# Habitat and floristic peculiarities of an isolated mountain mire in the Hyrcanian region of northern Iran: a harbour for rare and endangered plant species

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## SUMMARY

Except for the aquatic wetlands already designated under the Ramsar (Wetland) Convention, little is known about the flora and habitat ecology of mountain mire patches in the Hyrcanian forest of northern Iran. The present study describes the floristic composition and the life forms, chorology and habitat characteristics of plants at Chaman-e Kelar, an isolated mountain mire in the central Hyrcanian relict forests. Almost 75 % of the 103 plant taxa recorded in this mire were typical wetland plants, and the most abundant life form was hemicryptophytes. Phytogeographically, more than half of the recorded species were of pluriregional origin followed by Euro-Siberian, Irano-Turanian and Mediterranean elements. Despite the rather small area, six habitat types were recognised on the basis of physiognomy using the EUNIS habitat classification scheme, each type being characterised by particular microrelief (hummock/hollow) and floristic (dominant and accompanying species) features. A Kruskal-Wallis test of differences between the Ellenberg values of plant species for six indicator variables showed that only F (moisture value) and N (nutrients value) differed significantly among the six habitat types. PCA analysis of the species data indicated that the first main gradient was related to mire moisture, whereas the second axis reflected the gradient from shallow standing water to water table at or near the mire surface. Chaman-e Kelar is of high conservation importance, with three Iranian endemic species (*Trisetum bungei*, *Polygonum hyrcanicum* and *Ranunculus amblyolobus*) and six rare and endangered species (*Trisetum bungei*, *Phleum bertolonii*, *Epipactis palustris*, *Lysimachia vulgaris*, *Polygonum hyrcanicum* and *Ranunculus amblyolobus*). Any factors that might affect moisture and nutrient availability on this important mire should be cautiously monitored and managed.

**KEY WORDS:** biodiversity, Chamane-e Kelar Mire, chorology, Ellenberg indicator values, life forms, peatland

## INTRODUCTION

Peatlands provide many local and global environmental services and benefits all over the world. Archaeology, palaeoecology and conservation ecology are three interrelated aspects of these fragile ecosystems which make them worthy of the label “knowledge archives” (Gearey & Fyfe 2016). In arid and semi-arid regions, wetlands in general and mountain mires in particular are especially important for conserving biodiversity, regulating pollution and waste, and acting as natural water reservoirs (Sekulová *et al.* 2011, Ramsar Convention Secretariat 2013, Jalili *et al*. 2014, Mitsch & Gosselink 2015).

Small patches of wetland and mire habitat generally possess great potential for the conservation of biological diversity, yet have received little recognition and/or protection (Tiner 2003, Flinn *et al*. 2008, Nowak *et al.* 2016). Resembling geographically isolated islands within contrasting forests or steppes (cf. Naqinezhad *et al*. 2009), such small mires harbour high levels of local species richness (alpha diversity) along with spatial variation in community composition (beta diversity) (Tiner 2003, Williams *et al*. 2003, Nowak *et al*. 2016), and may support distinctive species assemblages that differ from those found in larger wetlands (Flinn *et al*. 2008). More importantly, they may serve as refugia for many rare species of large wetlands which are increasingly becoming degraded or being destroyed (Bedford & Godwin 2003, Williams *et al*. 2003, Cantonati *et al.* 2006, Hájková *et al.* 2006).

As human-induced pollution and drainage, along with grazing, are increasingly threatening small isolated wetlands, and considering that these ecosystems are usually ignored by national monitoring strategies (Williams *et al*. 2003, Moges *et* *al*. 2016), it is crucial to apply strict conservation policies to protect and restore (e.g. rewet) them.

Due to the overall scarcity of mire and peatland habitats in arid and semi-arid regions, environmental managers in such regions should pay special attention to the conservation of these unique ecosystems. This is particularly important for Iran where intense socio-economic activity has negatively affected many rivers, lakes, ponds, mires and other wetlands over the past 50 years (Jalili *et al*. 2014). Even more importantly, it is suggested that highland wetlands/mires in Iran can be regarded as 'interglacial refugia' for glacial boreal relict vascular species (Kürschner *et al.* 2015). The subfossil presence of the mosses *Meesia triquetra* (L. ex Jolycl.) Ångstr. and *Sphagnum squarrosum* Crome in peat cores from northern Iran (Kürschner & Djamali 2008, Kürschner *et al.* 2015) underlines the importance of small remnant patches of mire in the mountains of Iran for biodiversity conservation.

There have been recent studies of the vegetation and ecology of mires and peatlands on the southern slopes of the Alborz Mountains in northern Iran (Naqinezhad *et al*. 2009, Naqinezhad *et al*. 2010; Kamrani *et al*. 2010, 2011a, 2011b), which resemble the highland mires of Anatolia and Central Asia (Klein & Lacoste 1995, Vural 1996, Klimeš 2003, Parolly 2004, Nowak *et al*. 2016), but little attention has so far been devoted to 'truly Hyrcanian' mires. In a comprehensive study of the flora, fauna and vegetation of Sulukli Marshland (1357 m a.s.l.) in Golestan National Park (Akhani 1998, Akhani 2005, Soufi & Jafari 2011), two plant species new to the Iranian flora and an animal species new to science were reported. A tentative list of plant taxa growing on or in the immediate vicinity of some Hyrcanian peatlands/mires has been provided in recent palaeoecological studies (Ramezani *et al*. 2008, Khakpour Saeej *et al*. 2013, Ramezani *et al*. 2016), whereas Ramezani (2013) has provided the first palynological data on the Late-Holocene vegetation history of Kelardasht District (see later).

Despite extensive criticism, there is growing interest in the use of species indicator values, especially those of Ellenberg, to assess habitat quality and monitor its changes (Diekmann 2003). Ellenberg values are widely used not only in Central Europe but also in other parts of Europe and the Mediterranean region, and have been largely confirmed by field measurements (Såstad & Moen 1995, Schaffers & Sýkora 2000, Diekmann 2003, Horsák *et al*. 2007, Klaus *et al*. 2012). Average Ellenberg values (i.e. the mean values for all species from a particular site) are commonly used to describe the site characteristics of a plot (Ertsen *et al*. 1998). An average value can be calculated by both weighted and unweighted approaches (ter Braak & Barendregt 1986, Schaffers & Sýkora 2000, Horsak *et al*. 2007) and is resilient to incompleteness of the species record (Ewald 2003, Horsak *et al*. 2007).

The present study aimed (1) to assess the floristic composition, together with the life forms and chorology of the plant species, of Chamane-e Kelar Mire in the central Hyrcanian region of northern Iran; and (2) to classify the various habitats floristically and physiognomically, and to test whether the Ellenberg values for mire species support this differentiation.

## METHODS

### Site and study area

The site investigated is a mire (ca. 25 ha; 1080 m a.s.l.; 36º 31' 12" to 36º 31' 34" N; 51º 11' 46" to 51º 12' 09" E) in the central Hyrcanian region of northern Iran (Figure 1). It lies just south of an ancient archaeological mound (tell) called Tepe Kelar. Known as Chaman-e Kelar by local people, the mire lies in a flat area close to Kordichal village in Kelardasht District and is surrounded by farmland, gardens and residential areas. Currently, wheat and barley are cultivated, even on top of the mound.

Chaman-e Kelar Mire is mainly covered by cyperaceous plants such as *Carex* spp. and *Cyperus* spp. *Lonicera floribunda* Boiss. & Buhse, *Cornus sanguinea* subsp. *australis* (C.A.Mey.) Jáv., *Rhamnus pallasii* Fisch. & C.A.Mey., *Crataegus monogyna* Jacq., *Prunus cerasifera* Ehrh. and *Populus nigra* L. occur occasionally in the surroundings of the mire. Rather heavy grazing by local domestic herds, particularly of cattle and sheep, influence vegetation composition and structure on the mire and around its margins. In a study using a Russian type chamber corer, Ramezani (2013) found that peat thickness ranged from 1.2 m in the central part of the mire to less than 0.5 m in the drier peripheral parts.

The north-facing slopes of the surrounding mountains are densely covered by broadleaf deciduous forests with beech (*Fagus orientalis* Lipsky), hornbeam (*Carpinus betulus* L.), oaks (*Quercus macranthera* Fisch. & C.A.Mey. ex Hohen., *Quercus castaneifolia* C.A.Mey.), maples (*Acer cappadocicum* Gled., *Acer velutinum* Boiss., *Acer campestre* L.), elm (*Ulmus glabra* Huds.), lime (*Tilia* spp.) and alder (*Alnus subcordata* C.A.Mey.). The drier southern slopes are sparsely vegetated with scattered small trees or thorny scrub, e.g. *Pyrus*, *Malus* and *Crataegus* species.

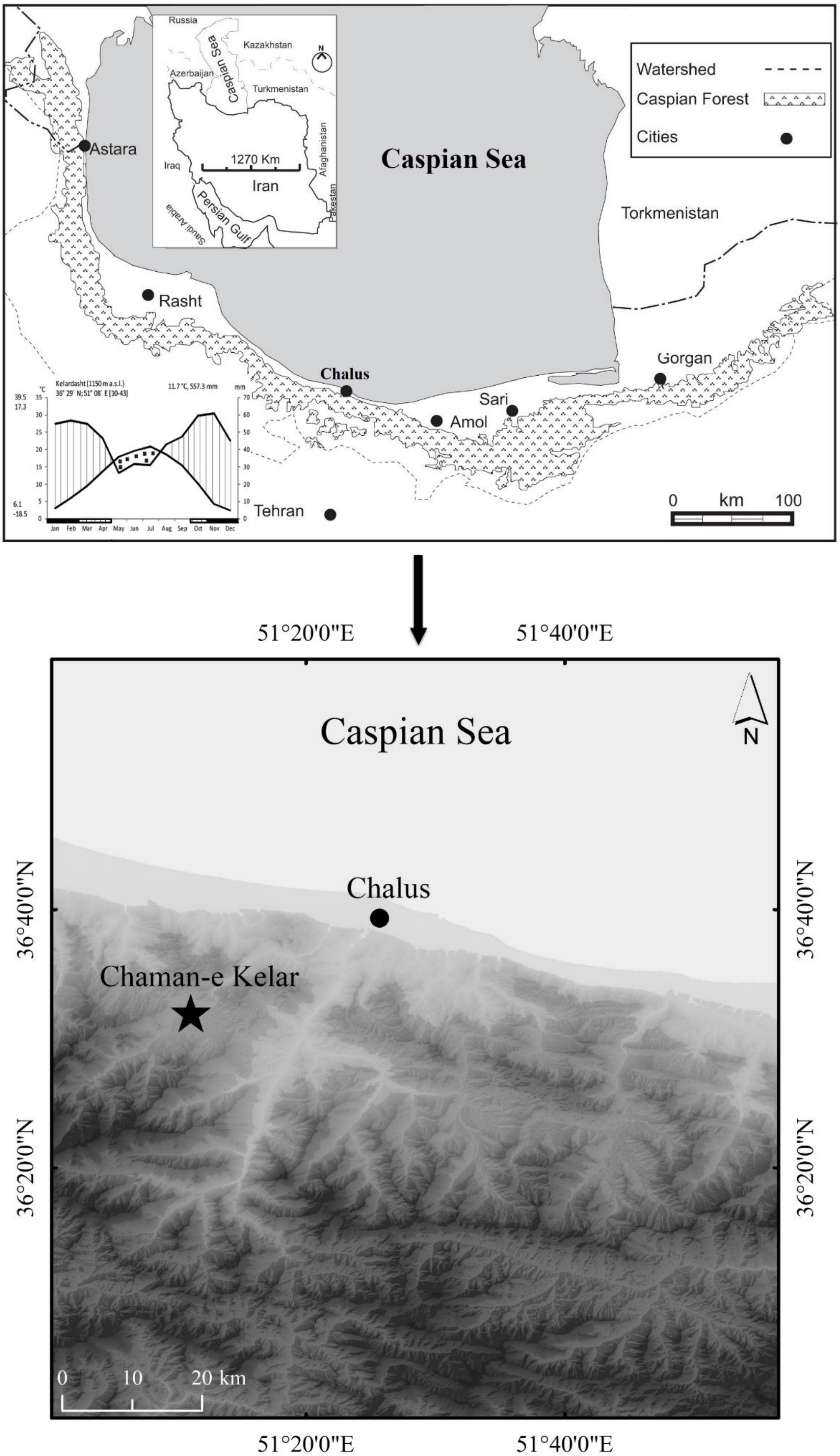



Figure 1. The location of the study area in Kelardasht, central Hyrcanian region, North Iran. Inset: climate diagram for the area (1966–2013).

According to a recent palaeoecological study (Ramezani 2013), human impact and climate change have brought about substantial changes in the local and regional vegetation of Chaman-e Kelar over the past millennium. Beech (*Fagus orientalis*), hornbeam (*Carpinus betulus* / *Carpinus orientalis*) and oak (*Quercus* spp.) were originally the most abundant tree species in the forests surrounding the Kelardasht Plain, whereas maple (*Acer* spp.), ash (*Fraxinus excelsior* L.) and elm (*Ulmus* spp.) were accompanying tree species over the entire record. However, oaks declined severely over the last 1–2 centuries due to intensive human interference. Furthermore, alder (*Alnus subcordata*) and wingnut (*Pterocarya fraxinifolia* (Poir.) Spach), once abundant in the plain, were decimated and/or entirely eliminated, most probably as a consequence of human-induced drainage. The occurrence of several pollen types indicating human presence, such as those of *Juglans regia* L. and *Avena-Triticum*, points to human habitation throughout the last millenium. Substantially higher concentrations of pollen attributable to *Sambucus ebulus*, *Polygonum aviculare* L. and *Plantago lanceolata* indicate intensified human land use and vegetation change over the past 300–400 years.

The geological map of Iran places the Kelardasht plain and Chaman-e Kelar Mire on a Quaternary rock formation which consists largely of heterogeneous and partly polymictic unconsolidated conglomerates.

The nearest climate station, i.e. Kelardasht (1986–2012), reports a mean annual temperature of 11.7 °C and mean annual precipitation 557.3 mm. Mean monthly temperature is lowest in January (0.8 °C) and highest in July (21.8 °C), and the highest mean monthly precipitation occurs in October. According to the recent bioclimatic classification of Iran, which uses bioclimatic data and indices of the Global Classification System of Rivas-Martínez (1997, 1999), the area has a Mediterranean pluviseasonal-oceanic (Mepo) bioclimate (Djamali *et al*. 2011).

**Floristic and habitat data**

Detailed floristic exploration was carried out during frequent visits to the site in 2014–2016. First, a physiognomic classification scheme for the various habitats of the mire was developed. The habitat delimitation was derived subjectively using microrelief features and dominant species of each habitat using EUNIS habitat classification criteria (see http://eunis.eea. europa.eu/habitats.jsp). Plants occurring within each habitat were then identified using *Flora Iranica* (Rechinger 1963–2015), *Flora of Iran* (Assadi *et al*. 1988–2014), *Flora of Turkey* (Davis 1965–1985, Davis *et al*. 1988), *Flora USSR* (Komarov 1934–1954) and *Flora Europaea* (Tutin *et al*. 1968, 1972, 1976, 1980, 1993). Ferns were determined using Khoshravesh *et al*. (2009). All plant names and authorities were double-checked with the online site *The Plant List* (2019). Plant specimens were deposited at the Herbarium of the University of Mazandaran (HUMZ).

**Data analysis**

We applied the Raunkiaer (1934) system for identifying life form categories. Data on species distribution were extracted mainly from *Flora Iranica* (Rechinger 1963–2015) and *Flora of Turkey* (Davis 1965–1985, Davis *et al*. 1988). Phytochoria (chorotypes) were identified using Zohary (1973), Takhtajan (1986) and Léonard (1988, 1989).

To determine habitat characteristics, we used Ellenberg indicator values (Ellenberg 1988, Ellenberg *et al.* 1992) for six variables and 81 plant species (~ 80 % of the total studied flora). Ellenberg values were originally developed for Central Europe but are also commonly used in other parts of the world (e.g. Diekmann 2003). The Ellenberg system assigns to each Central European vascular plant species an ordinal number indicating its preference for a position along a particular ecological gradient, i.e. light (L), temperature (T), continentality (K), moisture (F), soil reaction (R) and nutrients (N) using a 12-point scale for moisture and a 9-point scale for the others. The (weighted) mean indicator value of all species at a certain site for any one of the six environmental factors gives an indication of the overall position of that site along the gradient of that factor (ter Braak & Barendregt 1986, Horsák *et al*. 2007, Kent 2012) and may be used for monitoring the overall development of habitats.

We also assigned 'Ellenberg' indicator values to *Cirsium glaberrimum*, *Carex orbicularis*, *Carex diluta*, *Carex divisa* and *Ranunculus amblyolobus* based on our own data for site conditions in the Central Alborz Mountains (Jalili *et al*. 2014, Naqinezhad *et al*. in preparation). The value (x) of Ellenberg signifies a wide ecological amplitude and was treated as a missing value in our analyses (following Hill & Carey 1997).

We calculated unweighted average Ellenberg indicator values according to the presence/absence of species in each habitat (cf. Horsak *et al*. 2007). Because of the ordinal nature of the values, a Kruskal-Wallis test with a post-hoc Bonferroni correction was applied to identify differences in mean indicator values among the habitat types. A Principal Component Analysis (PCA) was run on species composition (ter Braak & Wiertz 1994, Lepš & Šmilauer 2003), and the physiognomically predefined habitat types for individual species were passively projected as nominal variables in the diagram. Univariate and multivariate analyses were conducted using SPSS (ver. 21) and CANOCO (ver. 4.5), respectively.

## RESULTS

### Floristic accounts

The floristic data are listed in the Appendix. In total, 103 plant taxa belonging to 74 genera and 35 families were recorded in Chaman-e Kelar Mire. They included 58 dicots, 39 monocots, five pteridophytes and one macroscopic alga. Poaceae (18.4 %), Cyperaceae (12.6 %), Fabaceae (7.8 %) and Asteraceae (6.8 %) were the best represented plant families.

The most abundant life forms were hemicryptophytes (60.2 %), therophytes (18.4 %) and helophytes (8.9 %). Phytogeographically, more than half of the recorded species were of pluriregional origin, followed by Euro-Siberian, Irano-Turanian and Mediterranean species (together accounting for 26.5 % of the recorded species) (Figure 2).

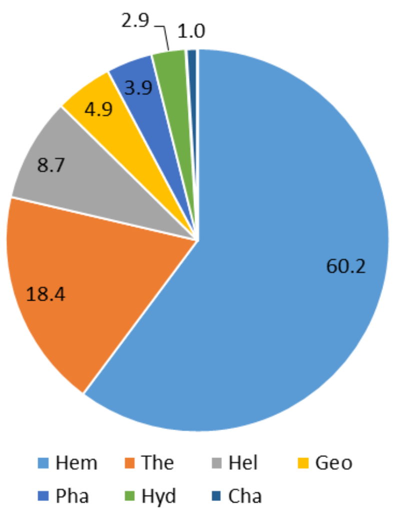
Three of the species recorded, namely *Trisetum bungei*, *Polygonum hyrcanicum* and *Ranunculus amblyolobus*, were Iranian endemics. Our list also included six species listed as rare and endangered in the Red Data Book of Iran (Jalili & Jamzad 1999): *Trisetum bungei*, *Phleum bertolonii* and *Epipactis palustris* in the category 'data deficient'; *Polygonum hyrcanicum* and *Ranunculus amblyolobus* in the category 'low risk plants'; and *Lysimachia vulgaris* in the category 'vulnerable species'.

### Habitat characteristics

Despite its small area, six habitat types were physiognomically recognised in the mire (Figure 3) on the basis of microrelief (hummocks and hollows) and floristic (dominant and accompanying species) features. The six habitat types (abbreviated names in parentheses; the numbers correspond to EUNIS habitat type codes) were:

<u>Patches of *Carex orbicularis* on wet peat hummocks</u> (WC; D4.1B):
This habitat type consisted of highly (> 50 %) organic and rather solid hummocks, occasionally with surface water in the hollows separating them. The vegetation was composed predominantly of *Carex orbicularis* accompanied by *Carex divisa*, *Carex flacca* subsp. *erythrostachys*, *Carex riparia*, *Epipactis palustris*, *Festuca rubra*, *Leontodon hispidus*, *Lysimachia vulgaris*, *Poa trivialis*, *Ranunculus amblyolobus*, *Ranunculus polyanthemos*, *Ranunculus repens*, *Rumex sanguineus* and *Taraxacum* sp.

<u>Peaty depressions with stagnant surface water</u> (PD; D5.2151):
This habitat type consisted of waterlogged depressions with 0.5–1 m thick layers of peat. The vegetation was dominated by *Carex acutiformis* and *Carex riparia*. *Alisma plantago-aquatica*, *Berula erecta*, *Eleocharis uniglumis*, *Glyceria notata*, *Lemna minor*, *Mentha aquatica*, *Phragmites australis*, *Sparganium erectum*, *Thelypteris confluens* and *Typha latifolia* were less frequent taxa.



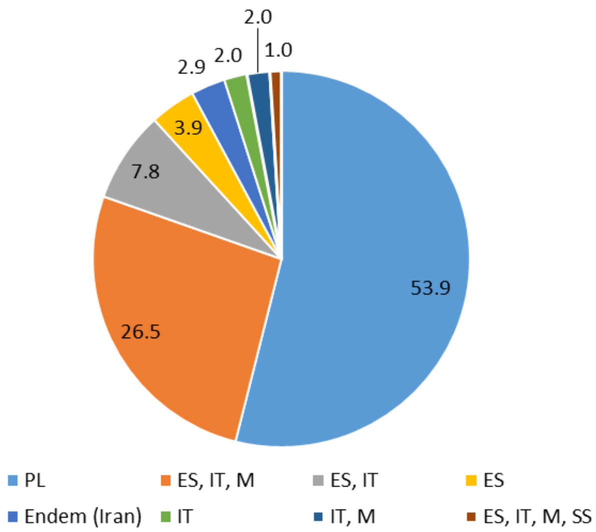




Figure 2. The life form (left) and chorotype spectrum (right) of the plant species in Chaman-e Kelar Mire. Life forms: Cha = chamaephyte; Geo = geophyte; Hel = helophyte; Hem = hemicryptophyte; Hyd = hydrophyte; Pha = phanerophyte; The = therophyte. Chorotypes: ES = Euro-Siberian; IT = Irano-Turanian; M = Mediterranean; PL = pluriregional; SS = Saharo-Sindian. Endem = endemic.

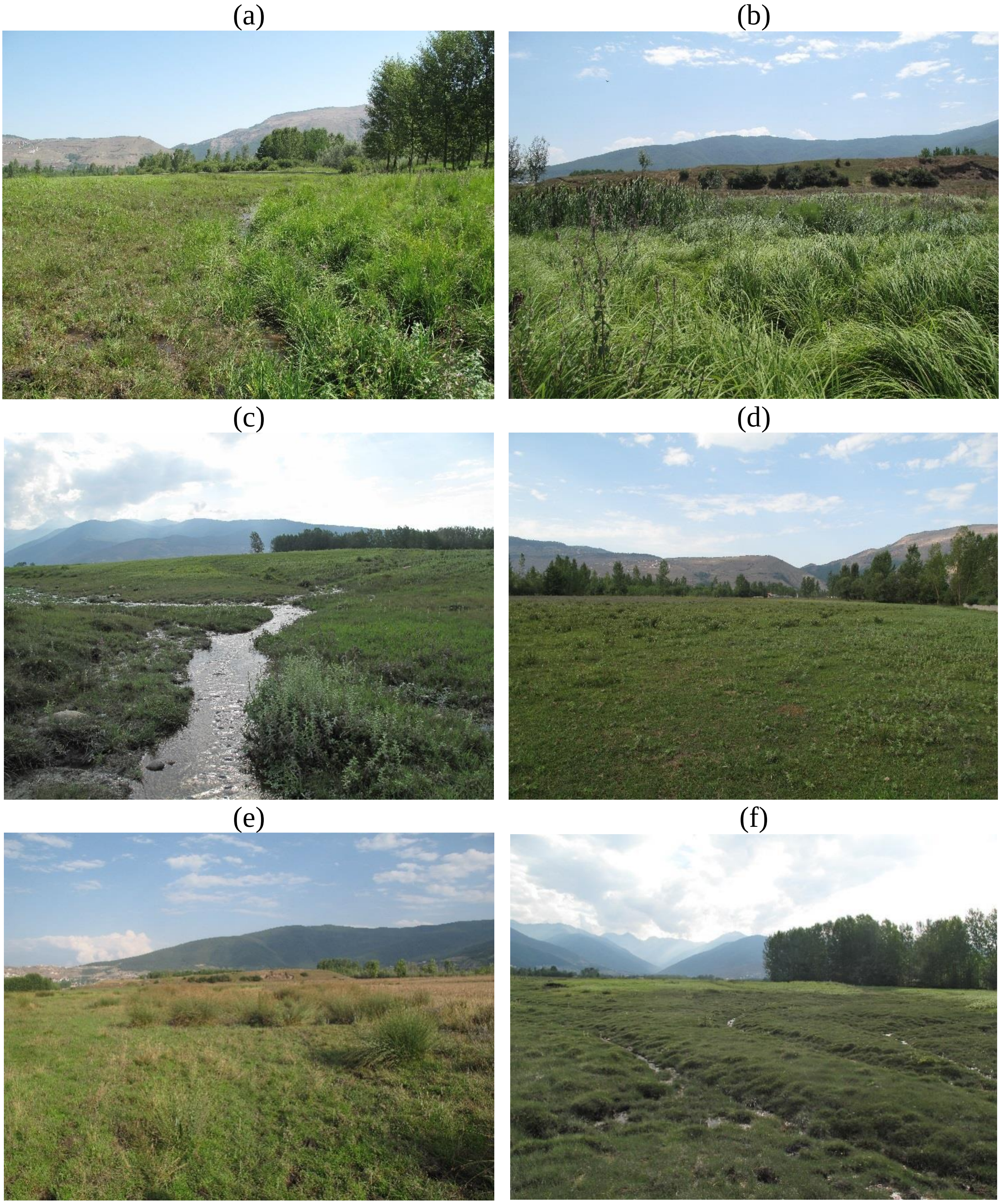



Figure 3. The six habitat types distinguished on Chaman-e Kelar Mire, Central Alborz Mountains, Iran. (a): WC = patches of *Carex orbicularis* on wet peat hummocks; (b): PD = peaty depressions with stagnant surface water; (c): BR = brooklets; (d): DH = dry hummocks; (e): WM = wet meadows; (f): WP = loose watery peat patches along the brooklets.

Brooklets (BR; C3.11):
This habitat type consisted of small ditches and streams, which originated from springs located south of the mire and flowed across it. *Nasturtium officinale* grew abundantly in the brooklets with running water. The following species were frequently observed in this habitat: *Epilobium montanum*, *Epilobium parviflorum*, *Equisetum arvense*, *Persicaria hydropiper*, *Populus alba*, *Salix* spp. (possibly planted by local people) and *Samolus valerandi*.

Dry hummocks (DH; E3.31):
This habitat type mainly covered the rather dry mineral upland soils of the western and southern parts of the mire complex. It was the most species-rich habitat with the following taxa being most abundant: *Carex diluta*, *Centaurium pulchellum*, *Dactylis glomerata*, *Eryngium caeruleum*, *Euphrasia hirtella*, *Festuca arundinacea*, *Linum catharticum*, *Medicago lupulina*, *Ononis spinosa*, *Paspalum distichum*, *Pimpinella affinis*, *Plantago lanceolata*, *Poa pratensis*, *Potentilla reptans*, *Prunella vulgaris*, *Trifolium* spp., *Trisetum bungei* and *Verbena officinalis*.

Wet meadows (WM; D5.221):
This densely vegetated habitat type was somewhat wetter than the previous type, and covered the eastern parts of the mire. Especially in the rainy season the water table was above the surface. The most abundant plant species were *Cyperus longus*, *Epilobium hirsutum*, *Equisetum palustre*, *Equisetum ramosissimum*, *Juncus inflexus* and *Pulicaria dysenterica*. Less abundant species included *Arthraxon hispidus*, *Geranium collinum* and *Sambucus ebulus*.

Loose watery peat patches along the brooklets (WP; D4.11):
This was a unique habitat type characterised by loose wet peat layers bordering both sides of the central main streams and their branches. The most important plant taxa were *Carex flacca* subsp. *erythrostachys*, *Eleocharis quinqueflora*, *Pycreus flavescens*, *Ranunculus sceleratus* and *Schoenus nigricans*. A number of aquatic plant species, e.g. the green alga *Chara* sp., *Lemna minor* and *Utricularia minor*, were encountered in small apparently temporary water bodies within this habitat type.

**Ellenberg indicator values**

The Kruskal-Wallis test adjusted using the Bonferroni correction revealed that only the average F (moisture) and N (nutrients) Ellenberg species values for each habitat type differed significantly between the habitat types ($p < 0.05$; Table 1). The Eigenvalues of the first two Principal Component Analysis (PCA) axes were 0.329 and 0.199, respectively, meaning that over 50 % of the species data were explained by these axes (Figure 4).

## DISCUSSION

Despite its small size (ca. 25 ha), Chaman-e Kelar Mire is rich in floral diversity with 103 recorded vascular plant species (of which 77 are typical wetland plants) and a number of bryophyte species (not identified). The high number of species can be explained by the wide distribution ranges of most wetland species (e.g. Naqinezhad *et al*. 2009, Jalili *et al*. 2014). Many of the species we found at Chaman-e Kelar - such as *Typha latifolia*, *Carex riparia*, *Cyperus longus*, *Pycreus flavescens*, *Pycreus flavidus*, *Equisetum* spp., *Mentha aquatica*, *Lemna minor*, *Catabrosa aquatica*, *Ranunculus sceleratus* and *Sparganium erectum* - also grow in Hyrcanian lowland wetlands (e.g. Ghahreman *et al*. 2004). More than 63 % of the Chaman-e Kelar flora have previously been observed in the patchy mountain mires on the southern slopes of the Alborz Mountains (Naqinezhad *et al*. 2009, Naqinezhad *et al*. 2010, Kamrani *et al*. 2011a). Furthermore, 79 % of the species found in ≥14 of 45 mires in the central Alborz Mountains also occur at Chaman-e Kelar (see Naqinezhad *et al*. 2010) (Table 2). This high similarity in plant composition may be explained by the variety of habitats (including springs/brooklets, peaty depressions and wet meadows) at Chaman-e Kelar. Our data indicate that the floristic composition of southern steppic mires in the Alborz and Central Asian mountains (cf. Nowak *et al*. 2016) is largely comparable with that of northern temperate mires. However, some wetland species that occur frequently on the southern slopes of the Alborz range (e.g. *Dactylorhiza umbrosa* (Kar. & Kir.) Nevski, *Primula auriculata* Lam., *Triglochin* spp. and *Trichophorum pumilum* (Vahl) Schinz & Thell.) and some characteristic taxa (such as *Ligularia persica* Boiss., *Heracleum* spp., *Pedicularis* spp., *Swertia longifolis* Boiss., *Gentiana* spp., *Carex pseudofoetida* subsp. *acrifolia* (V.I.Krecz.) Kukkonen and *Myosotis rivularis* (Vestergr.) A.P.Khokhr.) (Jalili *et al*. 2014, Naqinezhad *et al*. in preparation) were not encountered at Chaman-e Kelar Mire. Some of the latter species or their vicariant taxa similarly characterise plant communities in European and Turkish mires (Dierssen 1982, Vural 1996, Hájek & Háberová 2001, Hájek 2002, Dierssen & Dierssen 2005, Nowak *et al.* 2016). Moreover, *Carex orbicularis* (along with all of its vicariant subspecies) seems to be an indicator for mountain and alpine wetlands over vast areas of the Irano-Turanian region

Table 1. Kruskal-Wallis test of habitat differentiation for the plant taxa in Chaman-e Kelar Mire based on Ellenberg's indicator values. Significant results ($p < 0.05$) are indicated by **bold** type. Descriptive statistics shown separately for each Ellenberg indicator are: mean, standard deviation (SD), minimum (Min), maximum (Max) and number ($n$) of observations (plant species). Ellenberg indicators: L = light; T = temperature; K = continentality; F = moisture; R = soil reaction; N = nutrients. Habitat types: WC = patches of *Carex orbicularis* on wet peat hummocks; PD = peaty depressions with stagnant surface water; BR = brooklets; DH = dry hummocks; WM = wet meadows; WP = loose watery peat patches along brooklets.

| | L | T | K | F | R | N |
|---|---|---|---|---|---|---|
| Chi-Square | 5.911 | 4.929 | 4.663 | 50.366 | 1.854 | 13.639 |
| df | 5 | 5 | 5 | 5 | 5 | 5 |
| Asymp. Sig. ($p$) | 0.315 | 0.425 | 0.458 | **0.000** | 0.869 | **0.018** |

| Ellenberg indicator | Habitat | *n* | Mean value |
|---|---|---|---|
| L | WC | 37 | 6.78 |
| | PD | 27 | 7.19 |
| | DH | 26 | 7.31 |
| | BR | 16 | 7.06 |
| | WM | 28 | 6.89 |
| | WP | 19 | 7.37 |
| | Total (SD) [Min–Max] | 153 | 7.07 (1.08) [4–9] |
| T | WC | 21 | 5.00 |
| | PD | 23 | 5.22 |
| | DH | 17 | 5.71 |
| | BR | 12 | 5.42 |
| | WM | 24 | 5.50 |
| | WP | 15 | 5.00 |
| | Total (SD) [Min–Max] | 112 | 5.30 (1.31) [2–8] |
| K | WC | 31 | 3.87 |
| | PD | 19 | 4.42 |
| | DH | 21 | 3.81 |
| | BR | 12 | 4.17 |
| | WM | 26 | 4.46 |
| | WP | 16 | 4.25 |
| | Total (SD) [Min–Max] | 125 | 4.14 (1.73) [2–9] |

| Ellenberg indicator | Habitat | *n* | Mean value |
|---|---|---|---|
| F | WC | 35 | 7.11 |
| | PD | 26 | 8.69 |
| | DH | 24 | 5.00 |
| | BR | 14 | 8.36 |
| | WM | 30 | 6.87 |
| | WP | 19 | 8.26 |
| | Total (SD) [Min–Max] | 148 | 7.26 (2.06) [4–12] |
| R | WC | 25 | 6.96 |
| | PD | 20 | 7.00 |
| | DH | 19 | 7.00 |
| | BR | 11 | 7.18 |
| | WM | 24 | 7.25 |
| | WP | 12 | 7.33 |
| | Total (SD) [Min–Max] | 111 | 7.10 (0.96) [4–9] |
| N | WC | 30 | 4.47 |
| | PD | 24 | 6.04 |
| | DH | 23 | 4.78 |
| | BR | 15 | 5.93 |
| | WM | 26 | 5.69 |
| | WP | 15 | 4.80 |
| | Total (SD) [Min–Max] | 133 | 5.25 (2.01) [1–9] |

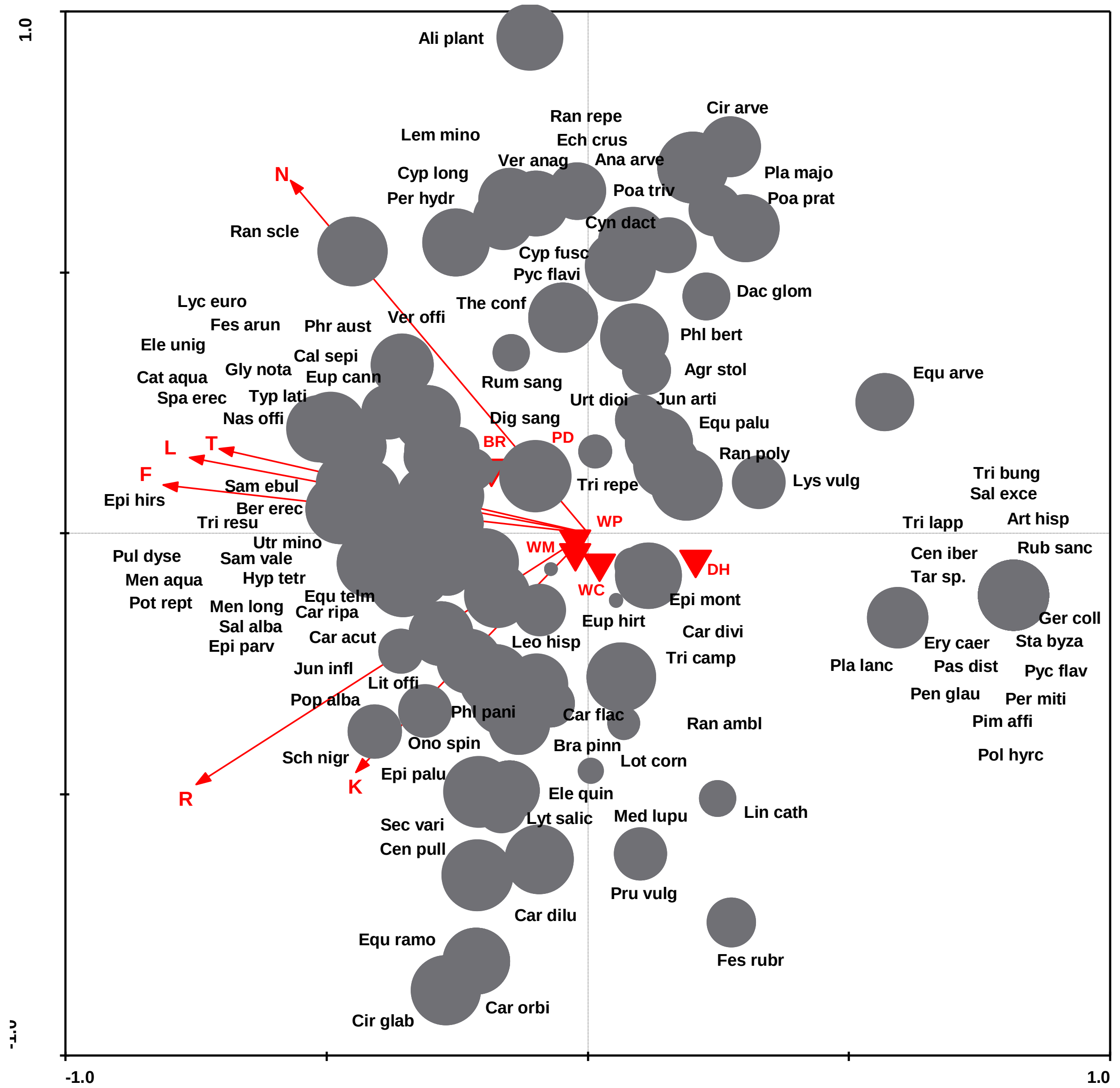



Figure 4. PCA of Ellenberg indicator values for species occurring in Chaman-e Kelar Mire. The fit of species into the ordination spaces is expressed by different dot sizes. Habitat types: WC = patches of *Carex orbicularis* on wet peat hummocks; PD = peaty depressions with stagnant surface water; BR = brooklets; DH = dry hummocks; WM = wet meadows; WP = loose watery peat patches along the brooklets. Ellenberg indicators: L = light; T = temperature; K = continentality; F = moisture; R = reaction; N = nutrients. Species names are abbreviated to the first three letters of the genus and the first four letters of the specific epithet.

The species included in the diagram are: *Agrostis stolonifera*, *Alisma plantago-aquatica*, *Anagallis arvensis*, *Arthraxon hispidus*, *Berula erecta*, *Brachypodium pinnatum*, *Calystegia sepium*, *Carex acutiformis*, *Carex diluta*, *Carex divisa*, *Carex flacca* subsp. *erythrostachys*, *Carex orbicularis* subsp. *kotschyana*, *Carex riparia*, *Catabrosa aquatica*, *Centaurea iberica*, *Centaurium pulchellum*, *Chara* sp., *Cirsium arvense*, *Cirsium glaberrimum*, *Cynodon dactylon*, *Cyperus fuscus*, *Cyperus longus*, *Dactylis glomerata*, *Digitaria sanguinalis*, *Echinochloa crus-galli*, *Eleocharis quinqueflora*, *Eleocharis uniglumis*, *Epilobium hirsutum*, *Epilobium montanum*, *Epilobium parviflorum*, *Epipactis palustris*, *Equisetum arvense*, *Equisetum palustre*, *Equisetum ramosissimum*, *Equisetum telmateia*, *Eryngium caeruleum*, *Eupatorium cannabinum*, *Euphrasia hirtella*, *Festuca arundinacea*, *Festuca rubra*, *Geranium collinum*, *Glyceria notata*, *Hypericum tetrapterum*, *Juncus articulatus*, *Juncus inflexus*, *Lemna minor*, *Leontodon hispidus*, *Linum catharticum*, *Lithospermum officinale*, *Lotus corniculatus*, *Lycopus europaeus*, *Lysimachia vulgaris*, *Lythrum salicaria*, *Medicago lupulina*, *Mentha aquatica*, *Mentha longifolia*, *Ononis spinosa*, *Paspalum distichum*, *Pennisetum glaucum*, *Persicaria hydropiper*, *Persicaria mitis*, *Phleum bertolonii*, *Phleum paniculatum* var. *paniculatum*, *Phragmites australis*, *Pimpinella affinis*, *Plantago lanceolata*, *Plantago major*, *Poa pratensis*, *Poa trivialis*, *Polygonum hyrcanicum*, *Populus alba*, *Potentilla reptans*, *Prunella vulgaris*, *Pulicaria dysenterica*, *Pycreus flavescens*, *Pycreus flavidus*, *Ranunculus amblyolobus*, *Ranunculus polyanthemos*, *Ranunculus repens*, *Ranunculus sceleratus*, *Rubus sanctus*, *Rumex sanguineus*, *Salix alba*, *Salix excelsa*, *Sambucus ebulus*, *Samolus valerandi*, *Schoenus nigricans*, *Securigera varia*, *Sparganium erectum*, *Stachys byzantina*, *Taraxacum* sp., *Thelypteris confluens*, *Trifolium campestre*, *Trifolium lappaceum*, *Trifolium repens*, *Trifolium resupinatum*, *Trisetum bungei*, *Typha latifolia*, *Urtica dioica*, *Utricularia minor*, *Verbena officinalis*, *Veronica anagallis-aquatica*.

Table 2. Comparison of floristic elements occurring in ≥14 of 45 Central Alborz mires (Naqinezhad *et al*. 2010, Jalili *et al*. 2014) with the flora of Chaman-e Kelar Mire.

| The most common taxa in Alborz mires | Percentage frequency in central Alborz mires | Occurrence in Chaman-e Kelar Mire |
|---|---|---|
| *Mentha longifolia* | 82.2 | X |
| *Juncus inflexus* | 77.8 | X |
| *Agrostis stolonifera* | 62.2 | X |
| *Carex orbicularis* subsp. *kotschyana* | 60.0 | X |
| *Juncus articulatus* | 57.8 | X |
| *Poa pratensis* | 55.6 | X |
| *Blysmus compressus* | 53.3 | |
| *Eleocharis uniglumis* | 51.1 | X |
| *Ranunculus amblyolobus* | 51.1 | X |
| *Trifolium repens* | 51.1 | X |
| *Lotus corniculatus* | 48.9 | X |
| *Phragmites australis* | 48.9 | X |
| *Dactylorhiza umbrosa* | 46.7 | |
| *Carex diluta* | 42.2 | X |
| *Primula auriculata* | 42.2 | |
| *Trichophorum pumilum* | 42.2 | |
| *Cirsium arvense* | 37.8 | X |
| *Equisetum arvense* | 37.8 | X |
| *Equisetum ramosissimum* | 37.8 | X |
| *Veronica anagallis-aquatica* | 37.8 | X |
| *Plantago lanceolata* | 35.6 | X |
| *Cardamine uliginosa* | 33.3 | |
| *Eleocharis quinqueflora* | 33.3 | X |
| *Triglochin palustris* | 33.3 | |
| *Carex divisa* | 31.1 | X |
| *Carex songorica* | 31.1 | |
| *Festuca rubra* | 31.1 | X |
| *Poa trivialis* | 31.1 | X |

from Iraq to the Pamir-Alaj Mountains (Klein & Lacoste 1995, Nowak *et al.* 2016, Naqinezhad *et al.* in preparation). The presence of *Cyperus longus*, *Trifolium campestre*, *Schoenus nigricans*, *Trifolium repens*, *Mentha longifolia*, *Mentha aquatica*, *Lysimachia vulgaris*, *Lythrum salicaria*, *Festuca rubra*, *Ononis spinosa*, *Pulicaria dysenterica*, *Carex flacca*, *Ranunculus repens*, *Lotus corniculatus*, *Potentilla reptans* and *Linum catharticum* means that our mire habitat resembles Molinio-Holoschoenion communities in Western Mediterranean Europe and the Taurus mountains of Turkey (cf. Hein *et al.* 1995, Parolly 2004, García-Madrid *et al.* 2016).

On the basis of a single AMS radiocarbon date from the deepest part of a 1.2 m sediment core, Chaman-e Kelar must have been a permanent wetland since at least 900 years ago (Ramezani 2013) and thus would not be classified as a temporary or intermittent wetland because of both permanent water springs and different floristic composition (cf. Kavgaci *et al*. 2010). According to the pollen diagram produced for this site (Ramezani 2013), wetland taxa such as Cyperaceae, *Equisetum* and *Lythrum salicaria* must have been among the dominant plants growing on the surface of the mire over the past millennium. Also, considering that there is a historical mound/tell in the close vicinity of the mire which archaeological evidence indicates dates back to at least 3000 BP, this wetland could have been a water source both for early humans and for their livestock.

Some species in Chaman-e Kelar are rather common aquatic and mire species in Europe, including *Eupatorium cannabinum*, *Equisetum telmateia*, *Lysimachia vulgaris*, *Pulicaria dysenterica*, *Hypericum tetrapterum*, *Epipactis palustris*, *Samolus valerandi*, *Persicaria hydropiper*, *Glyceria notata* and *Eleocharis quinqueflora* (Grime *et al*. 2007, Joosten *et al*. 2017).

Wetlands are generally not uniform, but may encompass considerable within-site diversity in water regime, microrelief and vegetation (Wheeler & Shaw 2000, Flinn *et al*. 2008). Therefore, it is often more practical to identify separate habitat types within wetlands than to categorise entire wetland sites (Succow & Joosten 2001, Joosten *et al*. 2017, Wheeler & Shaw 2000; cf. the 'tope' and 'chore' concepts in mire landscape ecology). This 'bottom up' approach intends to describe spatial units on the basis of real data from individual sites rather than working 'top down', i.e. using non-formalised subdivisions based on expert judgment.

We assumed that Ellenberg values can be used - with critical awareness - also for the Hyrcanian area because of the climatic and biogeographic similarity to the rest of the Euro-Siberian phytogeographical region (Zohary 1973, Akhani *et al*. 2010). We calculated unweighted average values according to presence/absence of species. Our results indicated that only the Ellenberg values for moisture and nutrients differed significantly among the different habitats that we studied (See Table 1, Figure 4). In wet habitats of the Mediterranean region, the waterlogging gradient (main driver) and soil factors (secondary level) were considered to be the major underlying pattern influencing the diversity and distribution of plants (cf. García-Madrid *et al*. 2016).

The first PCA axis (Figure 4) corresponds to a distinct moisture gradient, which ranges from the dry hummocks supporting species such as *Paspalum distichum*, *Pycreus flavidus*, *Persicaria mitis*, *Pimpinella affinis*, *Eryngium caeruleum* and *Plantago lanceolata* (the right part of the ordination diagram) towards the wetter parts of the mire and all other species, i.e. species adapted to various degrees of waterlogging (the left part of the diagram). This gradient is related to microtopography (cf. Kavgaci *et al*. 2010). While the first main gradient relates to soil moisture, the second axis reflects a gradient of water depth ranging from shallow surface water (PD, BR) to water table at or near ground level (WM, WP, WC). *Carex orbicularis*, *Carex diluta*, *Festuca rubra* and *Eleocharis quinqueflora* were observed on the wet peat hummocks and meadows, while *Lemna minor*, *Alisma plantago-aquatica*, *Phragmites australis* and *Ranunculus sceleratus* occurred in peaty depressions and brooklets with more soil nitrogen and consequently higher productivity (Figure 4). The nutrient-poor to nutrient-rich gradient is a major environmental gradient in European mires (Horsák *et al*. 2007, Joosten *et al*. 2017).

As in other parts of the world (Mountford & Chapman 1993), there is a marked shortage of quantitative information on the water-regime requirements of individual plant species in Chaman-e Kelar. However, a study on ecological patterns governing the composition and structure of the vegetation of Anzali lagoon (northern Iran) demonstrated that water depth plays a leading role in shaping the structure of different plant functional types and wetland diversity (Jalili *et al*. 2009).

Chaman-e Kelar was like other montane mires on the southern slopes of the Alborz Mountains (Naqinezhad *et al*. 2010, Kamrani *et al*. 2011a) in that hemicryptophytes dominated the life-form spectrum of the flora. A high proportion of hemicryptophytes and geophytes is typical of cold mountainous climates (Klimeš 2003). Therophytes were the second most abundant life form in Chaman-e Kelar, which may partly be explained by drought during summer resulting from the intermittent seepage water supply from outside the mire. Seasonality in water supply supports annual plants, which are more resistant to summer drought than other life forms (Danin & Orshan 1990, Archibald 1995). This is particularly true for the mire margins where grazing and other destructive activities provide habitats for ruderal annual plants (Grime 2001).

Phytogeographically, most of the species found in Chaman-e Kelar Mire are pluriregional elements, which is attributable to the widespread distribution of mire plants. Our results are in accordance with previous studies in the montane (Naqinezhad *et al*. 2010, Kamrani *et al*. 2011a) and lowland (Ghahreman *et al*. 2004, Naqinezhad *et al*. 2006, Mehravaran *et al*. 2016) wetlands of northern Iran.

Chaman-e Kelar Mire also provides important shelter for rare and threatened species. The submerged aquatic plant *Utricularia minor* was first recorded in the temporary wetland habitats of Baladeh and Firuzkuh in the north, outside the Hyrcanian region (Naqinezhad *et al*. 2008), and was later discovered in Lorestan Province in western Iran (Dinarvand 2012). Our report from Chaman-e Kelar Mire is the first record of its occurrence in the Hyrcanian relict region. *Arthraxon hispidus* (Thunb.)

Makino, which is native to Japan and eastern Asia, was first reported for Iran from Kiashahr Lagoon in Gilan Province (Hamzeh'ee & Naqinezhad 2009) and also collected from wet forest margins in Nur Forest Park (Naqinezhad & Zarehzadeh 2012). Our finding in Chaman-e Kelar Mire is the third record of this species for Iran.

Some species from Chaman-e Kelar are listed as rare and/or endangered in the Red Data Book of Iran (Jalili & Jamzad 1999). *Trisetum bungei*, a rare endemic plant, is catalogued as 'data deficient'. According to *Flora Iranica*, this species was previously collected only from Dimalu, Ziarat (Golestan) and Firuzkuh (Mazandaran). *Phleum bertolonii* is another 'data deficient' species known from just two localities in Gorgan and Golidagh, Golestan Province (Bor 1970). We also observed some scattered individuals of *Epipactis palustris* – yet another 'data deficient' species - in Chaman-e Kelar Mire. *Flora Iranica* (Renz 1978) gives a couple of records for this species from west of Urmia and Marivan (Kordistan Province) and it is not reported in the *Persian Flora of Iran* (Shahsavari 2008). Recently, Naqinezhad *et al*. (2010) found this species in montane mires on the southern slopes of the Alborz ranges. Its occurrence in the current investigation is the latest record of this species in Iran. For *Lysimachia vulgaris*, classified as 'vulnerable' in the Red Data Book of Iran, there is only one record, from Shahr Chay near Urmia (NW Iran) in *Flora Iranica* (Wendelbo 1969) and the *Persian Flora of Iran* (Jamzad 1999). Thus, Chaman-e Kelar is the second locality for this species in Iran and the first in northern Iran.

The rich floral composition and the occurrence of a number of Iranian endemic and rare plants at Chaman-e Kelar, a relatively small peatland in the Hyrcanian region, demonstrate its conservation importance. The conservation of small patches of mire and peatland within the green belt of Hyrcanian forest is of crucial importance both locally and internationally, and must be of highest priority for the conservation agencies of Iran. As is the case for many European fens and wet meadows, one general threat to Chaman-e Kelar and other lowland Hyrcanian wetlands seems to be eutrophication, i.e. nutrient enrichment, which generally leads to loss of species richness (e.g. Olde Venterink *et al*. 2002, Maskell *et al*. 2010). Stable site conditions controlling nutrient turnover rates in the soil are necessary for the conservation and restoration of low-productivity species-rich wetlands. This is especially true for small mires and peatlands hosting a high number of plant species with limited distribution. We postulate that intensified human activity, such as drainage of wetlands and construction, along with the concurrent dry periods over recent decades, have been directly responsible for the rarity of several wetland species like *Lysimachia vulgaris*. Conservation management of the important Chaman-e Kelar site must control all factors affecting moisture and nutrient availability.

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## AUTHOR CONTRIBUTIONS

AN and ER conceived the idea, initiated the fieldwork and led the writing; AHK participated in the fieldwork; AN identified the plants and conducted the analyses; and ER provided the palaeoecological data. All authors wrote sections of the manuscript and contributed to revisions.

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**Appendix:** List of macrophytes in Chaman-e Kelar Mire, Kelardasht. Species distribution information: S = not a typical wetland taxon (occurring only sporadically in wetlands); R = within the Alborz range, taxon restricted to Chaman-e Kelar Mire; L = taxon occurring on Chaman- Kelar Mire that also grows in other wetlands of the Hyrcanian region (all being lagoons with surface water); A = previously observed in other Alborz mires. Habitats: WC = patches of *Carex orbicularis* on wet peat hummocks; PD = peaty depressions with stagnant surface water; BR = brooklets; DH = dry hummocks; WM = wet meadows; WP = loose watery peat patches along brooklets. Life forms: Cha = chamaephyte; Geo = geophyte; Hel = helophyte; Hem = hemicryptophyte; Hyd = hydrophyte; Pha = phanerophyte; The = therophyte. Chorotypes: ES = Euro-Siberian; IT = Irano-Turanian; M = Mediterranean; PL = pluriregional; SS = Saharo-Sindian.

| **Taxon** | S | R | L | A | Habitats | Life form | Chorotypes |
|---|---|---|---|---|---|---|---|
| **Adoxaceae** | | | | | | | |
| *Sambucus ebulus* L. | X | | | | WM | Hem | ES, IT, M |
| **Alismataceae** | | | | | | | |
| *Alisma plantago-aquatica* L. | | | X | | PD | Hel | PL |
| **Apiaceae** | | | | | | | |
| *Berula erecta* (L.) (Huds.) Coville | | | | X | PD, BR | Hel | PL |
| *Eryngium caeruleum* M.Bieb. | X | | | | DH | Hem | ES, IT |
| *Pimpinella affinis* Ledeb. | X | | | X | DH | Hem | PL |
| **Asteraceae** | | | | | | | |
| *Centaurea iberica* Trevir. ex Spreng | X | | | | DH | The | ES, IT, M |
| *Cirsium arvense* (L.) Scop. | | | | X | PD, BR | Hem | PL |
| *Cirsium glaberrimum* (Petr.) Petr. | | | | X | PD, BR | Hem | IT (Iran+Turco) |
| *Eupatorium cannabinum* L. | | X | | | BR, WM | Hem | ES, IT, M |
| *Leontodon hispidus* L. | | | | X | WC, WP | Hem | ES, IT, M |
| *Pulicaria dysenterica* (L.) Gaertn. | | | X | | WM, PD | Hem | ES, IT |
| *Taraxacum* sp. | | | X | X | WC, WP | Hem | |
| **Boraginaceae** | | | | | | | |
| *Lithospermum officinale* L. | X | | | | DH | Hem | ES, IT, M |

| Taxon | S | R | L | A | Habitats | Life form | Chorotypes |
|---|---|---|---|---|---|---|---|
| **Brassicaceae** | | | | | | | |
| *Nasturtium officinale* R. Br. | | | X | X | BR | Hel | PL |
| **Characeae** | | | | | | | |
| *Chara* sp. | | | X | X | WP | Hyd | PL |
| **Convolvulaceae** | | | | | | | |
| *Calystegia sepium* (L.) R.Br. | X | | | | WM, PD | Hem | PL |
| **Cyperaceae** | | | | | | | |
| *Carex acutiformis* Ehrh. | | | | X | PD | Hel | ES, IT, M |
| *Carex diluta* M.Bieb. | | | | X | DH, WM | Hem | ES, IT |
| *Carex divisa* Huds. | | | | X | WC, WP | Hem | ES, IT, M |
| *Carex flacca* Schreb. subsp. *erythrostachys* (Hoppe) Holub | | X | | | WC, WP, PD | Hem | ES, IT, M |
| *Carex orbicularis* Boott subsp. *kotschyana* (Boiss. & Hohen.) Kukkonen | | | | X | WC, WP, PD, WM | Hem | IT |
| *Carex riparia* Curt. | | | X | X | WC, PD | Hel | ES, IT |
| *Cyperus fuscus* L. | | | | X | BR, WP | The | PL |
| *Cyperus longus* L. | | | X | | WM | Hem | PL |
| *Eleocharis quinqueflora* (Hartmann) Schwarz | | | | X | WP, WC | Hem | PL |
| *Eleocharis uniglumis* (Link) Schultes | | | | X | PD, WP | Hem | PL |
| *Pycreus flavescens* (L.) P.Beauv. ex Rchb. | | | X | | WP | The | PL |
| *Pycreus flavidus* (Retz.) Koyama | | | X | X | PD, WP | The | PL |
| *Schoenus nigricans* L. | | | X | X | WP, WC | Hem | PL |
| **Equisetaceae** | | | | | | | |
| *Equisetum arvense* L. | | | X | X | BR, WC | Geo | PL |
| *Equisetum palustre* L. | | | X | X | WM | Geo | PL |
| *Equisetum ramosissimum* Desf. | | | X | X | WM, WC | Geo | PL |
| *Equisetum telmateia* Ehrh. | | | X | X | WM, WC | Geo | PL |

| **Taxon** | S | R | L | A | Habitats | Life form | Chorotypes |
|---|---|---|---|---|---|---|---|
| **Fabaceae** | | | | | | | |
| *Lotus corniculatus* L. | | | | X | DH, WM | Hem | PL |
| *Medicago lupulina* L. | | | | X | DH | Hem | PL |
| *Ononis spinosa* L. | | | | X | DH | Cha | IT, M |
| *Securigera varia* (L.) Lassen | X | | | X | DH | Hem | ES, IT, M |
| *Trifolium campestre* Schreb. | | | | X | DH | The | ES, IT, M |
| *Trifolium lappaceum* L. | X | | | | DH | The | IT, M |
| *Trifolium repens* L. | | | | X | DH, WC | Hem | ES, IT, M |
| *Trifolium resupinatum* L. | X | | | | DH | The | ES, IT, M |
| **Gentianaceae** | | | | | | | |
| *Centaurium pulchellum* (Sw.) Druce | X | | | | DH | The | ES, IT, M |
| **Geraniaceae** | | | | | | | |
| *Geranium collinum* Steph. ex Willd. | | | | X | WM | Hem | ES, IT |
| **Hypericaceae** | | | | | | | |
| *Hypericum tetrapterum* Fries | X | X | | | WM, WC | Hem | ES, IT, M |
| **Juncaceae** | | | | | | | |
| *Juncus articulatus* L. | | | X | X | BR, WP, WC | Hem | PL |
| *Juncus inflexus* L. | | | | X | WM, WC, WP | Hem | PL |
| **Lamiaceae** | | | | | | | |
| *Lycopus europaeus* L. | | | X | X | WM, WC | Hem | PL |
| *Mentha aquatica* L. | | | X | X | PD, WM, WC | Hem | PL |
| *Mentha longifolia* (L.) L. | | | | X | PD, WP | Hem | PL |
| *Prunella vulgaris* L. | | | | X | DH, WC | Hem | PL |
| *Stachys byzantina* K.Koch. | X | | | | DH | Hem | ES |

| **Taxon** | S | R | L | A | Habitats | Life form | Chorotypes |
|---|---|---|---|---|---|---|---|
| **Lemnaceae** | | | | | | | |
| *Lemna minor* L. | | | X | X | PD, BR | Hyd | PL |
| **Lentibulariaceae** | | | | | | | |
| *Utricularia minor* L. | | | | X | WP, PD | Hyd | PL |
| **Linnaceae** | | | | | | | |
| *Linum catharticum* L. | | | | X | DH, WC | The | ES, IT, M |
| **Lythraceae** | | | | | | | |
| *Lythrum salicaria* L. | | | X | X | PD, WM, WC, WP | Hem | PL |
| **Onagraceae** | | | | | | | |
| *Epilobium hirsutum* L. | | | X | X | WM | Hem | PL |
| *Epilobium montanum* L. | | | | X | BR, WC | Hem | PL |
| *Epilobium parviflorum* Schreb. | | | | X | BR, WC | Hem | PL |
| **Orchidaceae** | | | | | | | |
| *Epipactis palustris* (L.) Crantz | | | | X | WC | Geo | ES, IT, M |
| **Orobanchaceae** | | | | | | | |
| *Euphrasia hirtella* Jordan ex Reut. | | | | X | DH, WC | The | ES |
| **Plantaginaceae** | | | | | | | |
| *Plantago lanceolata* L. | | | X | X | DH, WC | Hem | ES, IT, M |
| *Plantago major* L. | | | X | X | DH | Hem | PL |
| *Veronica anagallis-aquatica* L. | | | X | X | PD, WP | Hel | PL |
| **Poaceae** | | | | | | | |
| *Agrostis stolonifera* L. | | | | X | DH, WC, PD | Hem | PL |
| *Arthraxon hispidus* (Thunb.) Makino | X | | | | WM | The | PL |
| *Brachypodium pinnatum* (L.) P.Beauv. | | | | X | WM | Hem | ES, IT, M |
| *Catabrosa aquatica* (L.) P. Beauv. | | | X | X | WM, PD | Hem | PL |

| **Taxon** | S | R | L | A | Habitats | Life form | Chorotypes |
|---|---|---|---|---|---|---|---|
| **Poaceae** (continued) | | | | | | | |
| *Cynodon dactylon* (L.) Pers. | X | | | | DH | Hem | PL |
| *Dactylis glomerata* L. | X | | | | DH, WC, WM | Hem | PL |
| *Digitaria sanguinalis* (L.) Scop. | X | | | | DH | The | PL |
| *Echinochloa crus-galli* (L.) P. Beauv. | | | | X | WM, WP | The | PL |
| *Festuca arundinacea* Schreb. | | | | X | DH, WC, WM | Hem | ES, IT, M, SS |
| *Festuca rubra* L. | | | | X | WM, WC | Hem | PL |
| *Glyceria notata* Chevall. | | | | X | PD | Hem | ES, IT |
| *Paspalum distichum* L. | X | | | | DH | Hem | PL |
| *Pennisetum glaucum* (L.) R.Br. | X | | | | DH | The | PL |
| *Phleum bertolonii* DC. | | X | | | DH, WC | Hem | ES, IT |
| *Phleum paniculatum* Huds. var. *paniculatum* | X | | | | DH, WM | The | ES, IT, M |
| *Phragmites australis* (Cav.) Trin. ex Steud. | | | X | X | PD, WM | Hel | PL |
| *Poa pratensis* L. | | | | X | DH, WC | Hem | PL |
| *Poa trivialis* L. | | | X | X | WC | Hem | PL |
| *Trisetum bungei* Boiss. | | X | | | DH | Hem | Endem (Iran) |
| **Polygonaceae** | | | | | | | |
| *Persicaria hydropiper* (L.) Delarbre | | | X | | BR, PD | The | ES, IT, M |
| *Persicaria mitis* (Schrank) Holub | X | | X | | WC, WM | The | ES, IT, M |
| *Polygonum hyrcanicum* Rech.f. | X | | X | | DH | Hem | Endem (Iran) |
| *Rumex sanguineus* L. | | | X | X | WC, WP | Hem | ES |
| **Primulaceae** | | | | | | | |
| *Anagallis arvensis* L. | X | | | | DH | The | PL |
| *Lysimachia vulgaris* L. | | X | | | WC (no previous report from N Iran) | Hem | ES, IT, M |
| *Samolus valerandi* L. | | | X | | BR | Hem | PL |

| Taxon | S | R | L | A | Habitats | Life form | Chorotypes |
|---|---|---|---|---|---|---|---|
| **Ranunculaceae** | | | | | | | |
| *Ranunculus amblyolobus* Boiss. & Hohen. | | | | X | WC, WP | Hem | Endem (Iran) |
| *Ranunculus polyanthemos* L. | | | | X | WC, PD, WM | Hem | ES |
| *Ranunculus repens* L. | | | | X | WC, PD, WM | Hem | PL |
| *Ranunculus sceleratus* L. | | | X | | WP, BR | The | PL |
| **Rosaceae** | | | | | | | |
| *Potentilla reptans* L. | X | | | X | DH, WC | Hem | ES, IT, M |
| *Rubus sanctus* Schreb. | X | | | | WM | Pha | ES, IT, M |
| **Salicaceae** | | | | | | | |
| *Populus alba* L. | | | X | | BR, WM | Pha | ES, IT, M |
| *Salix alba* L. | | | X | X | BR, WM | Pha | ES, IT, M |
| *Salix excelsa* S. G. Gmelin | | | X | X | BR, WM | Pha | ES, IT |
| **Sparganiaceae** | | | | | | | |
| *Sparganium erectum* L. | | | X | | PD | Hel | ES, IT, M |
| **Thelypteridaceae** | | | | | | | |
| *Thelypteris confluens* (Thunb.) C.V.Morton | | | X | | PD, WC | Hem | PL |
| **Typhaceae** | | | | | | | |
| *Typha latifolia* L. | | | X | | PD | Hel | PL |
| **Urticaceae** | | | | | | | |
| *Urtica dioica* L. | X | | | | DH, WM | Hem | PL |
| **Verbenaceae** | | | | | | | |
| *Verbena officinalis* L. | X | | X | | DH | Hem | PL |