NORDIC JOURNAL OF
BOTANY

Research

Floristic composition and phytogeographical spectrum of *Pistacia vera* L. woodland remnants in northeastern Iran

Zohreh Atashgahi, Farshid Memariani, Vahid Jafari Polgerd and Mohammad Reza Joharchi

V. Jafari Polgerd, Dept of Biology, Faculty of Science, Ferdowsi Univ. of Mashhad, Mashhad, Iran. – Z. Atashgahi (https://orcid.org/0000-0001-6130-9261), F. Memariani (https://orcid.org/0000-0001-5478-1859) ✉ (memariani@um.ac.ir) and M. R. Joharchi, Herbarium FUMH, Dept of Botany, Research Center for Plant Sciences, Ferdowsi Univ. of Mashhad, Mashhad, Iran.

Nordic Journal of Botany
2022: e03510
doi: 10.1111/njb.03510
Subject Editor:
Jean Wan Hong Yong
Editor-in-Chief: Sara Cousins
Accepted 9 February 2022
Published 14 March 2022

The xerophilic woodlands of wild pistachio *Pistacia vera* L. remnants occur as several isolated stands in Central Asia. The Kopet Dagh mountain range, northeastern Iran, is the westernmost distribution range of wild pistachio. In this research, we present the annotated checklist of vascular plants of two remnants of *P. vera* woodlands along the Iran–Turkmenistan borders. We provide the life-forms, phytogeographical spectrum, endemism and conservation status of the flora. The field surveys were conducted through several field collection efforts during 2018–2020. A map showing the boundaries of the woodlands was prepared. We recorded 348 plant species distributed in 214 genera and 48 families. The richest families were Asteraceae (33 genera with 59 species), Poaceae (22 with 41), Brassicaceae (24 with 28) and Fabaceae (11 with 27), and the two richest genera were *Astragalus* (ten species) and *Galium* (nine species). The dominant life-forms were therophytes (54%) and hemicryptophytes (24%), which confirm a xeric climate condition. Irano–Turanian elements (195 species, 56%) were the most common plants, followed by bi-regional (21%) elements. Based on our samplings, the Khorassan-Kopet Dagh endemics represented only four percent of the flora. We recorded 34 endemics/sub-endemics of plants, eight of which were categorized as threatened or near-threatened. The results indicated the important role of pistachio remnant woodlands in plant biodiversity and conservation biogeography of northeastern Iran.

Keywords: biodiversity, chorology, conservation, endemism, floristics, Irano–Turanian

Introduction

A vast territory of Southwest and Middle Asia in the Holarctic phytogeographical kingdom belongs to the Irano–Turanian floristic region (IT). The new bioclimatic zonation of Iran based on the recently developed Global Bioclimatic Classification (GBC) system revealed that the IT region is highly differentiated from adjacent regions by its degree of bioclimatic continentality and seasonality (Djamali et al. 2011). Since the late Tertiary, long-term isolation caused by the continued presence of

NORDIC SOCIETY OIKOS
www.nordicjbotany.org

heterogeneous topography and relatively stable continental climate led to high rates of allopatric speciation and endemism in the IT region (Djamali et al. 2012). The geological and climatic changes since the Paleogene promoted the expansion of xerophytic species in the IT region and also to the neighboring regions. This led to the diversification of the large genera of *Astragalus*, *Cousinia*, *Acantholimon* and *Acanthophyllum* (Zohary 1973, Takhtajan 1986, Léonard 1991, Manafzadeh et al. 2014).

The landscape of central IT is dominated by mountain ridges composed of several significant mountainous systems, i.e. Alborz, Zagros, Kopet Dagh and Makran (Noroozi et al. 2008). The mountainous areas of northeastern Iran belong to the Khorassan-Kopet Dagh (KK) floristic province which is a separate biogeographic entity. This area is a transitional corridor connecting different phytogeographical units of the IT region which makes a unique mixture of elements from the surrounding areas. The presence of many widespread, wide-ranging elements, as well as the core IT species and many local and narrowly distributed endemic plants, have produced a biogeographically distinct area (Memariani et al. 2016a, b). The floristic composition of the KK shows a remarkable phytogeographical link to the adjacent Middle Asian, Alborz, Afghan and Caucasian mountain ranges. The KK is a part of the Irano–Anatolian mountain system, which is recognized to be amongst the thirty-five so-called hotspots of biodiversity in the World (Mittermeier et al. 2011). Simultaneously, the complicated topography, high habitat heterogeneity and long vegetation history since the Paleogene have permitted the formation of diverse community types in the KK. The main vegetation types are isolated Hyrcanian montane forests, widespread *Juniperus* woodlands, open mesophilic shrublands, diverse mountain steppes and subalpine thorn–cushion communities, chasmophytic vegetation, semi-desert steppes, halophytic formations and edaphic vegetation on calcareous, serpentine and gypsum soils, as well as aquatic, riverine and hygrophilic communities (Memariani 2020).

The isolated xerophilic woodlands of the wild pistachio *Pistacia vera* L. are among the several vegetation types of northeastern Iran. This vegetation type is usually known as savannoid vegetation or semisavanna, and is recently referred to as a particular type of 'forest–steppe' in the Middle East (Erdős et al. 2018). At the present time, the natural stands of *P. vera* are restricted to the foothills and lower mountains of Middle Asia (Tajikistan, Uzbekistan, Kyrgyzstan), north of Afghanistan (the Paropamisus and Hindu Kush mountains) and the Kopet Dagh in northeastern Iran and southern Turkmenistan (Kamakhina 1994, Popov 1994, Barazani et al. 2003, Kozhoridze et al. 2015, Tojibaev et al. 2017, Breckle and Rafiqpoor 2020). *Pistacia vera* generally grows at elevations of 300–1500–(2000) m a.s.l. which cover a total of 75 000 ha; however, the isolated woodlands occur between altitudes 800 and 1200 m (Zlotin 1994, Behboodi 2005, Khanazarov et al. 2009). The most significant woodlands of *P. vera*, with a surface area of 17 500 ha, are located in the Jangal-e Khajeh Protected Area, near Chahchaheh village adjacent to Iran–Turkmenistan border in the eastern Kopet Dagh. However, several remnants of wild pistachio occur as isolated stands in Qazanqayeh forest reserve (western Kopet Dagh, Golestan Province) and the northern foothills of the Hezar Masjed Mountains (east-central Kopet Dagh, Razavi Khorassan province) (Karimi et al. 2009, Memariani 2020). Very small and sparse patches of *P. vera* are observed in the southeastern extremes of Kopet Dagh near Saleh–Abad.

The wild pistachio trees can provide valuable genetic resources because *P. vera* is grown commercially for its nuts in a number of semi-arid regions worldwide. Iran is a major pistachio producer in the world (Khanazarov et al. 2009). Considering the wide native range and genetic diversity (Pazouki et al. 2010), the Iranian natural communities of *P. vera* are poorly known in terms of floristic composition, vegetation ecology and conservation. During the last century, except for few protected areas, vast pistachio woodlands have been over-grazed and/or over-exploited for nut and firewood (Zlotin 1994). So, natural reproduction is restricted, and biodiversity is threatened in these woodlands.

Although, the floristic diversity, phytogeography and plant endemism are well-documented in the whole area of KK (Memariani et al. 2016a, b), there are several knowledge gaps especially in several inaccessible areas and some poorly studied vegetation types. In this paper, we aim to evaluate the floristic diversity, life-form spectrum and phytogeographical affinities of the remnant of *P. vera* woodlands in the northern foothills of the Hezar Masjed Mountains. As a part of the research project on the flora and vegetation of wild pistachio communities in NE Iran, the results make basic knowledge for the persistent monitoring and conservation of the flora and genetic resources and, for human well-being in a dramatically changing arid and semi-arid environment.

Material and methods

Study area

Physical geography

The study area covers about 1591 ha of foothills in the northern slopes of the Hezar Masjed mountain range. The area belongs to Khorassan-Kopet Dagh floristic province and is located between Kalat-e Naderi and Dargaz cities in Razavi Khorassan province, northeastern Iran. There are two prominent but separated patches of *Pistacia vera* woodlands in the area between Polgerd and Layen villages (Fig. 1) that seem to have been connected in the past, based on data from the indigenous people. The first area called 'Polgerd Pistachio Forest' is oriented in a north to south direction and spans a length of 7 km (37°8′22.3″–37°11′46″N, 59°23′3″–59°26′21.7″E) and the second one, 'Layen', is located further eastward (37°8′47.2″–37°10′53.2″N, 59°27′43.5″–59°30′22″E). Because of very close distance and similar habitat characteristics, we studied these two patches as a whole. The southwestern extreme of the area towards the middle to higher mountain ranges is covered by *Juniperus polycarpos* K.Koch woodlands. The elevation of the study area ranges

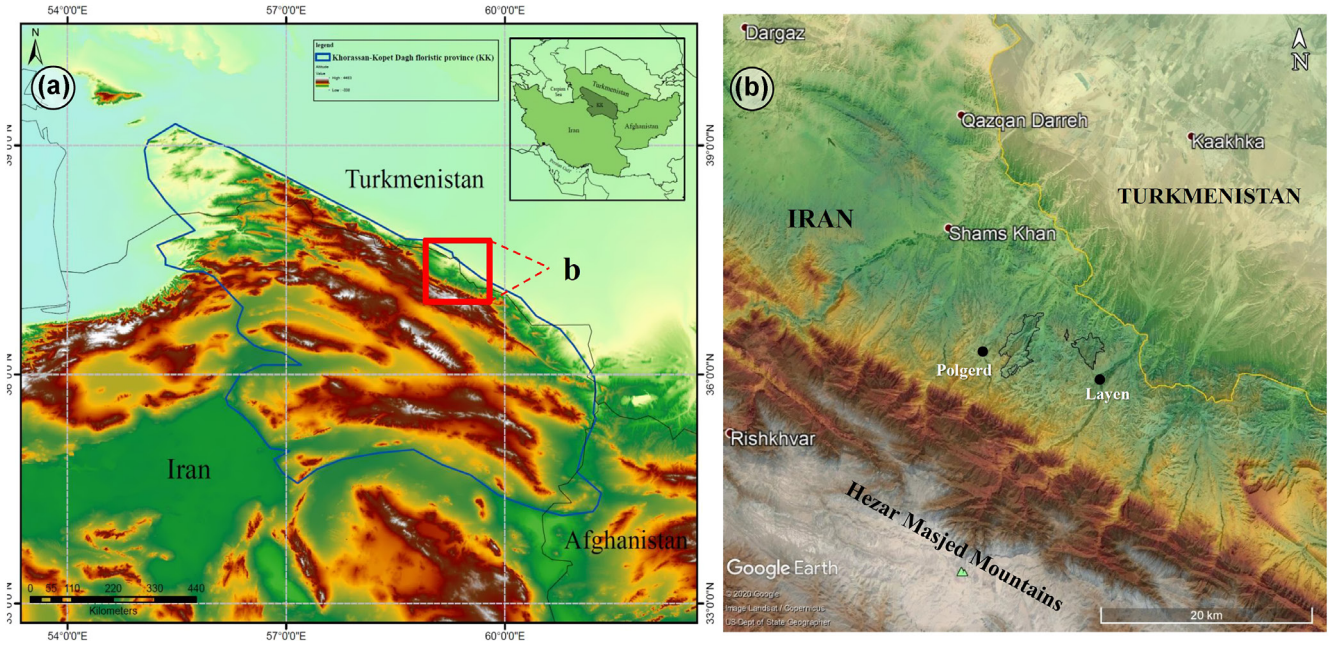

Figure 1. The map of the study area in the Khorassan-Kopet Dagh floristic province (a) and *Pistacia vera* woodland remnants (b) in northern foothills of the Hezar Masjed Mountains (east-central Kopet Dagh), NE Iran.

from 663 m a.s.l. at the bottom of the eastern entrance valley up to 1054 m to the west. These are the remnant patches of formerly more widespread woodlands, which are now limited to isolated patches in NE Iran (Zlotin 1994, Karimi et al. 2009) (Fig. 2). The sparse woodland of Polgerd was declared a 'national Forest' in 1962 and has been legally protected since 1994. Gathering pistachio nuts has been controlled, and grazing is prohibited since then. The illegal entrance of domestic livestock is observed, especially on the sidelines. Furthermore, in wet years, well-grown grasses are harvested from this savanna-like area for forage to keep the woodland safe from wildfire. Geologically, the study area is a part of the Kopet Dagh sedimentary zone. Pistachio woodlands are located on the Mozduran lithological formation with a body of permeable rock, which can contain and transmit the groundwater (Nabavi 1976, Afshar-Harb 1994). There are complex substrates ranging from calcareous to saline sediments with a considerable thickness of about four meters in the soil profile (Fig. 2d). There are no springs or permanent rivers in the area.

Climate

According to the available data from the nearest climatological station in Layen-e Now (1997–2013), the study area has a prolonged summer drought from June to October. The mean annual precipitation and mean annual temperature are 306.4 mm and 16.2°C, respectively (IRIMO 2019). The ombrothermic diagram of the stations shows most precipitation occurs in late winter and continues through mid-spring (Fig. 3). The mean monthly air temperature is the lowest in January (5°C) and the highest in July–August (28°C). The climate conditions imply the drought tolerance in wild pistachio trees.

Data collection and analysis

During the growing seasons in 2018–2020, we collected about 1300 vascular plant specimens in flowering and/or fruiting stage using several typical random plant collecting activities covering different habitats and vegetation types, and also from 58 vegetation samples (10 × 10 m relévés) in different slope aspects. The method of minimal area was used to determine the relévé size (Mueller-Dombois and Ellenberg 1974). The recorded species in the relévés were used to complete the floristic list. A detailed analysis of vegetation of the area will be presented in a forthcoming publication. The collected specimens were labeled, pressed and dried to preserve as herbarium specimens and identified using the relevant standard Floras for Iran and the adjacent countries, including 'Flora Iranica' (Rechinger 1963–2015), 'Flora of Iran' (Assadi et al. 1988–2019), and in some cases by additional updated monographs and revisions of individual plant groups (Tzvelev 1976, Iranshahr 1999, Maassoumi 2005, 2013, Memariani et al. 2007, 2012, Ranjbar et al. 2008, Fritsch and Abbasi 2013). Nomenclature of plant families is based on APG IV (Byng et al. 2016) for Angiosperms and Christenhusz et al. (2011) for Gymnosperms. We checked all scientific and author names of the plant species against the International Plant Name Index (IPNI 2020). The chorology of the species was determined using the distribution data in the relevant Floras and literature. We used classical works, particularly Zohary (1973), Takhtajan (1986) and Léonard (1988), for the delimitation of main phytogeographical units, i.e. Irano–Turanian (IT), Euro–Siberian (ES), Mediterranean (M) and Saharo–Sindian (SS) floristic regions, and also

Figure 2. (a) The landscape of *Pistacia vera* woodland in Polgerd area with the Hezar Masjed higher mountains in the background; (b) inflorescence on male pistachio trees; (c) fruits on female trees; and (d) a pistachio tree growing on deep soils in the study area.

Akhani (1998) and Memariani et al. (2016a) for phytogeographical subdivisions of the IT region. The life-form of each species was defined based on the position of renewing buds relative to the soil surface (Raunkiaer 1934). All voucher specimens were preserved in the Herbarium of Ferdowsi University of Mashhad (FUMH).

Results

Floristic composition

The final checklist of the plants in the study area includes a total of 348 species distributed in 214 genera and 48

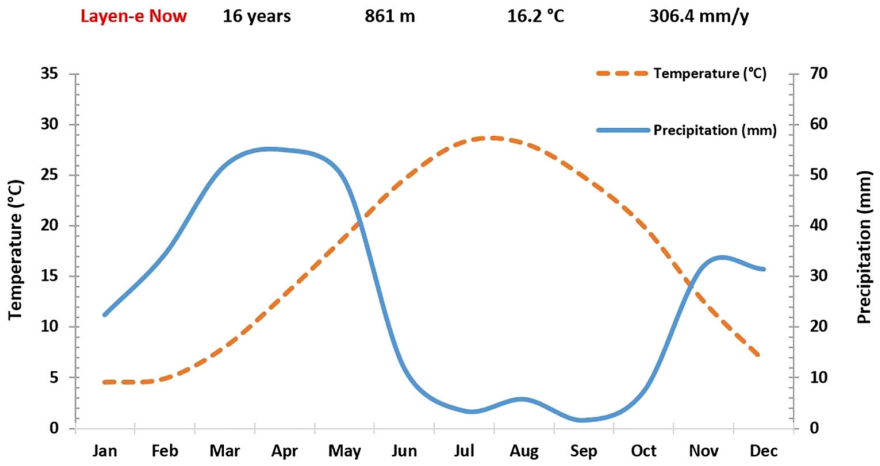

Figure 3. Ombrothermic graph of the nearest climatological station to the Polgerd and Layen *Pistacia vera* woodlands (Layen-e Now station for 1997–2013).

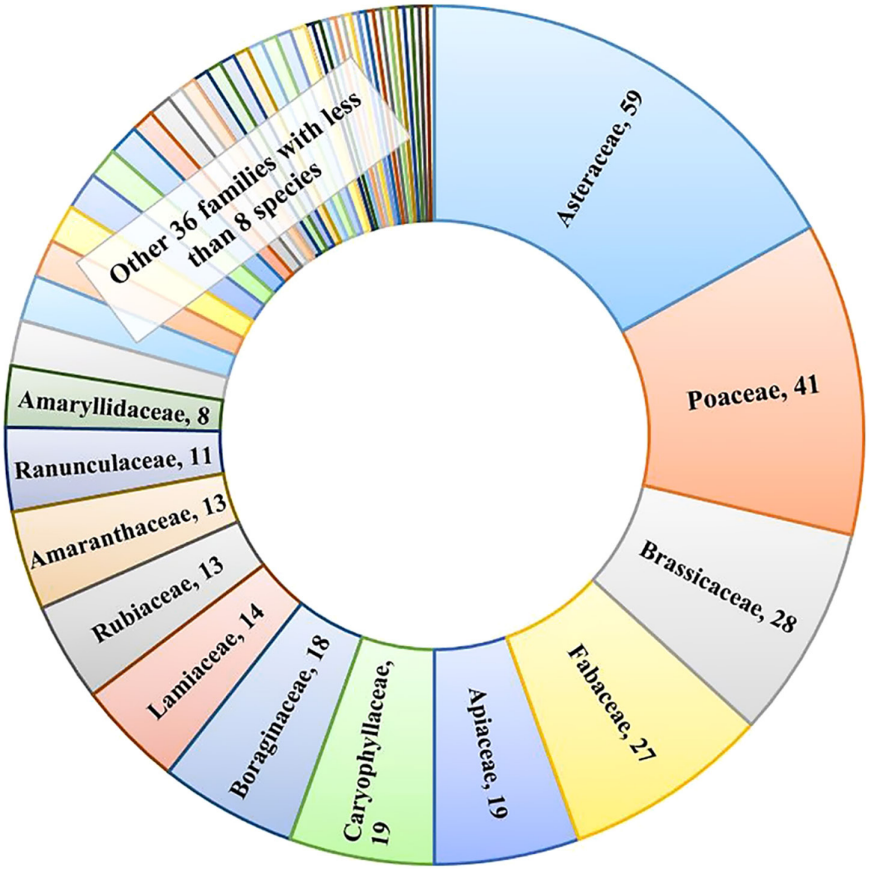

Figure 4. The most abundant families (≥ eight species) in the flora of *Pistacia vera* woodlands in Polgerd and Layen.

families (Appendix 1). Families with higher species richness were Asteraceae (59 species/33 genera), Poaceae (41/22), Brassicaceae (28/24), Fabaceae (27/11), Apiaceae (19/16), Caryophyllaceae (19/11) and Boraginaceae (18/11). These seven families account for 60% of the flora in the study area. A total number of 41 families were represented each one by less than 15 species (Fig. 4). The richest genera were *Astragalus* (ten species) and *Galium* (nine species), followed

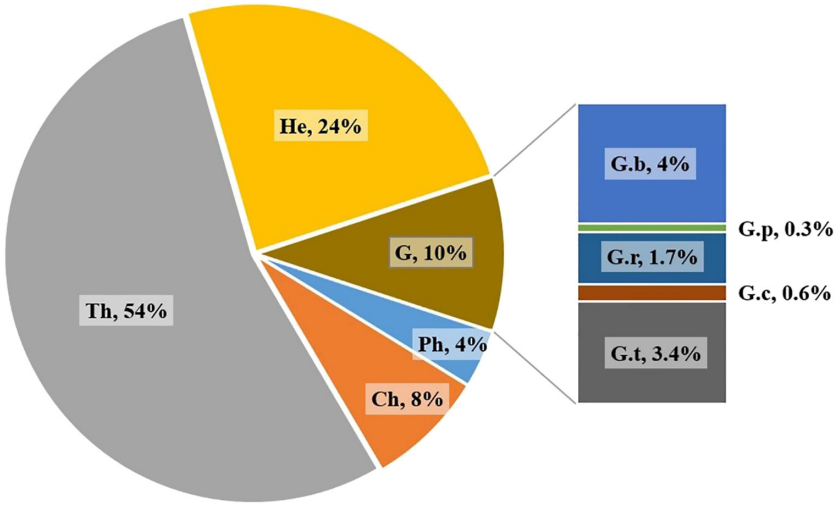

Figure 5. The life-form spectrum of the flora of pistachio woodlands in Polgerd and Layen: Ch (chamaephytes), G.b (bulbous geophytes), G.c (cormous geophytes), G.t (tuberous geophytes), G.r (rhizomatous geophytes), G.p (parasitic geophytes), He (hemicryptophyte), Ph (phanerophyte) and Th (therophyte).

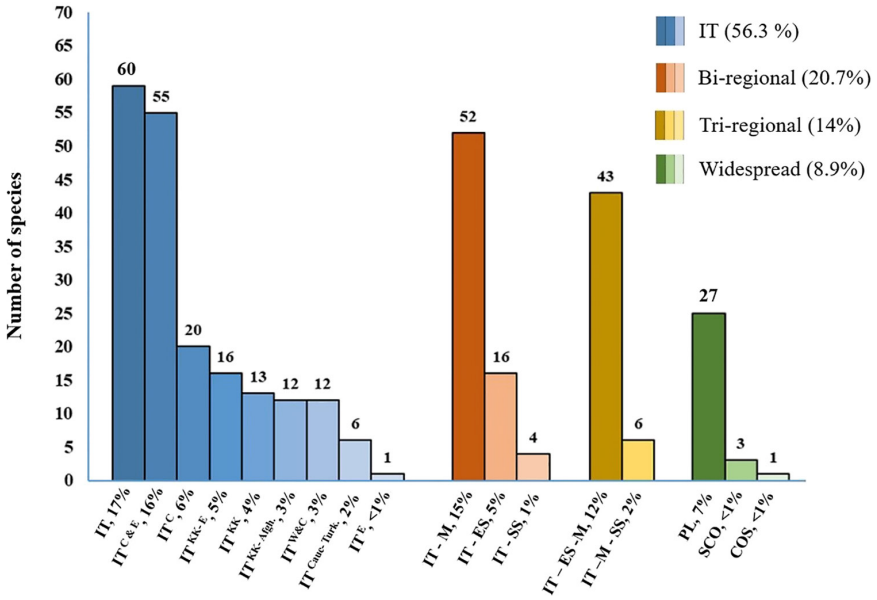

Figure 6. Chorological spectrum of the flora of pistachio woodlands in Polgerd and Layen. IT: Irano–Turanian, ES: Euro–Siberian; M: Mediterranean; SS: Saharo–Sindian; COS: cosmopolitan; SCO: sub-cosmopolitan; PL: pluri-regional. Phytogeographical subgroups of the IT elements are according to Akhani (1998) and Memariani et al. (2016a).

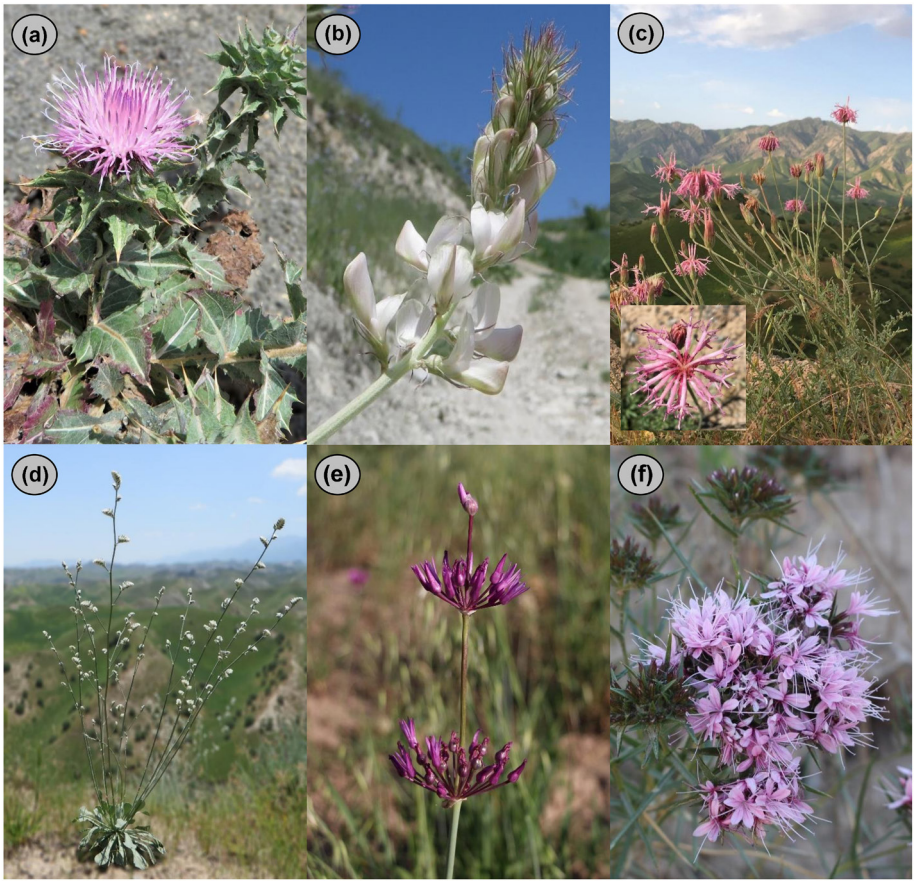

Figure 7. Three Iranian endemic (a–c) and selected sub-endemic (d–f) species in the pistachio woodlands of Polgerd and Layen; (a) *Cousinia verbascifolia* Bunge (near threatened), (b) *Hedysarum balchanense* Boriss. (vulnerable), (c) *Jurinea radians* Boiss. (least concern), (d) *Cephalorhizum turcomanicum* Popov (endangered), (e) *Allium regelii* Trautv. (least concern) and (f) *Acanthophyllum speciosum* Schiman-Czeika (endangered) (photos a–d by Z. Atashgahi and e–f by V. Jafari Polgerd).

Table 1. Red List of the threatened (EN: endangered, VU: vulnerable) and near-threatened (NT) plants in the flora of *Pistacia vera* woodlands in Polgerd and Layen.

No.	Species/subspecies	Red list categories*
1	*Acanthophyllum speciosum* Schiman-Czeika	EN
2	*Cephalorhizum turcomanicum* Popov	EN
3	*Cirsium bornmuelleri* Sint. ex Bornm.	VU
4	*Cousinia antonowii* C.Winkl.	VU
5	*Cousinia verbascifolia* Bunge	NT
6	*Hedysarum balchanense* Boriss.	VU
7	*Nepeta ucranica* L. subsp. *kopetdaghensis* (Pojark.) Rech.f.	NT
8	*Trigonella turkmena* Popov	VU

* The species classification is based on a globally red list assessment of the endemic plants in Khorassan-Kopet Dagh floristic province (Memariani et al. 2016b).

by *Allium* and *Bromus* (each with seven species), *Cousinia* and *Centaurea* (each with six species). Therophytes were the dominant life-form with 188 species (54%), followed by hemicryptophytes, geophytes, chamaephytes and phanerophytes, respectively (Fig. 5).

Phytogeographical spectrum

More than half of the flora (195 species, 56.3%) in the study area belongs to the Irano–Turanian floristic region (Fig. 6). Bi-regional (72 species, 20.7%) and tri-regional (49 species, 14%) patterns also make up a remarkable proportion of the flora. The widespread elements (8.9%), i.e. pluri-regional, subcosmopolitan and cosmopolitan species, had a little role in the floristic composition of the studied woodlands. The main distribution patterns of the Irano–Turanian elements were widespread IT (17% of total flora), central–eastern IT (16%), central IT (6%) and eastern–KK (5%). IT elements endemic to KK floristic province make up only 4% of the total flora (Fig. 6). Three species (< 1%) were endemic to Iran; however, there were 31 sub-endemic taxa (about 9%) in the study area occurring mainly in Iran and one or two adjacent countries, i.e. Turkmenistan and Afghanistan (Appendix 1, Fig. 7).

Discussion

The wild pistachio woodlands in Polgerd and Layen are remnants of extensive forests believed to have covered vast areas of the foothills in Kopet Dagh, including the Hezar Masjed mountain range; however, they have mostly been cleared during the last century (Zlotin 1994). Despite the long disturbance history, environmental conditions and relatively small surface area and elevation range, our study revealed considerable species richness compare to the other thermophilous savannoids in northeastern Iran. The leading families and genera in the floristic composition of the area are typical of Irano–Turanian flora. Based on our unpublished vegetation analysis, although *Pistacia vera* is the dominant species in the community type, phanerophytes make the least contribution to the life-form spectrum. Instead, therophytes or annuals dominate the flora, with more than half of the species, followed by hemicryptophytes. The dominance of the therophytes reflects the ecological adaptations of the flora to the arid climate and partly the disturbance history of the area. A similar life-form spectrum has been recorded in desert steppes of Khorassan (Sokhanvar et al. 2013); however, hemicryptophytes dominate in mountain steppes (Memariani et al. 2016c, Atashgahi et al. 2018).

Table 2. Floristic and climo-geographical comparison of the *Pistacia vera* woodlands in Polgerd and Layen with three other well-documented areas in Khorassan–Kopet Dagh floristic province, NE Iran.

Study area	Polgerd and Layen (this study)	Chahchaheh (Saberi et al. 2010)	Tirgan (Amiri et al. 2009)	Heydari (Atashgahi et al. 2018)
Vegetation	Pistachio woodland	Pistachio woodland	Grassland + Juniper woodland	Grassland + Juniper woodland
Surface area (ha)	1591	3000	3571	46350
Elevation (m a.s.l.)	663–1054	450–1000	1006–2384	1400–2900
N Latitude	37°8′22″–37°11′46″	36°35′–36°36′	37°1′–37°8′	36°31′–36°49′
E Longitude	59°23′31″–59°30′22″	60°21′–60°23′	59°16′–59°20′	58°29′7″–58°45′55″
Aerial distance to the study area (km)	N/A	106	8	89
Mean annual precipitation (mm)	306.4	254.8	412.7	315
Mean annual temperature (°C)	16.2	17.9	12	12.7
Total recorded plant species	348	244[a]	404	588
No. of species per area (100 ha)	21.9	8.1	11.3	1.27
No. of common species with the study area	N/A	149	140	192
Floristic similarity to the study area (%)	N/A	50.3	43.2	38.7

[a] Saberi et al. (2010) recorded 248 species for Chahchaheh area; however, some plant names have been reduced to the synonymy due to taxonomical changes. So, we used a refined checklist for calculating the floristic similarity.

The core flora of the area (56%) belongs to the Irano–Turanian region, which is the main center of diversification for several mega-genera like *Astragalus* and *Cousina*. The presence of wide-range bi-regional (21%) and tri-regional (14%), and widespread (9%) elements reflects the significant contribution of adjacent regions to the floristic composition of the area. Among the IT species, the widespread IT (17%) and the central–eastern IT (16%) elements are the most common (Fig. 6). However, the IT species endemic to the KK (4%) have a lower contribution to the flora. Memariani et al. (2016b) recorded that ca 13% of the flora of KK floristic province are local endemic to the area and about 80% of the endemic species are restricted to the middle and higher elevational zones of KK Mountains.

Although having a relatively lower endemism rate than the whole area of KK, the wild pistachio woodlands have an essential conservation value due to the unique thermophilous savannoid ecosystem in the IT region and several rare and threatened plants. *Halimocnemis commixta* is recorded as new to the Iranian flora (Atashgahi et al. 2022a), *Arctium triflorum* Kuntze (Syn.: *Cousinia triflora* Schrenk) as a scarce species known only from few localities in Iran, and *Psilurus incurvus* (Gouan) Schinz & Thell. as a new record for the flora of Khorassan, which fills the gaps for the western (SW Iran) and eastern (SW Afghanistan) range of distribution of this delicate species. Among 34 endemic and subendemic species in the area, there are six threatened (two Endangered, four Vulnerable) and two near-threatened species (Memariani et al. 2016b, Table 1).

In Table 2, we have compared the floristic composition, physical geography and climate of the wild pistachio woodlands in Polgerd and Layen (this study) and Chahchaheh as a part of Jangal-e Khajeh Protected Area (Saberi et al. 2010) with the nearest well-documented areas in the KK. The *P. vera* woodlands show a warmer and partly dryer climate and lower species richness than the grasslands and juniper communities in the middle to higher zones of KK mountains in Tirgan (Amiri et al. 2009) and Heydari Wildlife Refuge (Atashgahi et al. 2018). Despite two pistachio woodlands in the study area and Chahchaheh are more distant than the others, they show higher floristic similarity to each other (53%) compared to the higher mountains. Simultaneously, there is a fewer species number in the pistachio woodlands of Chahchaheh than in the study area, which may be due to a drier and slightly warmer climate (Table 2).

Conclusion

The *P. vera* woodland remnants in northeastern Iran showed considerable floristic diversity in spite of their isolation and smaller surface area. Biogeographically, the area belongs to the Irano–Turanian region with a unique mixture of the flora from the adjacent areas. So, these isolated plant communities have enriched the plant biodiversity of the Khorassan-Kopet Dagh floristic province. The wild pistachio woodlands are also inhabited by several narrow endemic, range-restricted and threatened plants. As a part of the Irano–Anatolian biodiversity hotspot, the higher mountains of central Kopet Dagh and their surrounding lower mountains, including the isolated patches of pistachio woodlands, merit simultaneous conservation attention.

Acknowledgements – We acknowledge gratefully the FUMH staff who confirmed the identity of some plant specimens. We thank Ali Asghar Basiri for his fieldwork assistance.
Funding – Zohreh Atashgahi was partially supported by a grant from the Ferdowsi University of Mashhad (No. FUM-14002794075).

Author contributions

Zohreh Atashgahi: Conceptualization (equal); Data curation (equal); Formal analysis (equal); Investigation (equal); Methodology (equal); Resources (equal); Writing – original draft (equal). **Farshid Memariani**: Conceptualization (equal); Funding acquisition (equal); Investigation (equal); Methodology (lead); Project administration (lead); Resources (equal); Supervision (lead); Writing – review and editing (equal). **Vahid Jafari Polgerd**: Investigation (equal). **Mohammad Reza Joharchi**: Investigation (equal).

Data availability statement

Data are available from the Figshare Digital Repository: <https://doi.org/10.6084/m9.figshare.19165385.v1> (Atashgahi et al. 2022b).

References

Afshar-Harb, A. 1994. Geology of Kopet Dagh. – In: Hushmandzadeh, A. (ed.), Treatise on the geology of Iran. Geological organization of Iran , in Persian.

Akhani, H. 1998. Plant biodiversity of Golestan National Park, Iran. – Stapfia 53: 1–411.

Amiri, M. S. et al. 2009. An introduction to the flora, life-form and phytogeography of Tirgan Watershed (Khorassan Province). – J. Sci. 8: 89–106 , in Persian.

Assadi, M. et al. (eds) 1988–2019. Flora of Iran, vol. 1–147. – Research Inst. of Forests and Rangelands , in Persian.

Atashgahi, Z. et al. 2018. Plant diversity of the Heydari Wildlife Refuge in northeastern Iran, with a checklist of vascular plants. – Phytotaxa 340: 101–127.

Atashgahi, Z. et al. 2022a. *Halimocnemis commixta* (Amaranthaceae), a new record for the flora of Iran. – Nova Biol. Rep. 9: A108643.

Atashgahi, Z. et al. 2022b. Data from: Floristic composition and phytogeographical spectrum of *Pistacia vera* L. woodland remnants in NE Iran. – Figshare Digital Repository, <https://doi.org/10.6084/m9.figshare.19165385.v1>.

Barazani, O. et al. 2003. Genetic variability in Turkmen populations of *Pistacia vera* L. – Gen. Res. Crop. Evol. 50: 383–389.

Behboodi, B. 2005. Ecological distribution study of wild pistachios for selection of rootstock. – Opt. Mediterr. Ser. A 63: 61–67.

Breckle, S. W. and Rafiqpoor, M. D. 2020. The Hindu Kush/Afghanistan Mountains. – In: Noroozi, J. (ed.), Plant biogeog-

raphy and vegetation of high mountains of central and south–west Asia. Springer, pp. 43–91.
Byng, J. W. et al. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. APG IV. – Bot. J. Linn. Soc. 181: 1–20.
Christenhusz, M. J. M. et al. 2011. A new classification and linear sequence of extant gymnosperms. – Phytotaxa 19: 55–70.
Djamali, M. et al. 2011. Application of the Global Bioclimatic Classification to Iran: implications for understanding the modern vegetation and biogeography. – Ecol. Mediterr. 37: 91–114.
Djamali, M. et al. 2012. Ecological implications of *Cousinia* Cass. (Asteraceae) persistence through the last two glacial–interglacial cycles in the continental Middle East for the Irano–Turanian flora. – Rev. Palaeobot. Palynol. 172: 10–20.
Erdős, L. et al. 2018. The edge of two worlds: a new review and synthesis on Eurasian forest–steppes. – Appl. Veg. Sci. 21: 345–362.
Fritsch, R. M. and Abbasi, M. 2013. A taxonomic review of *Allium* subg. *Melanocrommyum* in Iran. – Leibniz–Inst. für Pflanzengenetik und Kulturpflanzenforschung Gatersleben (IPK).
IPNI 2020. International Plant Names Index. – <www.ipni.org>, accessed 11 Dec 2020.
Iranshahr, M. 1999. Parasitic and semiparasitic flowering plants of Iran, vol. 1. – Agricultural Research Education and Extension Organization Press, in Persian.
IRIMO, Iran Meteorological Organization 2020. Analytical reports and climatic data. – <www.irimo.ir>, accessed 20 Oct 2020.
Kamakhina, G. L. 1994. Kopetdagh–Khorassan flora: regional features of central Kopetdagh. – In: Fet, V. and Atamuradov, K. I. (eds), Biogeography and ecology of Turkmenistan. Kluwer Academic Publisher, pp. 129–148.
Karimi, H. R. et al. 2009. Morphological diversity of *Pistacia* species in Iran. – Gen. Res. Crop. Evol. 56: 561–571.
Khanazarov, A. A. et al. 2009. Genetic resources of *Pistacia vera* L. in Central Asia. – Gen. Res. Crop. Evol. 56: 429–443.
Kozhoridze, G. et al. 2015. Geographic distribution and migration pathways of *Pistacia* – present, past and future. – Ecography 38: 1141–1154.
Léonard, J. 1988. Contribution to the study of the flora and vegetation of the Iranian desert, vol. 8: Study of distribution areas, phytochoria, chorotypes. – Jard. Bot. Natl Belg., in French.
Léonard, J. 1991. Contribution to the study of the flora and vegetation of the Iranian desert, vol. 10: Study of the vegetation: phytosociological and phytochorological analysis of plant groups. – Jard. Bot. Natl Belg., in French.
Maassoumi, A. A. 2005. The genus *Astragalus* in Iran, vol. 5. – Research Inst. of Forests and Rangelands Publications, in Persian.
Maassoumi, A. A. 2013. A contribution to the taxonomy of the genus *Oxytropis* (Fabaceae) in Iran. – Iran. J. Bot. 19: 1–28.
Manafzadeh, S. et al. 2014. A tale of migrations from east to west: the Irano–Turanian floristic region as a source of Mediterranean xerophytes. – J. Biogeogr. 41: 366–379.
Memariani, F. 2020. The Khorassan–Kopet Dagh Mountains. – In: Noroozi, J. (ed.), Plant biogeography and vegetation of high mountains of central and south–west Asia. Springer, pp. 93–116.
Memariani, F. et al. 2007. *Allium* L. subgen. *Rhizirideum* sensu lato in Iran, two new records and a synopsis of taxonomy and phytogeography. – Iran. J. Bot. 13: 12–20.
Memariani, F. et al. 2012. A revision of *Bromus* sect. *Triniusa* (Poaceae) in Khorassan (Iran). – Rostaniha 13: 189–196.
Memariani, F. et al. 2016a. A review of plant diversity, vegetation and phytogeography of the Khorassan–Kopet Dagh floristic province in the Irano–Turanian region (northeastern Iran–southern Turkmenistan). – Phytotaxa 249: 8–30.
Memariani, F. et al. 2016b. Endemic plants of the Khorassan–Kopet Dagh floristic province in the Irano–Turanian region: diversity, distribution patterns and conservation status. – Phytotaxa 249: 31–117.
Memariani, F. et al. 2016c. Plant diversity of Ghorkhod Protected Area, NE Iran. – Phytotaxa 249: 118–158.
Mittermeier, R. A. et al. 2011. Global biodiversity conservation: the critical role of hotspots. – In: Zachos, F. E. and Habel, J. C. (eds), Biodiversity hotspots: distribution and protection of conservation priority areas. Springer, pp. 3–22.
Mueller-Dombois, D. and Ellenberg, H. 1974. Aims and methods of vegetation ecology. – Wiley.
Nabavi, M. H. 1976. An introduction to geology of Iran. – Geological Survey of Iran, in Persian.
Noroozi, J. et al. 2008. Biodiversity and phytogeography of the alpine flora of Iran. – Biodivers. Conserv. 17: 493–521.
Pazouki, L. et al. 2010. Genetic diversity and relationships among *Pistacia* species and cultivars. – Conserv. Genet. 11: 311–318.
Popov, K. P. 1994. Trees, shrubs and semishrubs in the mountains of Turkmenistan. – In: Fet, V. and Atamuradov, K. I. (eds), Biogeography and ecology of Turkmenistan. Kluwer Academic Publishers, pp. 173–186.
Ranjbar, M. et al. 2008. A key and four new species of *Hedysarum* (Fabaceae) in Iran. – Nord. J. Bot. 26: 10–20.
Raunkiaer, C. 1934. The life form of plants and statistical plant geography. – Clarendon Press.
Rechinger, K. H. (ed.) 1963–2015. Flora Iranica. – Akademische Druck-und Verlagsanstalt, pp. 1–181.
Saberi, A. et al. 2010. A floristic study of Chahchaheh *Pistacia* forest, NE Iran. – Taxon. Biosyst. 2: 61–92, in Persian, with English Abstract, p. 6.
Sokhanvar, F. et al. 2013. Flora, life-form and chorology of plants of the Helali protected area in Razavi Khorassan province. – Taxon. Biosyst. 16: 85–100, in Persian, with English Abstract, p. 8.
Takhtajan, A. 1986. Floristic regions of the world (Translated from Russian). – Univ. of California Press.
Tojibaev, K. S. et al. 2017. Botanical geography of Uzbekistan. – Korea National Arboretum.
Tzvelev, N. N. 1976. Grasses of the Soviet Union. – Nauka Publishers.
Zlotin, R. I. 1994. Ecosystem structure of subtropical arid pistachio woodlands in Southern Turkmenistan. – In: Fet, V. and Atamuradov, K. I. (eds), Biogeography and ecology of Turkmenistan. Kluwer Academic Publishers, pp. 187–196.
Zohary, M. 1973. Geobotanical foundations of the Middle East, 2 vols. – Gustav Fischer Verlag.

Appendix 1. Checklist of the vascular flora of the remnant wild pistachio woodlands in Polgerd and Layen (NE Iran). Chorotypes are according to Akhani (1998) and Memariani et al. (2016a): C (central), E (eastern), W (western), Afgh. (Afghanistan), Cauc. (Caucasus), KK (Khorassan-Kopet Dagh), Turk. (Turkmenistan), EH (Euxino-Hyrcanian). Life-forms: Ch (chamaephyte), G.b (bulbous geophyte), G.c (cormous geophyte), G.t (tuberous geophyte), G.r (rhizomatous geophyte), G.p (parasitic geophyte), He (hemicryptophyte), Ph (phanerophyte), Th (therophyte). Regional endemics are marked by one, and Iranian endemics by two asterisks.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
	Amaranthaceae			
1	*Atriplex flabellum* Bunge *ex* Boiss.	IT $^{C, E}$	Th	9001, 9188, 9588, 9683
2	*Atriplex moneta* Bunge *ex* Boiss.	IT $^{C, E}$	Th	9589
3	*Caroxylon dendroides* (Pall.) Tzvelev (Syn.: *Salsola dendroides* Pall.)	IT	Ch	9725
4	*Caroxylon scleranthum* (C.A.Mey.) Akhani & E.H. Roalson	IT $^{C, E}$	Th	9766
5	*Halimocnemis commixta* (Bunge) Akhani (Syn.: *Gamanthus commixtus* Bunge)	IT $^{C, E}$	Th	9732
6	*Halothamnus auriculus* (Moq.) Botsch.	IT $^{C, E}$	Ch	9000, 9397, 9722
7	*Halothamnus glaucus* (M.Bieb.) Botsch.	IT	Ch	9002, 9260, 9591, 9592, 9261, 9682
8	*Halothamnus subaphyllus* (C.A.Mey.) Botsch.	IT $^{C, E}$	Ch	9723
9	*Kaviria tomentosa* (Moq.) Akhani (Syn.: *Salsola tomentosa* (Moq.) Spach)	IT $^{C, E}$	Ch	9733, 9736
10	*Noaea mucronata* (Forssk.) Asch. & Schweinf.	IT–ES–M	Ch	9724
11	*Salsola arbusculiformis* Drobow	IT $^{KK–E}$	Ch	9590
12	*Spinacia turkestanica* Iljin	IT $^{C, E}$	Th	9011, 9259
13	*Suaeda microphylla* Pall.	IT	Ch	9189
	Amaryllidaceae			
14	*Allium ampeloprasum* L.	IT–ES–M	G.b	9665, 9663
15	*Allium cristophii* Trautv. *	IT ^{KK}	G.b	9570
16	*Allium giganteum* Regel	IT $^{KK–E}$	G.b	9168, 9708
17	*Allium regelii* Trautv. *	IT ^{C}	G.b	9166, 9476, 9707
18	*Allium rubellum* M.Bieb.	IT $^{Cauc.–Turk.}$	G.b	9169, 9374, 9571, 9666
19	*Allium umbilicatum* Boiss.	IT $^{C, E}$	G.b	9097, 9662, 9664
20	*Allium xiphopetalum* Aitch. & Baker	IT $^{C, E}$	G.b	9167, 9373
21	*Ungernia trisphaera* Bunge *	IT $^{KK–Afgh.}$	G.b	9101
	Anacardiaceae			
22	*Pistacia vera* L.	IT $^{KK–E}$	Ph	9457, 9651, 9652, 9653, 9700, 9740
	Apiaceae			
23	*Aphanopleura leptoclada* (Aitch. & Hemsl.) Lipsky	IT $^{KK–E}$	Th	9696, 9697
24	*Caucalis platycarpos* L.	IT–M	Th	9132
25	*Cuminum setifolium* (Boiss.) Koso–Pol.	IT $^{C, E}$	Th	9341
26	*Elaeosticta allioides* (Regel & Schmalh.) Kljuykov, Pimenov & V.N.Tikhom.	IT $^{C, E}$	G.t	9345, 9541, 9642, 9695
27	*Elwendia cylindrica* (Boiss. & Hausskn.) Pimenov & Kljuykov (Syn.: *Bunium cylindricum* (Boiss. & Hohen.) Drude)	IT	G.t	9128, 9343, 9344, 9455, 9638
28	*Elwendia persica* (Boiss.) Pimenov & Kljuykov (Syn.: *Bunium persicum* (Boiss.) B.Fedtsch.	IT $^{C, E}$	G.t	9127, 9337, 9637
29	*Eremodaucus lehmannii* Bunge	IT $^{C, E}$	Th	9338, 9075, 9129, 9639
30	*Eryngium bungei* Boiss. *	IT ^{C}	He	9133, 9456, 9643
31	*Eryngium caeruleum* M.Bieb.	IT	He	9134
32	*Falcaria vulgaris* Bernh.	IT–ES–M	He	9136
33	*Ferula diversivittata* Regel & Schmalh.	IT $^{C, E}$	He	9540, 9126, 9335
34	*Ferula ovina* (Boiss.) Boiss.	IT $^{C, E}$	He	9076, 9336, 9693
35	*Galagania tenuisecta* (Regel & Schmalh.) M.G.Vassiljeva & Pimenov	IT $^{KK–E}$	G.t	9339, 9641, 9694
36	*Pimpinella affinis* Ledeb.	IT–ES ^{EH}	He	9137, 9645
37	*Scandix stellata* Banks & Sol.	IT–M	Th	9074, 9131, 9340
38	*Seseli transcaucasicum* (Schischk.) Pimenov & Sdobnina (Syn.: *Libanotis transcaucasica* Schischk.)	IT $^{Cauc.–Turk.}$	He	9747
39	*Torilis leptophylla* (L.) Rchb.f.	IT–M	Th	9072
40	*Turgenia latifolia* (L.) Hoffm.	IT–ES–M	Th	9135, 9342, 9644
41	*Zosima absinthiifolia* (Vent.) Link	IT	He	9073
	Asclepiadaceae			
42	*Cynanchum acutum* L.	IT–ES–M	Ph	9501, 9719
	Asparagaceae			
43	*Asparagus verticillatus* L.	IT–ES	Ch	9372

(Continued)

Appendix 1. Continued.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
44	*Bellevalia saviczii* Woronow	IT [C]	G.b	9098, 9165
45	*Muscari neglectum* Guss. *ex* Ten.	IT–ES–M	G.b	9161
	Asphodelaceae			
46	*Eremurus olgae* Regel	IT [KK–E]	G.r	9710
	Asteraceae			
47	*Achillea arabica* Kotschy	IT–M	He	9071, 9321, 9536
48	*Achillea santolinoides* subsp. *wilhelmsii* (K.Koch) Greuter	IT–M	He	9243
49	*Amberboa amberboi* (L.) Tzvelev	IT [Cauc.–Turk.]	Th	9066, 9441
50	*Amberboa turanica* Iljin	IT [C, E]	Th	9749
51	*Arctium triflorum* Kuntze (Syn.: *Cousinia triflora* Schrenk)	IT [KK–E]	He	9252
52	*Artemisia absinthium* L.	IT–ES	Ch	9322, 9722
53	*Artemisia gypsacea* Krasch., Popov & Lincz. *ex* Poljakov *	IT [KK]	Ch	9727, 9728
54	*Artemisia kopetdaghensis* 'Krasch., Popov & Lincz. ex Poljakov'*	IT [KK–Afgh.]	Ch	9057, 9241
55	*Artemisia scoparia* Waldst. & Kitam.	PL	He	s.n.
56	*Aster altaicus* Willd. (Syn.: *Heteropappus altaicus* (Willd.) Novopokr.)	IT–ES	He	9691
57	*Calendula arvensis* (Vaill.) L.	IT–ES–M	Th	9249
58	*Carduus pycnocephalus* L.	IT–ES–M	Th	9065, 9327
59	*Carthamus lanatus* L. subsp. *turkestanicus* (Popov) Hanelt (Syn.: *Carthamus turkestanicus* Popov)	IT	Th	9069, 9245, 9454, 9627
60	*Carthamus oxyacantha* M.Bieb.	IT	Th	s.n.
61	*Centaurea behen* L.	IT [W, C]	He	9525
62	*Centaurea benedicta* (L.) L.	IT–ES–M	Th	9064
63	*Centaurea bruguierana* subsp. *belangeriana* (DC.) Bornm.	IT [C, E]	Th	9329, 9633
64	*Centaurea iberica* Trevir. *ex* Spreng.	IT–ES	Th	9524
65	*Centaurea solstitialis* L.	IT–ES–M	Th	9528
66	*Centaurea virgata* Lam. subsp. *squarrosa* (Boiss.) Gugler	IT	Ch	9632
67	*Chardinia orientalis* (L.) Kuntze	IT [W, C]	Th	9532
68	*Cirsium arvense* (L.) Scop.	PL	He	9451
69	*Cirsium bornmuelleri* Sint. *ex* Bornm. *	IT [KK]	He	9251
70	*Cota altissima* (L.) J.Gay	IT–ES	Th	9248
71	*Cousinia antonowi* C.Winkl. *	IT [KK]	He	9068, 9438, 9625
72	*Cousinia congesta* Bunge *	IT [C]	He	9326, 9529, 9621
73	*Cousinia microcarpa* Boiss.	IT [KK–E]	He	9323, 9439, 9531, 9630, 9539
74	*Cousinia tenella* Fisch. & C.A.Mey.	IT [C, E]	He	9437, 9631
75	*Cousinia turkmenorum* Bornm. & Gauba	IT [C, E]	He	9442, 9533, 9690
76	*Cousinia verbascifolia* Bunge **	IT [KK]	He	9440, 9530, 9629
77	*Crepis kotschyana* (Boiss.) Boiss.	IT	Th	9634
78	*Crepis pulchra* L.	IT–ES–M	Th	9059, 9330, 9444, 9534
79	*Crepis sancta* (L.) Bornm.	IT–ES–M	Th	9626
80	*Crupina vulgaris* Pers. *ex* Cass.	IT–ES–M	Th	9247, 9324, 9443, 9623
81	*Echinops leiopolyceras* Bornm.	IT [C]	He	9537
82	*Echinops orientalis* Trautv.	IT [W, C]	He	s.n.
83	*Epilasia hemilasia* (Bunge) C.B.Clarke	IT [C, E]	Th	9449, 9636, 9767
84	*Filago arvensis* L.	IT–ES–M	Th	9254, 9320, 9452, 9526, 9622
85	*Filago griffithii* (A.Gray) Andrés–Sánchez & Galbany (Syn.: *Cymbolaena griffithii* (A.Gray) Wagenitz)	IT	Th	9450
86	*Garhadiolus hedypnois* Jaub. & Spach	IT	Th	9058, 9242, 9319, 9624, 9453, 9522
87	*Garhadiolus papposus* Boiss. & Buhse	IT	Th	9448, 9521
88	*Gundelia tournefortii* L.	IT	He	9062
89	*Inula peacockiana* (Aitch. & Hemsl.) Korovin	IT	He	9067, 9628
90	*Jurinea radians* Boiss. **	IT [C]	He	9063
91	*Klasea latifolia* (Boiss.) L.Martins (Syn.: *Serratula latifolia* Boiss.)*	IT [C]	He	9246, 9640
92	*Koelpinia linearis* Pall.	IT–M–SS	Th	9070, 9253, 9334
93	*Lactuca serriola* L.	IT–ES–M	Ch	9325, 9692
94	*Lactuca undulata* Ledeb.	IT–M	Th	9250, 9523
95	*Leuzea repens* (L.) D.J.N.Hind	PL	He	9328
96	*Onopordum leptolepis* DC.	IT	He	9333
97	*Pseudohandelia umbellifera* (Boiss.) Tzvelev	IT [C, E]	He	9244, 9620
98	*Scorzonera laciniata* Jacq.	IT–ES–M	He	9535

(Continued)

Appendix 1. Continued.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
99	*Scorzonera raddeana* C.Winkl.	IT [C]	G.t	9255
100	*Scorzonera stenocephala* Boiss.	IT [C]	G.t	9256
101	*Senecio vernalis* Waldst. & Kit.	IT–ES	Th	9257, 9445, 9331
102	*Taraxacum stanjukoviczii* Schischk.	IT [C, E]	He	9538
103	*Tragopogon coelesyriacus* Boiss. (Syn.: *Tragopogon longirostris* Bischoff *ex* Sch.Bip.)	IT–M	He	9768
104	*Zoegea crinita* Boiss. (Syn.: *Zoegea baldschuanica* C.Winkl.)	IT [C, E]	Th	9061, 9332, 9446, 9635, 9689
105	*Zoegea purpurea* Fresen.	IT	Th	9060, 9447
	Berberidaceae			
106	*Bongardia chrysogonum* (L.) Spach	IT–M	G.t	9021
	Boraginaceae			
107	*Arnebia decumbens* (Vent.) Coss. & Kralik	IT–SS	Th	9031, 9222, 9418, 9686, 9761
108	*Asperugo procumbens* L.	PL	Th	9297
109	*Buglossoides tenuiflora* (L.f.) I.M.Johnst.	IT–M	Th	9420
110	*Caccinia macranthera* (Banks & Sol.) Brand	IT	Th	9035, 9231
111	*Lappula barbata* (M.Bieb.) Gürke	IT–M	Th	9034, 9230, 9298, 9424, 9511, 9613
112	*Lappula microcarpa* (Ledeb.) Gürke	IT [C, E]	Th	9224, 9299, 9425, 9746, 9758
113	*Lappula sessiliflora* Gürke	IT	Th	9223, 9419
114	*Lappula sinaica* (A.DC.) Asch. & Schweinf.	IT	Th	9030
115	*Myosotis stricta* Link *ex* Roem. & Schult.	IT–ES–M	Th	9426
116	*Nonea turcomanica* Popov	IT [C]	Th	9294, 9226
117	*Onosma dichroantha* Boiss.	IT [C, E]	He	9750
118	*Onosma longiloba* Bunge *	IT [KK–Alborz]	He	9225
119	*Paracaryum crista-galli* (Rech.f. & Riedl) Kamelin & Raenko *	IT [KK–Afgh.]	He	9227
120	*Pseudoheterocaryum rigidum* (A.DC.) Kaz. Osaloo & Saadati (Syn.: *Heterocaryum rigidum* Fisch. & C.A.Mey.)	IT	Th	9032, 9295, 9422, 9687, 9509
121	*Pseudoheterocaryum subsessile* (Vatke) Kaz. Osaloo & Saadati (Syn.: *Heterocaryum subsessile* Vatke)	IT [C, E]	Th	9033, 9228, 9229, 9296, 9423, 9508, 9510, 9612
122	*Rochelia cardiosepala* Bunge	IT	Th	9301
123	*Rochelia mirheydari* Riedl & Esfand. **	IT [KK]	Th	9421
124	*Rochelia persica* Bunge *ex* Boiss.	IT [C, E]	Th	9738
	Brassicaceae			
125	*Aethionema carneum* (Banks & Sol.) B.Fedtsch.	IT	Th	9237
126	*Alyssum desertorum* Stapf	IT–ES	Th	9051, 9052, 9240, 9314, 9429
127	*Alyssum stapfii* Vierh.	IT	Th	9313
128	*Alyssum szovitsianum* Fisch. & C.A.Mey.	IT	Th	9516, 9617
129	*Arabis nova* Vill.	IT–ES–M	Th	9055, 9317, 9427, 9619
130	*Camelina rumelica* Velen.	IT–ES	Th	9235, 9315, 9054, 9435, 9518, 9688
131	*Capsella bursa-pastoris* (L.) Medik.	PL	Th	9739
132	*Clypeola jonthlaspi* L.	IT–M	Th	9040
133	*Crambe cordifolia* subsp. *kotschyana* (Boiss.) Jafri	IT [C, E]	He	9316
134	*Cryptospora falcata* Kar. & Kir.	IT [C, E]	Th	9037, 9309, 9432, 9514
135	*Descurainia sophia* (L.) Webb *ex* Prantl	PL	Th	9307a
136	*Diptychocarpus strictus* (Fisch. *ex* M.Bieb.) Trautv.	IT–ES	Th	9041, 9430, 9513, 9615, 9308b
137	*Euclidium syriacum* (L.) R.Br.	PL	Th	9042, 9234, 9306, 9614
138	*Goldbachia laevigata* (M.Bieb.) DC.	IT	Th	9039
139	*Lepidium draba* L. (Syn.: *Cardaria draba* (L.) Desv.)	PL	Th	s.n.
140	*Leptaleum filifolium* (Willd.) DC.	IT	Th	9043, 9305, 9512
141	*Litwinowia tenuissima* (Pall.) Woronow *ex* Pavlov	IT [C, E]	Th	9049
142	*Matthiola afghanica* Rech. fil. & Koie *	IT [KK–Afgh.]	He	9236
143	*Meniocus linifolius* (Stephan *ex* Willd.) DC. (Syn.: *Alyssum linifolium* Stephan *ex* Willd.)	IT–M	Th	9038, 9431, 9308a
144	*Neotorularia dentata* (Freyn & Sint.) Hedge & J. Léonard	IT [C]	Th	9036, 9310, 9436, 9515, 9616
145	*Neotorularia torulosa* (Desf.) Hedge & J.Léonard	IT–M	Th	9238, 9239, 9312, 9050
146	*Neslia paniculata* subsp. *thracica* (Velen.) Bornm.	IT–ES–M	Th	9053, 9517
147	*Noccaea perfoliata* (L.) Al-Shehbaz (Syn.: *Thlaspi perfoliatum* L.)	IT–ES–M	Th	9048
148	*Olimarabidopsis pumila* (Celak.) Al-Shehbaz, O'Kane & R.A.Price	IT	Th	9044, 9232, 9302, 9303, 9428
149	*Rapistrum rugosum* (L.) All.	IT–ES–M	Th	9045, 9233, 9304, 9519
150	*Sisymbrium altissimum* L.	IT–ES	Th	9307b
151	*Strigosella africana* (L.) Botsch. (Syn.: *Malcolmia africana* (L.) R.Br.)	PL	Th	9047, 9311, 9434, 9618

(Continued)

Appendix 1. Continued.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
152	*Strigosella turkestanica* (Litv.) Botsch. (Syn.: *Malcolmia turkestanica* Litv.)	IT [C, E]	Th	9046, 9433
	Capparidaceae			
153	*Capparis spinosa* L.	PL	Ph	9402, 9607
	Caprifoliaceae			
154	*Lomelosia olivieri* (Coult.) Greuter & Burdet (Syn.: *Scabiosa olivieri* Coult.)	IT	Th	s.n.
155	*Lomelosia rotata* (M.Bieb.) Greuter & Burdet (Syn.: *Scabiosa rotata* M.Bieb.)	IT [W, C]	Th	9130, 9318, 9520
156	*Valeriana coronata* (L.) Mill. (Syn.; *Valerianella coronata* (L.) DC.)	IT–ES	Th	9271
157	*Valeriana oxyrhyncha* (Fisch. & C.A.Mey.) Christenh. & Byng (Syn.: *Valerianella oxyrhyncha* Fisch. & C.A.Mey.)	IT	Th	9505
158	*Valerianella muricata* (Steven *ex* M.Bieb.) W.H.Baxter	IT–M	Th	9272
159	*Valerianella platycarpa* Trautv.	IT [Cauc.–Turk.]	Th	9504
	Caryophyllaceae			
160	*Acanthophyllum speciosum* Schiman-Czeika *	IT [KK]	Ch	9648
161	*Arenaria serpyllifolia* L.	SCO	Th	9139, 9077, 9346, 9459, 9542
162	*Cerastium dichotomum* L.	IT–M	Th	9463
163	*Cerastium perfoliatum* L.	IT–M	Th	9756, 9763
164	*Dianthus crinitus* subsp. *turcomanicus* (Schischk.) Rech.f. *	IT [KK–Afgh.]	Ch	9078, 9647, 9140, 9470
165	*Dianthus nudiflorus* Griff. (Syn.: *Velezia rigida* L.)	IT–M	Th	9081, 9138, 9351, 9546, 9547, 9650, 9699
166	*Gypsophila bicolor* (Freyn. & Sint.) Grossh.	IT [W, C]	He	9698
167	*Gypsophila pilosa* Huds.	IT [W, C]	Th	9460, 9646
168	*Gypsophila vaccaria* (L.) Sm. (Syn.: *Vaccaria hispanica* (Mill.) Rauschert)	IT–ES–M	Th	9461
169	*Herniaria cinerea* DC. (Syn.: *Herniaria hirsuta* subsp. *cinerea* (DC.) Cout.)	IT–M	Th	9146, 9352, 9548, 9082
170	*Holosteum umbellatum* subsp. *glutinosum* (M.Bieb.) Nyman	IT	Th	9147, 9348
171	*Lepyrodiclis holosteoides* (C.A.Mey.) Fenzl *ex* Fisch. & C.A.Mey.	IT	Th	9079, 9145, 9347
172	*Lepyrodiclis stellarioides* Schrenk.	IT [C, E]	Th	9757
173	*Minuartia hamata* (Hausskn.) Mattf.	IT–M	Th	9144, 9349, 9543
174	*Minuartia meyeri* (Boiss.) Bornm.	IT	Th	9143, 9462, 9544
175	*Silene brahuica* Boiss.	IT [C, E]	Ch	9469
176	*Silene conoidea* L.	IT–M	Th	9080, 9142, 9350
177	*Silene swertiifolia* Boiss.	IT [W, C]	He	9141
178	*Stellaria kotschyana* Fenzl ex Boiss. (Syn.: *Mesostemma kotschyana* (Fenzl *ex* Boiss.) Vved.)	IT [C]	He	9649
	Cistaceae			
179	*Helianthemum ledifolium* (L.) Mill	IT–M	Th	9458, 9083, 9282, 9735
	Cleomaceae			
180	*Cleome coluteoides* Boiss.	IT [W, C]	He	9193
	Convolvulaceae			
181	*Convolvulus arvensis* L.	SCO	He	s.n.
182	*Convolvulus dorycnium* L.	IT [C, E]	He	9267, 9012, 9197, 9497, 9599
183	*Convolvulus pseudocantabrica* Schrenk	IT [KK–E]	Ch	9600
184	*Cuscuta approximata* Bab.	PL	Th	9681, 9731
185	*Cuscuta campestris* Yunck.	PL	Th	9003, 9258
	Crassulaceae			
186	*Sedum aetnense* Tineo	IT–M	Th	9016, 9201, 9595, 9276
187	*Sedum hispanicum* L.	IT–ES	Th	9277, 9399, 9496, 9596
	Cyperaceae			
188	*Carex pachystylis* J.Gay	IT	G.r	9293
	Ephedraceae			
189	*Ephedra intermedia* Schrenk & C.A.Mey.	IT [C]	Ph	9009
190	*Ephedra foliata* Boiss. *ex* C.A.Mey.	IT–SS	Ph	9010, 9200, 9275, 9721, 9752
	Euphorbiaceae			
191	*Chrozophora tinctoria* (L.) A.Juss.	IT–M–SS	Th	9720
192	*Euphorbia bungei* Boiss.	IT [W, C]	He	9013
193	*Euphorbia falcata* L.	IT–ES–M	Th	9199, 9274, 9597, 9685
194	*Euphorbia inderiensis* Less. ex Kar. & Kir.	IT [C, E]	Th	9744

(Continued)

Appendix 1. Continued.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
195	*Euphorbia szovitsii* Fisch. & C.A.Mey.	IT	Th	9598
	Fabaceae			
196	*Alhagi maurorum* Medik.	IT–M–SS	He	9726
197	*Astragalus campylotrichus* Bunge	IT [C, E]	Th	9358, 9552
198	*Astragalus citrinus* subsp. *barrowianus* (Aitch. & Baker) Podlech *	IT [KK–Afgh.]	He	9359, 9468
199	*Astragalus commixtus* Bunge	IT	Th	9560
200	*Astragalus filicaulis* Kar. & Kir.	IT [C & E]	Th	9086, 9149, 9354, 9466, 9551, 9655
201	*Astragalus globiceps* Bunge	IT [KK–E]	He	9355
202	*Astragalus nephtonensis* Freyn *	IT [KK–Afgh.]	He	9471, 9561
203	*Astragalus nigrolineatus* Sirj. & Rech.f. *	IT [KK–Afgh.]	Ch	9559, 9357
204	*Astragalus pendulinus* Popov & B.Fedtsch. *	IT [KK]	He	9152
205	*Astragalus pseudobrachystachys* Sirj. & Rech.f. *	IT [C]	He	9760
206	*Astragalus* sp. (Sect. Ammodendron)	IT [?]	Ch	9495
207	*Colutea buhsei* (Boiss.) Shap. *	IT [KK–Alborz]	Ph	9148
208	*Cullen drupacea* (Bunge) C.H.Stirt.	IT [C, E]	He	9093, 9362, 9703, 9730
209	*Hedysarum balchanense* Boriss. **	IT [KK]	He	9154, 9657
210	*Lathyrus inconspicuus* L.	IT–M	Th	9748
211	*Lathyrus sphaericus* Retz.	IT–ES–M	Th	9088, 9150, 9555
212	*Medicago monantha* (C.A.Mey.) Trautv.	IT	Th	9056, 9091, 9361, 9467
213	*Medicago radiata* L.	IT–M	Th	9087, 9553
214	*Medicago rigidula* (L.) All.	IT–M	Th	9360, 9090, 9153, 9562
215	*Onobrychis chorassanica* Boiss.	IT [KK–E]	He	9085, 9550
216	*Onobrychis pulchella* Schrenk	IT [C, E]	Th	9084, 9353, 9464, 9549, 9654
217	*Trigonella turkmena* Popov *	IT [KK]	Th	9092
218	*Vicia anatolica* Turrill	IT	Th	9089, 9702
219	*Vicia cappadocica* Boiss.	IT [W, C]	He	9765
220	*Vicia orientalis* (Boiss.) Bég. & Diratz. (Syn.: *Lens orientalis* (Boiss.) Hand.–Mazz.	IT–M	Th	9554
221	*Vicia peregrina* L.	IT–ES–M	Th	9151, 9356, 9465, 9556, 9557, 9558, 9656, 9701
222	*Vicia sativa* L.	PL	Th	9745, 9764
	Gentianaceae			
223	*Gentiana olivieri* Griseb.	IT	G.r	9195, 9503
	Geraniaceae			
224	*Erodium ciconium* (L.) L'Hér.	IT–M	Th	9194, 9264, 9265
225	*Erodium cicutarium* (L.) L'Hér.	IT–ES–M	Th	9018, 9262, 9408, 9602
226	*Erodium litwinowii* Woronow	IT [E]	Th	9407, 9603
227	*Geranium divaricatum* Ehrh.	IT–ES	Th	9755
228	*Geranium kotschyi* Boiss. *	IT [C]	G.t	9017, 9406
229	*Geranium pusillum* L.	IT–ES–M	Th	9263, 9755
	Hypericaceae			
230	*Hypericum helianthemoides* (Spach) Boiss.	IT [C]	He	9604
231	*Hypericum scabrum* L.	IT [W, C]	He	9192
	Iridaceae			
232	*Gladiolus atroviolaceus* Boiss.	IT–M	G.c	9102, 9162, 9568
233	*Iris kopetdagensis* (Vved.) B.Mathew & Wendelbo	IT [C]	G.t	9100
234	*Iris songarica* Schrenk	IT [C, E]	G.r	9569
235	*Moraea sisyrinchium* (L.) Ker Gawl.	IT–M	G.c	9103, 9163
	Ixioliriaceae			
236	*Ixiolirion tataricum* (Pall.) Schult. & Schult.f.	IT	G.b	9567
	Lamiaceae			
237	*Hymenocrater calycinus* (Boiss.) Benth. *	IT [KK–Alborz]	Ch	9417
238	*Hymenocrater platystegius* Rech.f. **	IT [C]	Ch	9221
239	*Lallemantia royleana* (Benth.) Benth.	IT [C, E]	Th	9026, 9216, 9288
240	*Lamium amplexicaule* L.	PL	Th	9290
241	*Marrubium vulgare* L.	PL	He	9416
242	*Nepeta ucranica* subsp. *kopetdaghensis* (Pojark.) Rech.f. *	IT [KK]	He	9291
243	*Phlomis cancellata* Bunge *	IT [C]	He	9219, 9292, 9415
244	*Phlomoides labiosa* (Bunge) Adylov, Kamelin & Makhm.	IT [KK–E]	He	9217
245	*Salvia abrotanoides* (Kar.) Sytsma (Syn.: *Perovskia abrotanoides* Kar.)	IT [C, E]	Ch	s.n.

(Continued)

Appendix 1. Continued.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
246	*Salvia macrosiphon* Boiss.	IT [C, E]	He	9220
247	*Sideritis montana* L.	IT–ES–M	Th	9609
248	*Teucrium polium* L.	IT–M	Ch	9027, 9218
249	*Ziziphora persica* Bunge	IT	Th	9507, 9610, 9028
250	*Ziziphora tenuior* L.	IT–ES	Th	9289, 9414, 9611
	Liliaceae			
251	*Gagea kunawurensis* (Royle) Greuter	IT [C & E]	G.b	9096, 9164
252	*Tulipa hoogiana* B.Fedtsch.	IT [KK–E]	G.b	9099
	Linaceae			
253	*Linum corymbulosum* Rchb.	PL	Th	9266, 9502, 9601
254	*Linum nodiflorum* L.	IT–M	Th	9398, 9196
	Malvaceae			
255	*Malva parviflora* L.	IT–M	Th	9191, 9270
	Nitrariaceae			
256	*Peganum harmala* L.	IT–M–SS	He	9605
	Orobanchaceae			
257	*Orobanche lavandulacea* Rchb.	IT–M	G.p	9029
258	*Parentucellia latifolia* Caruel (var. *latifolia)*	IT–M	Th	9410, 9208, 9025
	Papaveraceae			
259	*Glaucium elegans* Fisch. & C.A.Mey.	IT [C, E]	Th	9205
260	*Hypecoum pendulum* L.	IT–M	Th	9022
261	*Papaver dodecandrum* (Forssk.) Medik. (Syn.: *Roemeria hybrida* (L.) DC.)	IT–M–SS	Th	9273
262	*Papaver pavoninum* C.A.Mey.	IT [C, E]	Th	9023, 9206
263	*Papaver refractum* (DC.) K.-F.Günther (Syn.: *Roemeria refracta* DC.)	IT	Th	9024, 9207
	Plantaginaceae			
264	*Linaria micrantha* (Cav.) Hoffmanns. & Link	IT–M	Th	9608
265	*Veronica campylopoda* Boiss.	IT	Th	9211, 9287
266	*Veronica polita* Fr.	PL	Th	9209, 9286, 9409, 9506
	Plumbaginaceae			
267	*Cephalorhizum turcomanicum* Popov *	IT [KK]	He	9210, 9269
	Poaceae			
268	*Aegilops crassa* Bioss. *ex* Hohen.	IT	Th	9677
269	*Aegilops tauschii* Coss.	IT	Th	9112, 9185, 9382, 9678
270	*Aegilops triuncialis* L.	IT–M	Th	9671
271	*Agropyron cristatum* (L.) Gaertn.	PL	He	9679
272	*Alopecurus arundinaceus* Poir.	PL	He	9577
273	*Avena barbata* Pott *ex* Link	IT–M–SS	Th	9113, 9386, 9673, 9715
274	*Avena eriantha* Durieu	IT–M	Th	9743
275	*Avena sterilis* subsp. *ludoviciana* (Durieu) Gillet & Magne	IT–ES–M	Th	9114, 9173, 9387, 9672, 9713
276	*Bromus danthoniae* Trin.	PL	Th	9106, 9171, 9378, 9488, 9583, 9676
277	*Bromus lanceolatus* Roth	IT–M	Th	9742, 9751, 9762
278	*Bromus oxyodon* Schrenk	IT [C, E]	Th	9107, 9108, 9170, 9380, 9381, 9490, 9491, 9578
279	*Bromus pseudodanthoniae* Drobow	IT [C, E]	Th	9480, 9581
280	*Bromus scoparius* L.	IT–M	Th	9752
281	*Bromus sterilis* L.	IT–ES–M	Th	9479
282	*Bromus tectorum* L.	PL	Th	9121, 9376, 9376, 9377, 9489, 9576
283	*Cynodon dactylon* (L.) Pers.	PL	He	9670
284	*Elymus hispidus* (Opiz) Melderis	IT–ES–M	He	9390
285	*Eremopyrum bonaepartis* (Spreng.) Nevski	IT	Th	9111, 9487, 9714
286	*Heteranthelium piliferum* (Sol.) Hochst. *ex* Jaub. & Spach	IT	Th	9754
287	*Hordeum bulbosum* L.	IT–M	G.b	9174, 9393
288	*Hordeum murinum* L.	IT–M	Th	9119, 9120, 9186, 9392, 9494, 9582
289	*Hordeum spontaneum* K.Koch	IT–M	Th	9118, 9394, 9493, 9580, 9711
290	*Loliolum subulatum* (Banks & Sol.) Eig	IT	Th	9175, 9486, 9674, 9675
291	*Lolium multiflorum* Lam.	PL	Th	9124
292	*Lolium rigidum* Gaudin	IT–M	Th	9125, 9396, 9492, 9587, 9680, 9716
293	*Phalaris minor* Retz.	COS	Th	9172, 9667
294	*Phleum paniculatum* Huds.	IT–ES–M	Th	9717

(Continued)

Appendix 1. Continued.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
295	*Phragmites australis* (Cav.) Trin. ex Steud.	SCO	He	9576
296	*Piptatherum holciforme* (M.Bieb.) Roem. & Schult.	IT–M	He	9379, 9478, 9109
297	*Poa bulbosa* L.	IT–ES–M	He	9117, 9178, 9179, 9183, 9395, 9482, 9585
298	*Poa sinaica* Steud.	IT–SS	He	9180, 9572
299	*Psilurus incurvus* (Gouan) Schinz & Thell.	IT–M	Th	9389, 9753
300	*Rostraria cristata* (L.) Tzvelev	PL	Th	9123, 9184, 9383, 9384, 9110, 9385
301	*Schismus arabicus* Nees	PL	Th	9481
302	*Stipa arabica* Trin. & Rupr.	IT	He	9105, 9574, 9575, 9669, 9709
303	*Stipa hohenackeriana* Trin. & Rupr.	IT	He	9741
304	*Stipa holosericea* Trin.	IT Cauc.–Turk.	He	9104, 9176, 9177, 9375, 9477, 9573, 9668
305	*Taeniatherum caput-medusae* (L.) Nevski	IT–ES–M	Th	9181, 9391, 9579, 9712
306	*Vulpia ciliata* Dumort.	IT–M	Th	9115
307	*Vulpia myuros* (L.) C.C.Gmel.	IT–M	Th	9485
308	*Vulpia persica* (Boiss. & Buhse) Krecz. & Bobrov	IT	Th	9483, 9484, 9584, 9586, 9122, 9182, 9388
	Polygonaceae			
309	*Atraphaxis* sp.	IT ?	Ph	9187
310	*Atraphaxis spinosa* L.	IT	Ph	9718
	Primulaceae			
311	*Androsace maxima* L.	IT–ES–M	Th	9015
312	*Lysimachia arvensis* (L.) U.Manns & Anderb. (Syn.: *Anagallis arvensis* L.)	PL	Th	9401, 9400, 9734
	Ranunculaceae			
313	*Adonis aestivalis* L.	IT–ES–M	Th	9007, 9203
314	*Delphinium semibarbatum* Bien. *ex* Boiss.	IT KK–E	He	9006, 9279, 9403, 9499, 9593
315	*Delphinium stocksianum* Boiss. (Syn.: *Consolida stocksiana* (Boiss.) Nevski)	IT C, E	Th	9278, 9500
316	*Eranthis longistipitata* Regel	IT KK–E	G.t	9005
317	*Nigella integrifolia* Regel	IT C, E	Th	9202, 9405, 9594
318	*Ranunculus cicutarius* Schltdl.	IT Cauc.–Turk.	G.t	9498
319	*Ranunculus falcatus* L. (Syn.: *Ceratocephala falcata* (L.) Pers.)	IT–ES–M	Th	9008
320	*Ranunculus sewerzowii* Regel	IT C, E	G.t	9004
321	*Ranunculus testiculatus* Crantz (Syn.: *Ceratocephala testiculata* (Crantz) Besser)	IT–ES–M	Th	9204, 9404
322	*Thalictrum isopyroides* C.A.Mey.	IT	G.r	9280
323	*Thalictrum sultanabadense* Stapf	IT	He	9281
	Resedaceae			
324	*Reseda lutea* L.	IT–ES–M	He	9606
	Rosaceae			
325	*Prunus microcarpa* C.A.Mey.	IT W, C	Ph	9212, 9285, 9413
326	*Prunus turcomanica* (Lincz.) Kitam. *	IT KK	Ph	9411
327	*Rosa persica* Michx. *ex* Juss.	IT C, E	Ch	9214, 9284
328	*Sanguisorba minor* Scop.	IT–ES–M	He	9412, 9213
	Rubiaceae			
329	*Asperula glomerata* subsp. *turcomanica* (Pobed.) Ehrend. & Schönb.-Tem. *	IT KK–Afgh.	Ch	9159
330	*Callipeltis cucullaris* (L.) DC.	IT–M	Th	9371
331	*Crucianella gilanica* Trin. subsp. *transcaspica* (Ehrend.) Ehrend. & Schönb.-Tem.	IT	He	9158
332	*Galium ceratopodum* Boiss.	IT–SS	Th	9095, 9157, 9367, 9661
333	*Galium ghilanicum* Stapf	IT	Th	9705, 9364
334	*Galium humifusum* M.Bieb.	IT–M	He	9094, 9156
335	*Galium setaceum* Lam.	IT–M	Th	9365, 9563, 9564, 9659, 9706
336	*Galium spurium* L.	IT–ES–M	Th	9368, 9369, 9473, 9474, 9566
337	*Galium tenuissimum* M.Bieb.	IT–ES	Th	9658
338	*Galium tricornutum* Dandy	IT–ES–SS	Th	9155, 9366, 9472, 9565, 9660
339	*Galium verticillatum* Danthoine *ex* Lam.	IT–M	Th	9363, 9475
340	*Galium verum* L.	PL	G.r	9370, 9704

(Continued)

Appendix 1. Continued.

	Species/Families	Chorotype	Life form	voucher numbers (FUMH)
341	*Rubia florida* Boiss. *	IT [C]	Ch	9160
	Rutaceae			
342	*Haplophyllum acutifolium* (DC.) G.Don	IT [C, E]	He	9198, 9684
343	*Haplophyllum pedicellatum* Bunge *ex* Boiss. (Syn.: *Haplophyllum pilosum* Franch.)	IT [C, E]	He	9014, 9268
	Solanaceae			
344	*Hyoscyamus turcomanicus* Pojark.	IT [KK–E]	He	9019
345	*Lycium depressum* Stocks	IT	Ph	9283
	Tamaricaceae			
346	*Tamarix meyeri* Boiss.	IT–ES–M	Ph	9215
	Thymelaeaceae			
347	*Diarthron vesiculosum* (Fisch. & C.A.Mey.) C.A.Mey.	IT	Th	s.n.
	Zygophyllaceae			
348	*Zygophyllum atriplicoides* Fisch. & C.A.Mey.	IT [C, E]	Ph	9020