Asperula* sp.	[He]
Rubiaceae	*Callipeltis cucullaris* (L.) DC.	[Th]
Rubiaceae	*Galium* sp.	[Th]

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Boraginales		
Boraginaceae	*Alkanna frigida* Boiss.	E [IT] [He]
Boraginaceae	*Anchusa strigosa* Banks & Sol.	M [IT] [He]
Boraginaceae	*Asperugo procumbens* L.	M [Plur] [Th]
Boraginaceae	*Buglossoides arvensis* (L.) I.M.Johnst.	M [ES, Med, IT, SS] [Th]
Boraginaceae	*Lappula microcarpa* Gürke	[ES, IT] [Th]
Boraginaceae	*Nonea caspica* G.Don	M [ES, IT] [Th]
Boraginaceae	*Onosma elivendica* Wettst. ex Stapf	E [IT] [He]
Boraginaceae	*Onosma microcarpa* DC.	M [IT] [He]
Boraginaceae	*Onosma* sp.	[He]
Boraginaceae	*Rindera lanata* Bunge	[IT] [He]
Boraginaceae	*Solenanthus bakhtiaricus* Khat.	E [IT] [He]
Boraginaceae	*Solenanthus circinatus* Ledeb.	M [IT] [He]
Boraginaceae	*Trichodesma aucheri* DC.	LE [IT] [He]
Solanales		
Convolvolaceae	*Convolvulus arvensis* L.	M [Cosm] [Th]
Convolvolaceae	*Convolvulus commutatus* Boiss.	M [IT] [He]
Solanaceae	*Hyoscyamus reticulatus* L.	M [IT] [He]
Lamiales		
Plantaginaceae	*Linaria michauxii* Chav.	EM [IT] [He]
Plantaginaceae	*Veronica hederifolia* L.	[ES] [Th]
Plantaginaceae	*Veronica* sp.	[He]
Scrophulariaceae	*Verbascum nudicaule* (Wydler) Takht.	[IT] [He]
Lamiaceae	*Ajuga chamaecistus* Ging. ex Benth.	LEM [IT] [Ch]
Lamiaceae	*Clinopodium graveolens* (M.Bieb.) Kuntze	M [ES, Med, IT] [Th]
Lamiaceae	*Eremostachys molucelloides* Bunge	[IT] [He]
Lamiaceae	*Hymenocrater bituminosus* Fisch. & C.A.Mey.	[IT] [Ch]
Lamiaceae	*Lagochilus aucheri* Boiss.	LE [IT] [Ch]
Lamiaceae	*Marrubium cuneatum* Banks & Sol.	M [IT] [He]
Lamiaceae	*Nepeta ispahanica* Boiss.	M [IT] [Th]
Lamiaceae	*Nepeta pungens* (Bunge) Benth.	M [IT] [Th]
Lamiaceae	*Nepeta saccharata* Bunge	M [IT] [Th]
Lamiaceae	*Nepeta* sp.	[Th]
Lamiaceae	*Nepeta straussii* Hausskn. & Bornm.	LEM [IT] [Th]
Lamiaceae	*Nepeta supina* Steven	[IT] [He]
Lamiaceae	*Phlomis olivieri* Benth.	EM [IT] [He]
Lamiaceae	*Phlomis persica* Boiss.	LEM [ES, IT, SS] [He]
Lamiaceae	*Salvia aristata* Aucher ex Benth.	LEM [IT] [He]
Lamiaceae	*Salvia atropatana* Bunge	M [IT] [He]
Lamiaceae	*Salvia hydrangea* DC. ex Benth.	M [IT] [He]
Lamiaceae	*Salvia multicaulis* Vahl	M [IT] [He]
Lamiaceae	*Salvia reuteriana* Boiss.	EM [IT] [He]
Lamiaceae	*Scutellaria multicaulis* Boiss.	LEM [IT] [Ch]
Lamiaceae	*Scutellaria tomentosa* Bertol.	[IT] [He]
Lamiaceae	*Stachys aucheri* Benth.	LE [IT] [Ch]
Lamiaceae	*Stachys inflata* Benth.	M [ES, IT] [He]
Lamiaceae	*Stachys lavandulifolia* Vahl	M [IT] [He]
Lamiaceae	*Stachys pilifera* Benth.	LEM [IT] [Ch]
Lamiaceae	*Teucrium orientale* L.	M [IT] [He]
Lamiaceae	*Teucrium polium* L.	M [Med, IT] [Ch]
Lamiaceae	*Ziziphora clinopodioides* Lam.	VM [IT] [Ch]
Lamiaceae	*Ziziphora tenuior* L.	M [IT] [Th]
Orobanchaceae	*Orobanche oxyloba* (Reut.) Beck	[ES, IT] [Cr]
Asterales		
Campanulaceae	*Campanula incanescens* Boiss.	M [IT] [He]
Campanulaceae	*Michauxia laevigata* Vent.	[IT] [He]

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Asteraceae	*Achillea santolinoides* Lag.	M [IT] [He]
Asteraceae	*Anthemis odontostephana* Boiss.	M [IT] [Th]
Asteraceae	*Carduus pycnocephalus* L.	M [Med, IT] [Th]
Asteraceae	*Carthamus oxyacantha* M.Bieb.	M [IT] [Th]
Asteraceae	*Centaurea aucheri* (DC.) Wagenitz	LEM [IT] [He]
Asteraceae	*Centaurea gaubae* (Bornm.) Wagenitz	LE [IT] [He]
Asteraceae	*Centaurea ispahanica* Boiss.	LEM [IT] [He]
Asteraceae	*Centaurea virgata* Lam.	M [ES, Med, IT] [He]
Asteraceae	*Centaurea xeranthemoides* Rech.f.	E [IT] [He]
Asteraceae	*Chardinia orientalis* (L.) Kuntze	M [IT] [Th]
Asteraceae	*Cichorium intybus* L.	M [Plur] [He]
Asteraceae	*Cirsium bracteosum* DC.	LEM [IT] [He]
Asteraceae	*Cirsium sorocephalum* Fisch. & C.A.Mey.	[Med, IT] [He]
Asteraceae	*Cirsium* sp.	[He]
Asteraceae	*Cirsium spectabile* DC.	LE [IT] [He]
Asteraceae	*Cousinia calcitrapa* Boiss.	LE [IT] [He]
Asteraceae	*Cousinia* sp.	[He]
Asteraceae	*Cousinia tenuiramula* Rech.f.	ER [IT] [He]
Asteraceae	*Crepis sancta* (L.) Babc.	M [Med, IT, SS] [Th]
Asteraceae	*Crupina crupinastrum* Vis.	M [Med, IT] [Th]
Asteraceae	*Cyanus depressus* (M.Bieb.) Soják	M [IT] [Th]
Asteraceae	*Echinops leiopolyceras* Bornm.	[IT] [He]
Asteraceae	*Gundelia tournefortii* L.	M [Med, IT] [He]
Asteraceae	*Helichrysum oligocephalum* DC.	LEM [IT] [Ch]
Asteraceae	*Hertia angustifolia* Kuntze	LEM [IT] [Ch]
Asteraceae	*Jurinea berardioides* (Boiss.) O.Hoffm.	[IT] [He]
Asteraceae	*Jurinea carduiformis* Boiss.	[IT] [He]
Asteraceae	*Lactuca microcephala* DC.	[IT] [He]
Asteraceae	*Lactuca orientalis* Boiss.	[IT] [He]
Asteraceae	*Lactuca persica* Boiss.	[IT] [Th]
Asteraceae	*Launaea acanthodes* (Boiss.) Kuntze	EM [IT] [He]
Asteraceae	*Onopordum leptolepis* DC.	M [IT, SS] [He]
Asteraceae	*Phagnalon nitidum* Fresen.	[IT] [He]
Asteraceae	*Picris strigosa* M.Bieb.	E [IT] [He]
Asteraceae	*Rhaponticum repens* (L.) Hidalgo	M [IT] [He]
Asteraceae	*Scorzonera laciniata* Jacq.	M [ES, Med, IT] [He]
Asteraceae	*Serratula latifolia* Boiss.	M [IT] [He]
Asteraceae	*Siebera nana* (DC.) Bornm.	[IT] [Th]
Asteraceae	*Sonchus oleraceus* L.	M [Cosm] [Th]
Asteraceae	*Stizolophus balsamita* (Lam.) Cass. ex Takht.	[IT] [Th]
Asteraceae	*Tanacetum polycephalum* Sch.Bip.	LEM [IT] [He]
Asteraceae	*Tragopogon porrifolius* L.	[ES, Med, IT] [He]
Dipsacales		
Caprifoliaceae	*Lomelosia olivieri* (Coulter) Greuter & Burdet	[IT] [Th]
Caprifoliaceae	*Pterocephalus canus* Coult. ex DC.	[IT] [He]
Caprifoliaceae	*Valeriana sisymbriifolia* Vahl	M [IT] [He]
Caprifoliaceae	*Valerianella oxyrhyncha* Fisch. & C.A.Mey.	M [IT] [Th]
Caprifoliaceae	*Valerianella* sp.	[Th]
Apiales		
Apiaceae	*Bunium* sp.	[Cr]
Apiaceae	*Chaerophyllum macrospermum* (Willd. ex Schult.) Fisch. & C.A.Mey.	[IT] [He]
Apiaceae	*Ducrosia anethifolia* Boiss.	M [IT, SS] [He]
Apiaceae	*Echinophora platyloba* DC.	LEM [IT] [He]
Apiaceae	*Eryngium billardierei* Heldr. ex Boiss.	M [ES, Med, IT] [He]
Apiaceae	*Ferula ovina* Boiss.	M [IT] [He]
Apiaceae	*Ferula* sp.	[He]
Apiaceae	*Ferulago* sp.	[He]

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Apiaceae	*Prangos ferulacea* Lindl.	M [ES, IT] [He]
Apiaceae	*Scandix stellata* Banks & Sol.	M [ES, IT, SS] [Th]
Apiaceae	*Smyrniopsis* sp.	[He]
Apiaceae	*Smyrnium cordifolium* Boiss.	M [IT] [He]
Apiaceae	*Turgenia latifolia* Hoffm.	M [ES, Med, IT] [Th]
Apiaceae	*Zosima absinthifolia* absinthifolia	M [IT] [He]

Right column: L: Lower risk, E: Endemic (to Iran), M: Medicinal, V: Vulnerable. First Backet: Chorotypes; IT: Irano-Turanian, ES: Euro-Siberian, Med: Mediterranean, SS: Saharo-Sindian. Second Backet: Life Form: Ph: Phanerophyte, Ch: Chamaephyte, He: Hemicryptophyte, Cr: Cryptophyte, Th: Therophyte

The second dataset which was compiled to compare among local floras in north-eastern Bakhtiari province (*Table 2*, map in *Fig. 3*), consisted of a matrix of species occurrence data in 8 adjacent floras (Heydari-Ghahfarrokhi et al., 2012; Tahmasebi, 2014a; Kafash-Saei et al., 2014b; Jalali et al., 2016; Dehghani et al., 2016; Naghipoor-Borj et al., 2016; Vahabi et al., 2018). This dataset comprises of 714 species (9.5% of the total species in Iran), belonging to 323 genera and 60 families. Species to family, genera to family and species to genus ratios are 11.9, 5.38, and 2.21, respectively. This compiled dataset consists of 16 rare, 133 endemics (to Iran), and 258 medicinal plant species. The largest families in dataset 2 in terms of species richness are Asteraceae (15.4%), Fabaceae (11.2%), and Brassicaceae (8.4%). The largest families in terms of generic richness are Asteraceae (14%), Brassicaceae (11%) and Poaceae (10%). The most-rich genera are *Astragalus* (35 spp), *Euphorbia* (18 spp), and *Salvia* (12 spp). 244 genera (out of of 323) are represented in this area by only one or two species, resulting in sp/gen ratio as low as 2.21. Although components (local floras) of dataset 2 encompass an area of only 146000 ha; i.e. they are not much far apart, beta diversity (variation between sites) was significant. *Table 1* presents names, geographical coordinates, alpha and beta diversity measures of each local flora in the second dataset. Flora of Sheida protected area (id: 229) was the most species-rich site in this area (alpha diversity = 314). Beta diversity (variation between sites) ranged from 112 to 363. Flora Farrokhshahr (id: 264, alpha= 95) and Margh (id: 213, alpha= 55) were the most similar local floras, and flora Sheida (id: 229, alpha= 314) and Babazaki (dataset 1, id: 534, alpha= 257) were the most dissimilar local floras (*Table 1*). Gamma diversity (net count of species in the second dataset) was 714. Beta diversity between Babazaki and its adjacent floras range from 260 to 363, indicating a relatively high variation between sites.

Comparison between dataset 1 (Babazaki flora) and the set of its adjacent local floras in dataset 2 is summarized in *Fig. 5*. Babazaki flora (set A) shares 178 species with its adjacent local floras (set B). There are 457 species growing in local floras of set B, which are not observed in Babazaki (set A). Babazaki flora, on the other hand, comprises of 79 species not reported from set B floras. Results demonstrated that diversity of plant species in Babazaki flora is significantly different from its adjacent sites.

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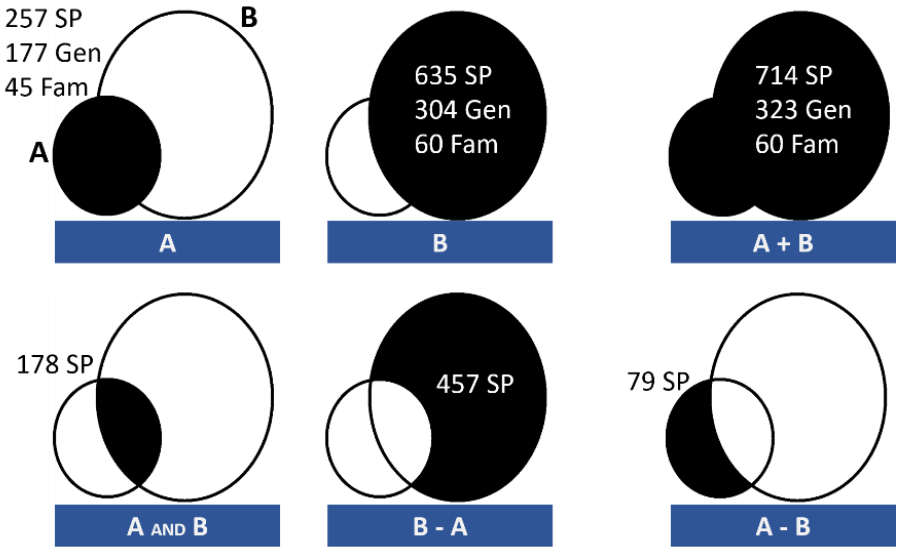

Figure 5. *A brief comparison of Babazaki flora (set A) with a compilation of seven adjacent local floras (set B). See text for more details*

The third dataset in this study, comprises of twenty-two local floras (*Table 2*) in a broader area consisting various sites in two provinces Bakhtiari and Esfahan (Parishani, 2005; Shahrokhi, 2005; Yousofi, 2006; Assadi et al., 2009; Yousofi et al., 2011; Pairanj et al., 2011; Heidari et al., 2012; Kafash-Saei et al., 2014a,b; Shirmardi et al., 2014a,b; Tahmasebi, 2014a,b; Dehghani et al., 2016; Jalali et al., 2016; Naghipoor-Borj et al., 2016; Hasanzadeh et al., 2017; Iranmanesh et al., 2017; Gholami et al., 2018; Vahabi et al., 2018). The map in *Fig. 3* shows geographical distribution of the local floras in the third dataset, in which the location of Babazaki is shown with a black arrow. This dataset comprises of 1512 species (20.1% of the Iranian flora), belonging to 517 genera and 96 families. Species to family, genera to family and species to genus ratios were 15.75, 5.38, and 2.92, respectively. Checklist of the third dataset consists of 60 rare, 318 endemics (to Iran), and 510 medicinal plant species. There are 4 endangered, 22 vulnerable and 202 lower-risk category species present in this dataset.

Discussion

Results of multivariate analysis of the third dataset (22 sites × 1439 spp), using different K values, showed that the 22 local floras (objects) could be separated into four well-defined groups. Flora of Babazaki and Sheet mountain area, along with six more adjacent local floras: Kakolak (id 380), Karsanak (id 259), Tang-e-Sayad (id 211), Farrokh-Shahr (id 264), Darreh_Sir (id 260) and Broujen (id 214) made the first group. This group consists of 624 species, 299 genera and 60 families. There are 74 descriptive species in local floras of group 1 which are not found in other three groups of local floras in the third dataset. Local floras of group 1, are characterized also by 115 endemics (to Iran), 13 rare, 222 medicinal and 100 range species. One endangered species (*Ferula assa-foetida*), five vulnerable (*Astragalus cyclophyllon*, *A. griseus*, *A. pinetorum*, *Isatis campylocarpa*, *Ziziphora clinopodioides*) and 84 species in lower risk category, are growing in this group of local floras.

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Second group in *Fig. 6* consists of five local floras including flora Jahanbin mountain area (id 232), Saldaran protected area (id 344) and Vanak (id 2), and also two small floras Margh (id 213), and wetlands of the province (id 438). This group consists of 852 species, 386 genera and 86 families. There are 271 descriptive species in local floras of group 2, not found in other groups. Local floras of group 2, consist of 154 endemics (to Iran), 31 rare, 292 medicinal and 152 range species. One endangered species (*Ferula persica*), ten vulnerable and 105 species in lower risk category, are growing in local floras of this group.

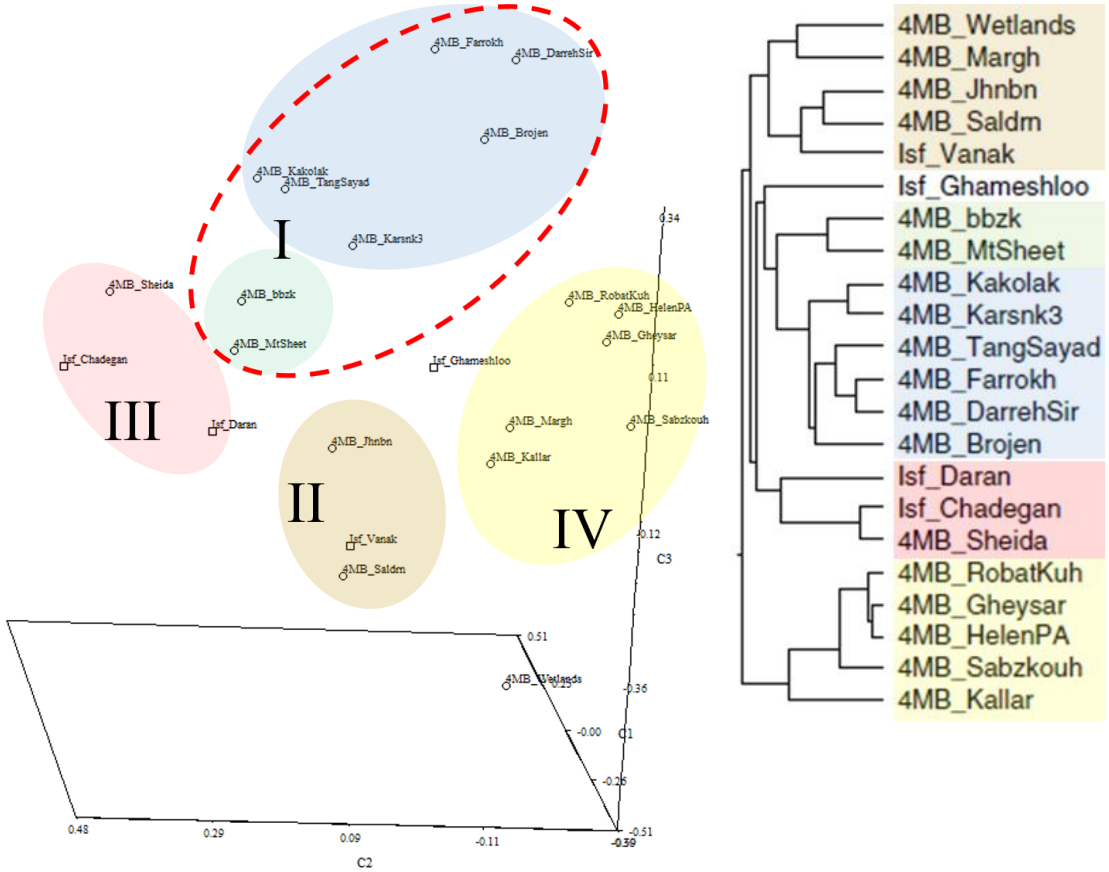

Figure 6. *Left: Ordination plot of third dataset (data matrix of presence/absence data of 22 local floras). Right: Clustering diagram demonstrating four coherent groups (K=4). Floras Babazaki and Sheet mountain areas are a subgroup of the group 1 (colored with pale blue); see text for more details*

Three closely related floras Daran (id 348), Chadegan (id 7) and Sheida (id 229) constitute the third group in *Fig. 6*. Group 3 consists of 601 species, 309 genera and 71 families. There are 139 descriptive species in group 3 which are not found in other three groups. Group 3 local floras, consist of 119 endemics (to Iran), 21 rare, 322 medicinal and 93 range species. Two endangered species (*Ferula assa-foetida* and *Dracocephalum kotschyi*), four vulnerable (*Tribulus terrestris*, *Astragalus cyclophyllon*, *Ziziphora clinopodioides* and *Scabiosa persica*) and 78 species in lower risk category, are growing in local floras of this group.

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Forth group on the dendrogram consists of five local floras: Robat-Kouh (id 515), Gheysari protected area (id 183), Helen protected area (id 194), Sabzkouh protected area (id 254) and Kallar mountain area (id 149). This group consists of 828 species, 402 genera and 86 families, and there are 216 descriptive species in local floras of group 4, not found in other three groups. Group 4 *local* floras, consist of 178 endemics (to Iran), 26 rare, 308 medicinal and 114 range species. Two endangered species (*Ferula assa-foetida* and *Astragalus phlomoides*), 13 vulnerable and 111 lower risk category species are growing in this group.

Flora of Ghameshloo (id 31) which is poorly studied, appeared as an outlier of the groups described above. Of 78 species (61 genera and 22 fams), identified from this site, 26 species were exclusive relative to other 21 members of the third dataset. The majority of taxa in the three datasets in this study are hemicryptophytes; a life form adopted by plants of this region to cope with the relatively scarce water, and cold temperature in the high-*altitude* region of central Zagros. Most of the species in family Asteraceae, prevalent in this region, showed this life form. The checklist of northeastern Bakhtiari Province of Iran (dataset 2) counts 714 species of flowering plants belonging to 60 families, with 65% of the species belonging to the 6 largest families, i.e. Asteraceae (110 spp), Fabaceae (80 spp), Brassicaceae (60 spp), Lamiaceae (54 spp), Poaceae (52 spp), and Apiaceae (42 spp).

Conclusion

Sixty species growing in Babazaki flora, which were not reported from adjacent local floras in dataset 2 could be regarded as an indication of significant variation among nearby local floras in this study. Understanding the biodiversity and distribution of taxa in this region is difficult, because datasets are usually incomplete, not easily accessible or inconsistent. Compilation of datasets and comparisons between them could easily become unreliable due to ongoing taxonomic revisions. Floristic databases such as Alamut (is developing and used by the author in this study), are necessary tools for converting scientific names to consistent data. Diversity, endemism and IUCN conservation categories in the central Zagros have been underestimated in previously reports (Vajari et al., 2014). Results of this study may provide a considerable update on the available information on the floristic diversity and distribution of taxa in the studied local floras. Conservation of biodiversity in central Zagros could be challenging for more reasons, including: incomplete knowledge, unassessed dark diversity, land-use histories, gradual climate change, and the increasing encroachment of habitats by humans. Resulting checklist in this study would help botanical research and nature conservation planning in the region. Datasets compiled in this study are deposited in the Alamut floristic database, which is intended to grow in size, to be the core base for future investigations. Further sampling in gap location may elucidate the dark diversity although it is also expected that certain missing taxa could simply have not habituated in some sites.

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