Flora and vegetation of Golestanak (Alborz Mts), Iran

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Abstract. This study deals with the floristic and vegetation investigations of Golestanak Protected Area, an ecotone with nearly 1800 ha area located between the timberline and subalpine-alpine zone in the central part of the Alborz Mountain Range (Mazandaran Province). A total of 172 taxa, belonging to 39 families and 126 genera were identified, including 138 dicotyledones (99 genera) and 32 monocotyledones (25 genera). Based on a system of sixty sample plots taken randomly along five transects and using Sørensen's distance measure (Index BC=Bray and Curtis) and Ward's group linkage methods in a cluster analysis, nine plant communities were identified.

Key words: Alborz, cluster analysis, Golestanak, Iran, plant community, vegetation

Introduction

Iran is a mountainous country and four-fifths of its surface lies at altitudes above 1000 m (Zohary 1973). It is situated among three main phytochoria, including the Euro-Siberian (Boreal), Irano-Turanian and Saharo-Sindian, or Saharo-Arabian, and is influenced by the introgression of Somalian-Masaei and Mediterranean species (Jafari & Akhani 2008). The Euro-Siberian region extends to the northern parts of Iran via the Caucasian-Euxino-Hyrcanian Province. The Hyrcanian district includes the South Caspian coastal plain and the northern slopes of the Alborz Mts, up to altitudes of 2500 m (Frey & Probst 1986). The northern slopes of these ridges are dominated by a humid-temperate to warm-temperate climate (at lower altitudes); the southern slopes have a dry steppe climate. The Alborz Mts with the volcanic summit of Damavand (5670 m) stretch over an area 650 km long and 150–500 km wide.

Many studies of the flora and vegetation ecology of the Alborz Mts have been carried out in this area (e.g. Kotschy 1861; Gilli 1939; Klein 1984, 2001; Nazarian & al. 2004; Naqinezhad & al. 2009, 2010; Noroozi & al. 2010). Klein (1982) described the chionophilous vegetation units of the central Alborz Mts. Five phytosociological units have been distinguished: *Oxytropidetea persicae*, *Trachydietalia depressae*, *Catabroselletalia parviflora*, *Jurinelletum frigidae*, and *Erigeronetum elbursensis* (Klein 1982). Noroozi & al. (2008) described a number of plant communities and habitats in this area: the *Prangos uloptera* and *Onobrychis cornuta* communities, rocky habitats of subalpine-alpine areas, high alpine xerophytic areas, alpine meadow communities, and scree habitats. The three main vegetation types (based on Frey & Prob-

st 1986) which can be distinguished in the study area are forb vegetation, grasslands with thorn-cushions and plant formations of the alpine zone. Lack of any floristic or vegetation information regarding the Golestanak Protected Area explains the selection of that area for this study.

Study area

Situation and delimitation

The Golestanak Protected Area is located in the central part of the Alborz Mountain Range (Mazandaran Province), between 36°14'–36°16' N and 51°24'–51°26' E. The area covers 1800 hectares, including the northern and southern slopes of the Shamjar Small Mountain. It is a transitional zone between the timberline and the subalpine-alpine zone, between 3000 and 4000 m a.s.l., with the highest and lowest points ranging from 2300 m to 3935 m a.s.l. Notably the timberline lies lower, between 2300 m and 2600 m a.s.l. (Fig. 1).

Climate and vegetation

In most parts of the Alborz Mts precipitation is directly connected to altitude. However, over the northern slopes of the Alborz Mts the influence of the moist Hyrcanian climate weakens above the timberline, where precipitation decreases at higher altitudes. The summer is arid, hot and sunny, with intensive sun radiation most of the time. As any meteorological data were lacking from the area under study, the climatic parameters were estimated from data provided by the nearest meteorological station to it (Siahbisheh Station, 20 km away from the study area, at 1855 m a.s.l.). The annual mean temperature is 10.5 °C, with an annual average maximum of 14.8 °C and minimum of 6.3 °C. The lowest temperature reported is minus 14.6 °C in January (2001) and the highest temperature recorded is 34 °C in August (2000).

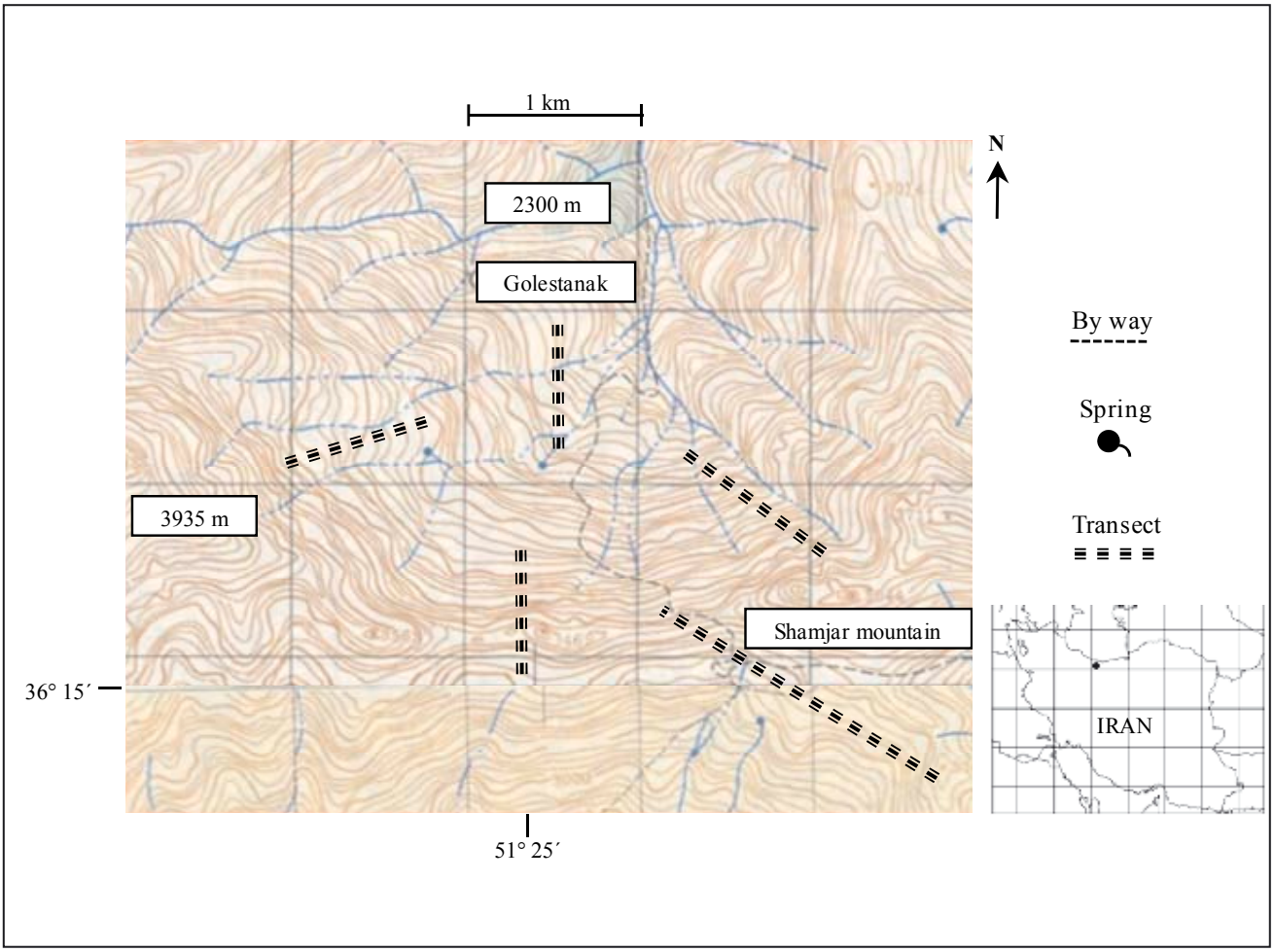

Fig. 1. The topographic map of the study area.

Material and methods

Flora

Floristic explorations and collections were made during the period 2006–2008. Specimens were collected according to the traditional taxonomic methods. The specimens are stored at the Herbarium of the University of Isfahan (HUI), Biology Department. Delimitations and distributional data were mainly based on *Flora Iranica* (Rechinger 1963–2005) and *Flora of Iran* (Assadi & al. 1988–2003), and on other related references, depending on the studied taxa (Davis 1965–1985; Tutin & al. 1964–1980; Townsend & al. 1966–1985). Life form definitions were based on Raunkiaer's classification (Raunkiaer 1934). The specimens are presented in the Appendix.

Vegetation

Systematic random sampling was used for vegetation description. Sixty sample plots (S_1–S_{60}) were set in five transects, with every point having an equal chance of being chosen in each transect (Table 1). Selection of the sampling design was discussed by many authors (e.g. Kenkel & al. 1989; Legendre & Fortin 1989; Fortin & al. 1989; Legendre & al. 2002; Dungan & al. 2002; Hirzel & Guisan 2002). Whereas the study area showed rapid changes in vegetation and floristic composition, transects were set up along the altitude gradients, starting from lower altitudes towards the summit of Mt Shamjar (2300–3935 m a.s.l.). Sample plot size is very important and varies from one type of vegetation to another (Kent & Coker 1992). Hence, on the basis of the concept of minimal area and species-area curves (Cain & Castro 1959), three different sample plot sizes were used; 10×6 m (northern slopes), 9×4 m (southern, eastern and western slopes) and 2.5×2.5 m (around springs and rivulets). The sample plots were located and mapped using GPS equipment to ensure a high degree of accuracy. The percentage of foliar cover for each vascular plant species was estimated on the Braun-Blanquet scale (Braun-Blanquet 1964). Cluster analysis (CA) performed with PC-ORD (V. 4.17) software (McCune & Mefford 1999) was applied to assess the plant communities. Some researchers have used PC-ORD software for the investigation of vegetation (Sperduto & Cogbill 1999; Willoughby 2001; Kimball & al. 2004; Dulamsuren & al. 2005; Oswalt & al. 2006). A species matrix including species cover data was constructed (1: <1 %, 2: 1–5 %, 3: 6–25 %, 4: 26–50 %, 5: 51–75 % and 6: 76–100 %). To determine the relationship between sample plots, clustering was applied using Sørensen's distance measure (Index *BC*=Bray and Curtis; Mueller-Dombois & Ellenberg 1974) and Ward's group linkage method (Ward 1963). Initially, the distances between all pairwise combinations of sample plots were summarized to a Q×Q distance, or *D* matrix. Next, the hierarchical grouping method of Ward was operated on this *D* matrix.

Table 1. Characteristics of study sample plots in the Golestanak Protected Area. 60 sample plots at 5 transects: Transect 1: 18 sample plots, 3.3 km long, 237 m amplitude altitude; Transect 2: 7 sample plots, 470 m long, 198 m amplitude altitude; Transect 3: 8 sample plots, 550 m long, 242 m amplitude altitude; Transect 4: 8 sample plots, 740 m long, 310 m amplitude altitude; Transect 5: 18 sample plots, 2 km long, 631 m amplitude altitude; Three different sizes of sample plot were used; 10×6 m (northern slopes), 9×4 m (southern, eastern and western slopes) and 2×2 m (around stream and rivulet). Abbreviations: Q: sample plot; T: transect.

Q&T	Altitude (m)	Aspect	Latitude (N)	Longitude (E)
$Q_{12}T_1$	3163	S	36°14'09.52"	51°14'42.28"
$Q_{08}T_1$	3220	S	36°14'15.40"	51°26'33.20"
$Q_{01}T_1$	3237	E	36°14'18.25"	51°26'34.50"
$Q_{02}T_1$	3263	E	36°14'19.60"	51°26'31.85"
$Q_{09}T_1$	3287	S	36°14'21.35"	51°26'35.00"
$Q_{03}T_1$	3314	E	36°14'26.05"	51°26'28.75"
$Q_{11}T_1$	3341	S	36°14'28.95"	51°26'26.00"
$Q_{10}T_1$	3300	S	36°14'28.25"	51°26'27.25"
$Q_{19}T_1$	3341	W	36°14'30.00"	51°26'26.50"
$Q_{20}T_1$	3349	W	36°14'33.01"	51°26'25.76"
$Q_{21}T_1$	3342	W	36°14'33.35"	51°26'25.90"
$Q_{22}T_1$	3328	W	36°14'37.35"	51°26'26.01"
$Q_{23}T_1$	3346	W	36°14'47.45"	51°26'12.35"
$Q_{24}T_1$	3356	S	36°14'48.65"	51°26'10.85"
$Q_{25}T_1$	3375	S	36°14'49.01"	51°26'09.55"
$Q_{26}T_1$	3380	S	36°14'49.50"	51°26'07.50"
$Q_{27}T_1$	3385	S	36°14'54.00"	51°26'05.50"
$Q_{28}T_1$	3398	S	36°14'31.06"	51°25'33.00"
$Q_{29}T_1$	3400	S	36°14'18.25"	51°25'29.60"
$Q_{30}T_2$	3422	S	36°15'08.48"	51°25'28.07"
$Q_{31}T_2$	3386	N	36°15'08.50"	51°25'26.03"
$Q_{32}T_2$	3340	N	36°15'10.04"	51°25'25.65"
$Q_{33}T_2$	3286	N	36°15'10.70"	51°25'22.01"
$Q_{34}T_2$	3246	N	36°15'11.95"	51°25'16.05"
$Q_{35}T_2$	3236	N	36°15'12.50"	51°25'13.00"
$Q_{36}T_2$	3224	N	36°15'13.55"	51°25'14.60"

Table 1. Continuation.

Q&T	Altitude (m)	Aspect	Latitude (N)	Longitude (E)
$Q_{04}T_3$	3012	N	36°15'33.80"	51°24'56.58"
$Q_{15}T_3$	2888	N	36°15'43.28"	51°24'58.61"
$Q_{13}T_3$	2870	N	36°15'54.78"	51°24'50.50"
$Q_{07}T_3$	2830	N	36°15'52.08"	51°24'56.58"
$Q_{14}T_3$	2874	N	36°16'07.44"	51°25'02.00"
$Q_{18}T_3$	2830	N	36°16'13.74"	51°25'52.52"
$Q_{17}T_3$	2812	N	36°16'10.35"	51°25'02.00"
$Q_{16}T_3$	2770	N	36°16'09.32"	51°25'12.00"
$Q_{37}T_4$	2932	W	36°14'33.20"	51°24'48.18"
$Q_{38}T_4$	2996	W	36°14'38.09"	51°24'43.22"
$Q_{39}T_4$	3035	W	36°14'41.70"	51°24'45.34"
$Q_{40}T_4$	3049	W	36°14'43.21"	51°24'46.12"
$Q_{41}T_4$	3074	W	36°14'45.37"	51°24'45.12"
$Q_{42}T_4$	3152	S	36°14'50.83"	51°24'40.24"
$Q_{43}T_4$	3198	S	36°14'53.82"	51°24'48.43"
$Q_{44}T_4$	3224	S	36°14'57.81"	51°24'48.19"
$Q_{45}T_5$	3385	S	36°15'05.77"	51°24'48.18"
$Q_{46}T_5$	3279	N	36°15'12.09"	51°24'47.00"
$Q_{47}T_5$	3190	N	36°15'18.40"	51°24'45.34"
$Q_{48}T_5$	3161	N	36°15'24.42"	51°24'47.80"
$Q_{49}T_5$	3083	N	36°15'33.74"	51°24'43.64"
$Q_{50}T_5$	2997	N	36°15'43.97"	51°24'39.25"
$Q_{51}T_5$	2953	N	36°15'51.19"	51°24'36.67"
$Q_{52}T_5$	2910	N	36°15'51.19"	51°24'40.32"
$Q_{53}T_5$	2893	N	36°16'04.13"	51°24'44.18"
$Q_{54}T_5$	2824	N	36°16'09.83"	51°24'42.76"
$Q_{56}T_5$	2754	N	36°16'11.82"	51°24'39.36"
$Q_{05}T_5$	2734	N	36°16'13.56"	51°24'44.28"
$Q_{06}T_5$	2712	N	36°16'15.22"	51°24'48.42"
$Q_{56}T_5$	2680	N	36°16'17.13"	51°24'41.04"
$Q_{57}T_5$	2660	N	36°16'18.69"	51°24'40.83"
$Q_{58}T_5$	2655	N	36°16'22.33"	51°24'42.31"
$Q_{59}T_5$	2630	N	36°16'24.53"	51°24'45.05"
$Q_{60}T_5$	2628	N	36°16'26.14"	51°24'47.55"

Results

Flora

One hundred and 72 plant taxa, belonging to 39 families and 126 genera were identified in the area. The floristic list is presented in the Appendix. One hundred and 38 taxa were dicotyledones (99 genera) and 32 taxa were monocotyledons (25 genera). The largest families were *Asteraceae* (28 taxa), *Poaceae* (20 taxa) and *Lamiaceae* (16 taxa). The largest genera were *Astragalus* with seven and *Tanacetum* with four species. Eight genera could not be determined to a species level, owing to the inadequate plant material for identification. Categorization according to the phytogeographic region was as follows: Irano-Turanian – 105 taxa (63.65 %), Euro-Siberian-Irano-Turanian – 23 taxa (14 %), Euro-Siberian – 11 taxa (6.7 %), Euro-Siberian-Irano-Turanian-Mediterranean – 7 taxa (4.25 %), Irano-Turanian-Mediterranean – 6 taxa (3.7 %), Pluriregional – 6 taxa (3.7 %), Euro-Siberian-Mediterranean – 3 taxa (2 %), and Cosmopolitan – 3 taxa (2 %). Hemicryptophytes were the commonest in the study area, followed by chamaephytes, geophytes, therophytes, and phanerophytes. Three new species were reported for the flora of Iran in our earlier paper (Naderi & al. 2009): *Achillea millefolium* L. subsp. *sudetica* (Opiz) Weiss in Koch (*Asteraceae*), *Cardaria draba* (L.) Desv. subsp. *draba* (*Brassicaceae*) and *Scorzonera kirpicznikovii* Lipsch. (*Asteraceae*).

Vegetation

Species frequency and foliar cover

Of the 172 identified taxa, 131 species were recorded in the sample plots; i.e. 41 species (23.83 %) were not presented in any of the 60 sample plots. Some of these remarkable species are: *Iranecio elbursensis, Huynhia pulchra, Centaurea iberica, Crepis multicaulis*, *Phleum iranicum*, *Ferula ovina*, *Pimpinella tragium*, *Verbascum cheiranthifolium*, *Linaria genistifolia*, *Orbanche pulchra,* and *Rosa canina.* The species *Alopecurus textilis* and *Tragopogon kotschyi* were the most common sample species occurring in 33 sample plots, followed by *Bromus tomentellus* (32), *Plantago atrata* and *Onobrychis cornuta* (29), *Tanacetum polycephalum* (28), and *Ranunculus amblyolobus* (23). The maximum foliar cover was exhibited by *Onobrychis cornuta*, followed by *Plantago atrara*, *Alopecurus textilis*, *Bromus tomentellus*, *Tanacetum polycephalum*, *Tragopogon kotschyi,* and *Asyneuma amplexicaule*.

Community determination

Clustering analysis of sixty sample plots is summarized in a dendrogram (Fig. 2). The process of delimiting communities (or groups) from the information provided by the clustering analysis is usually subjec-

tive (Ludwig & Reynolds 1988). A community coefficient (CC) of 100 represents an identity, while a CC of 0 represents complete difference. The sample plots of one community are often expected to share a CC above 50 (Barbour & al. 1987). A vertical dashed line across the dendrogram at a threshold value of 60 percent created 11 vegetation groups. Nine plant communities were identified, distinctive from each other with their ecological and floristic features (Fig. 2).

Group I: includes sample plots 1, 30, 45 and 46 (Fig. 2; e.g. S_1). This group comprises two communities: *Grammosciadium platycarpum* and *Plantago atrata*.

1 – *Grammosciadium platycarpum* communities: they are situated between 3200 m to 3260 m a.s.l., on the slopes of an east-southeastern region with shallow-sandstone soils. The accompanying species include *Nepeta racemosa*, *Hieracium procerum*, *Tragopogon kotschyi*, *Astragalus magistratus*, *Alopecurus textilis*, *Geranium tuberosum,* and *Ranunculus amblyolobus.*

2 – *Plantago atrata* communities: they overlap with many other communities and usually occur at low slopes. High moisture is one of the major characteristics for the establishment of these communities. They appear when the snow cover begins to melt, close to the end of April. The accompanying species include *Astragalus magistratus*, *Ranunculus amblyolobus*, *Cirsium* sp., *Arabis caucasica,* and *Anchonium elichrysifolium*.

Group II: constitutes only of *Helichrysum* spp. communities (*H. oligocephalum* and *H. plicatum*), which lie between 3300 m to 3350 m a.s.l. on the steep slopes of an east-southeastern region with shallow-sandstone soils. Their characteristic species is *Hypericum scabrum*. The accompanying species include *Arenaria gypsophiloides*, *Tanacetum polycephalum*, *Nepeta racemosa*, *Silene* sp., *Phlomis anisodonta*, *Thymus kotschyanus*, *Ziziphora clinopodioides*, *Bromus tomentellus*, *Poa bulbosa*, *plantago atrata,* and *Ranunculus amblyolobus*.

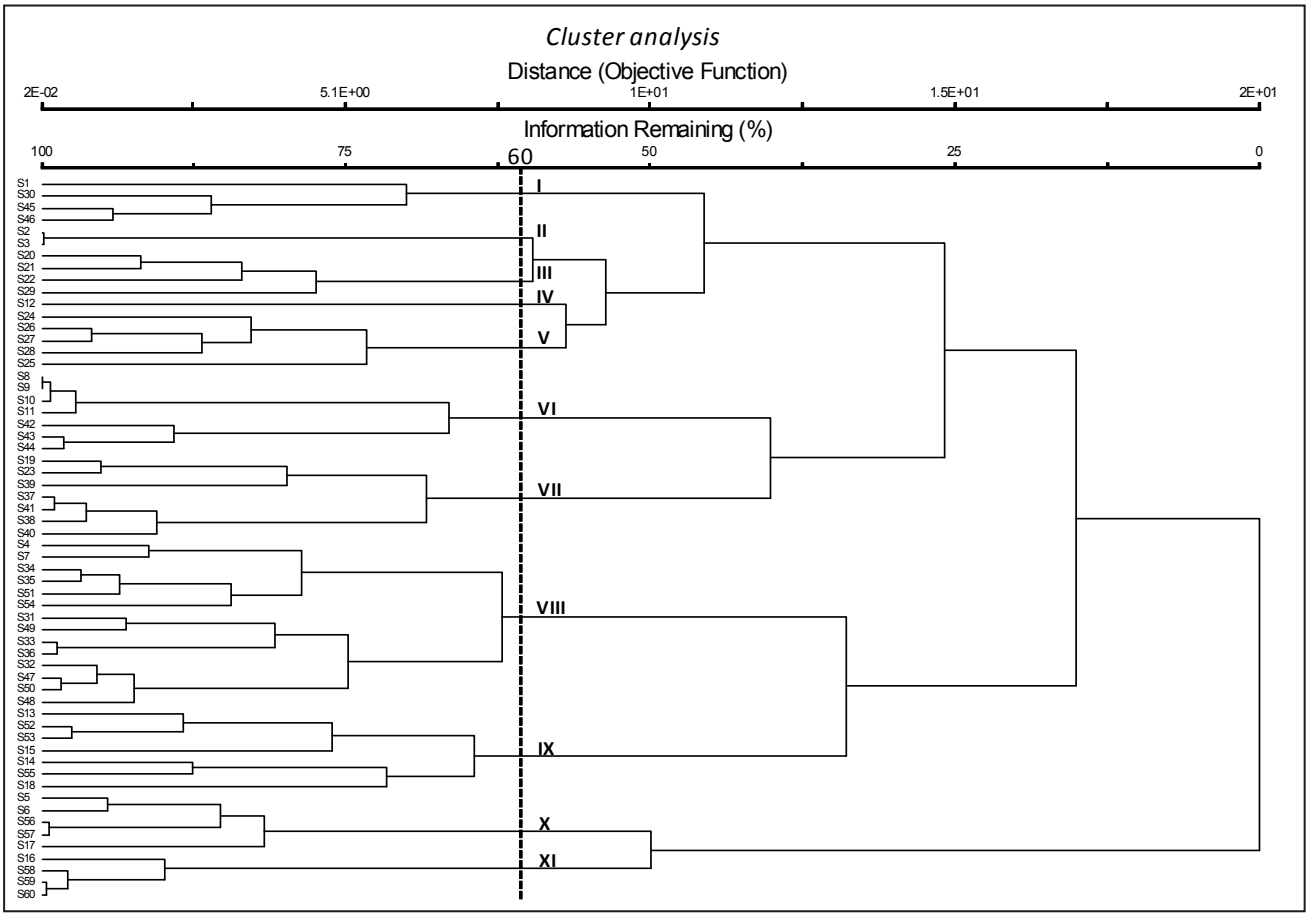

Fig. 2. The dendrogram resulted from a cluster analysis of sixty quadrats using Sørensen distance measure and Ward's method. A vertical dashed line represents reference point for delimiting 11 ecological groups.

Group III: includes sample plots 20, 21, 22, and 29. It comprises two communities: *Bromus tomentellus* and *Cirsium* sp.

1 – *Bromus tomentellus* communities: whereas the *Bromus tomentellus* species is represented in half of the sample plots, like *Alopecurus textilis*, *Tragopogon kotschyi* and *Plantago atrata*, therefore, their community border is not easily recognizable. The accompanying species include *Tanacetum polycephalum*, *Tragopogon kotschyi*, *Taraxacum serotinum*, *Silene* sp., *Clastopus erubescens*, *Marrubium astracanicum*, *Nepeta racemosa*, *Ziziphora clinopodioides*, *Alopecurus textiles,* and *Plantago atrata*.

2 – *Cirsium* sp. communities: these communities are often dominant on the western slopes with shallow-sandstone soils, particularly near byways. They include the following accompanying species: *Tanacetum polycephalum*, *Tragopogon kotschyi*, *Minuartia recurva*, *M. lineata*, *Clastopus erubescens*, *Astragalus magistratus*, *Scutellaria pinnatifida*, *Thymus pubescens,* and *Plantago atrata*.

Group IV: comprises only one sample plot related to the first sample plot in the first transect. The species-composition of this sample plot was very different from the others. It was set near an asphalt road without any specific community.

Group V: includes sample plots 24, 25, 26, 27 and 28 related to Transect 1 (southern slopes, altitude 3350–3400 m). The most important characteristic of these sample plots is their presence in a semi-wet environment. *Rumex elbursensis* and *Onobrychis cornuta* are two recognizable communities of this group.

1 – *Rumex elbursensis* communities: these communities occurred along the melt-water streams in avalanche tracks and erosional channels, and next to the major river in the Alborz Mts. They are covered with such species as *Cousinia crispa*, *Tanacetum polycephalum*, *Onobrychis cornuta*, *Dianthus orientalis*, *Astragalus citrinus*, *Dactylis glomerata*, *Bromus tomentellus,* and *Cirsium* sp.

2 – *Onobrychis cornuta* communities: large parts of the south slopes were covered with these communities. Their outlook is determined by the following accompanying species: *Achillea millefolium*, *Cousinia crispa*, *Seratula latifolia*, *Tanacetum polycephalum*, *Silene* sp., *Phlomis anisodonta*, *Leonurus cardiaca*, *Marrubium astracanicum*, *Stachys lavanulifolia*, *Ziziphora clinopodioides*, *Alopecurus textilis*, *Bromus tomentellus*, *Plantago atrata,* and *Nepeta racemosa*.

Group VI: comprises sample plots 8, 9, 10, 11, 42, 43, and 44. They were in the windswept areas of the study area (3300–3600 m) occupied by *Astragalus* spp.-*Onobrychis cornuta* communities. These communities are composed of thorn-cushion and graminoid species. They form a distinct unit above the timberline in the subalpine zone, also on the northern slopes of the Alborz Mts. *Astragalus magistratus* and *A. capax* are dominant species in these communities. On the basis of the systematic random sampling the distribution of *Linaria genistifolia* and *Camphorosma monspeliaca* are restricted to this unit. Other species common for this vegetation type are *Seratula latifolia*, *Tanacetum polycephalum*, *Draba nemorosa*, *Clastopus erubescens*, *Thymus kotchyanus*, *T. pubescens*, *Stachys lavandulifolia*, *Alopecurus textilis*, *Bromus tomentellus*, *Poa bulbosa*, *Acantholimon demavendicum,* and *A. hohenackeri*.

Group VII: comprises sample plots 19, 23, 37, 39, 38, 40, and 41, which are restricted to the high slopes of the west regions with shallow-dry soils. This group was formed by *Acantholimon* spp.-*Alopecurus textilis* communities, which are dominated by thorn-cushions (*Acantholimon demavendicum* and *A. hohenackeri*) and graminoid species (*Alopecurus textilis*). The species richness and plant cover of these communities is very low. The accompanying species were as follows: *Tanacetum polycephalum*, *Clastopus erubescens*, *Minuartia recurva*, *Astragalus magistratus*, *Onobrychis cornuta* and *Poa bulbosa*.

Group VIII: consists of sample plots 31, 32, 33, 34, 35, 36, 4, 7, 47, 48, 49, 50, 51, and 54. The sample plots are referred to the northern slopes with high soil moisture. *Onobrychis cornuta* communities were distinguished. Nonetheless, owing to the presence of sample plots on the northern slopes and an easy access to nutrient sources, the floristic composition of this group differed from the *Onobrychis cornuta* communities of Group V. The species richness was very high; e.g. sample plots 7, 4, 35 and 31, with the minimal area of 10×6 m^2, contained 29, 24, 19 and 18 species, respectively. Dominant species with high cover-abundance were as follows: *Bromus tomentellus*, *Alopecurus textilis*, *Ranunculus amblyolobus*, *Asyneuma amplexicaule*, *Plantago atrata*, *Cousinia crispa*, *Silene* sp., *Betonica nivea*, *Thymus pubescens*, *Anthriscus nemorosa*, and *Minuartia lineata*.

Group IX: the soil moisture in this group was higher than in Group VIII, because these sample plots were located near rivulets. The sample plots overlapped with the *Onobrychis cornuta* community (Group VIII). However, density of the thorn-cushion formation was very low. The existence of springs and of some environment protection constructions has disturbed vegetation in these sample plots. Therefore, no community was recognized. The dominant species were: *Achillea millefolium*, *Stachys byzantina*, *Tanacetum coccineum* and *Campanula glomerata*. Other species include *Centaurea zuvandica*, *Asyneuma amplexicaule*, *Sempervivum iranicum*, *Phlomis anisodonta*, *Nepeta racemosa*, *Polygala anatolica*, and *Pedicularis sibthorpii*.

Group X & XI: the sample plots of these groups are referred to the spring spots and rivulet tracks with the minimal area of 2.5×2.5 m. According to the dendrogram following from the cluster analysis (see Fig. 2), the community coefficient of these groups was zero, as compared to the other groups. Because of the multiple-layer vegetations, the total cover values of these groups exceeded 100 per cent. No community was recognized in these groups too. Dominant species of the upper stratifications were: *Ligularia persica*, *Heracleum rechingeri* and *Alchemilla persica*. The lower stratifications of these groups are formed by *Carex orbicularis*, *Eleocharis quinqueflora*, *Gentiana septemfida*, *Swertia aucheri*, *Mentha longifolia*, *Dactylorhiza umbrosa*, *Primula macrocalyx*, *P. auriculata,* and *Veronica anagallis-aquatica*.

Discussion

Flora

The results of floristic study have shown that the area is located in the transitional zone between the Irano-Turanian and Euro-Siberian region. Six hundred and 82 species, belonging to 193 genera and 39 families, are known from the alpine zone of Iran (Noroozi & al. 2008). Approximately 58 % of the alpine and nival species are endemic and sub-endemic for Iran (394 taxa). Ca. 32 % of the alpine endemic species are restricted to the Alborz Mts. In our study, 19 % of the species (34 taxa) of Golestanak are endemic to *Flora Iranica* and most of them are restricted to the Alborz Mts. Some of the endemic taxa to the Alborz Mts occur in Golestanak, including *Achillea millefolium* subsp. *elbursensis*, *Crepis heterotricha* subsp. *lobata*, *Iranecio elbursensis*, *Leontodon hispidus* var. *mazanderanicus*, *Ligularia persica*, *Tanacetum hololeucum*, *Asyneuma mazanderanicum,* and *Betonica nivea* subsp. *mazandarana*. These results show that Golestanak is rich in endemic taxa in comparison with the endemic species of the Alborz Mts and some study regions in the neighboring countries (e.g. Ocakverdi 2001; Akçiçek 2003; Palabaş & Anşin 2006).

Vegetation

The cluster analysis of the 60 sample plots has identified nine plant communities that differed in species-composition and abundance. Kent & Coker (1992) stressed that although the numerical classification process can be described as objective, the interpretation and the problem of how to choose the final groups still remains subjective and relies on the ecological knowledge and experience of the user. On the other hand, the transitional areas of the Alborz Mts cannot be examined with the technique of Braun-Blanquet. Hence, plant communities of Golestanak Protected Area are presented by the cluster analysis without using the hierarchical classification units of the Braun-Blanquet system (e.g. class -etea, order -etalia, alliance -ion and association -etum). The presence of two distinct communities of *Onobrychis cornuta* with different species-compositions in the Groups V and VIII can be described as follows: *Onobrychis cornuta* is a species compatible with the environmental factors, which occurred almost in half of the sample plots, therefore, this species repeated itself with great regularity over the study area (see Clements 1916, 1928), but the accompanying species of the *Onobrychis cornuta* communities respond individually to variations in environmental factors and also every species has its own tolerance range for the study area (see Gleason 1917, 1926, 1939). All accompanying species are distributed as a continuum, but classification of the cluster analysis based on the species-composition of each sample plot has divided this continuum into distinguishable partitions (Group V on southern slopes and Group VIII on northern slopes).

Conclusions

The statistical tools used in the study were cluster analysis and its subparts, namely Ward's linkage method and Sørensen's similarity coefficient (Index BC=Bray and Curtis). These tools seem to provide a meticulous

method for determining plant communities. However, a further painstaking investigation will reveal some yet hidden facts needed for determination of the ecological group's boundaries, especially within the transitional zones of the Alborz Mts.

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Appendix

Floristic list

The following abbreviations are used: He = Hemicrytophyte; Ch = Chamaephyte; Th = Therophyte; Ge = Geophyte; Ph = Phanarophyte; ES = Euro-Siberian element; IT = Irano-Turanian element; M = Mediterranean element; Cosm = Cosmopolitan; PL = Pluriregional; End = Endemic.

***Apiaceae* (*Umbelliferae*):** *Anthriscus nemorosa* (M. Bieb.) Spreng., He, Es-IT. *Cervaria cervariifolia* (C.A.Mey.) Pimenov, He, ES. *Diplotaenia cachrydifolia* Boiss., He, IT. *Ferula ovina* (Boiss.) Boiss., Ch, IT. *Grammosciadium platycarpum* Boiss. & Hausskn., He, IT. *Heracleum rechingeri* Manden., He, IT [End.]. *Pimpinella tragium* Vill. subsp. *polyclada* (Boiss. & Heldr.) Tutin, He, IT. *Trinia leiogona* (C.A.Mey.) B. Fedtsch., He, IT. ***Asteraceae* (*Compositae*):** *Achillea millefolium* L. subsp. *elbursensis* Hub.-Mor., He, IT [End.]. *A. millefolium* L. subsp. *millefolium*, He, ES-IT. *A. millefolium* L. subsp. *sudetica* (Opiz) Weiss in Koch, He, IT [End.]. *A. vermicularis* Trin., Ch, IT. *Artemisia absinthium* L., Ch, ES-IT. *A. chamaemelifolia* Vill., Ch, ES-IT. *Centaurea iberica* Trev. ex Spreng., He, IT-M. *C. zuvandica* (Sosn.) Sosn., He, ES-M. *Centaurea* sp., He. *Cirsium* sp., He. *Cousinia crispa* Jaub. & Spach, He, IT. *Crepis heterotricha* DC. subsp. *lobata* Babcock, He, IT [End.]. *C. multicaulis* Ledeb. subsp. *multicaulis*, He, IT. *Erigeron acer* L., He, IT. *Helichrysum oligocephalum* DC., Ch, IT [End.]. *H. plicatum* DC., He, IT. *Hieracium procerum* Fr., He, ES. *Iranecio elbursensis* (Boiss.) B. Nord., He, IT [End.]. *Leontodon hispidus* L. var. *mazanderanicus* Rech. f., He, IT [End.]. *Ligularia persica* Boiss., He, IT [End.]. *Scariola orientalis* (Boiss.) Soják subsp. *orientalis*, Ch, IT. *Scorzonera kirpicznikovii* Lipsch., He, Es. *Seratula latifolia* Boiss., He, ES. *Tanacetum coccineum* (Willd.) Grierson subsp. *coccineum*, He, ES. *T. hololeucum* (Bornm.) Podlech, He, IT [End.]. *T. polycephalum* Sch. Bip. subsp. *duderanum* (Boiss.) Podlech, Ch, IT. *Taraxacum serotinum* (Waldst. & Kit.) Poir., He, ES. *Tragopogon kotschyi* Boiss., He, IT [End.]. ***Boraginaceae*:** *Huynhia pulchra* (Willd. ex Roemer & Schultes) Greuter & Burdet, He, ES. *Lappula microcarpa* (Ledeb.) Gürke, Th, IT. *Onosma demavendica* Riedl, He, IT. *O. dichroantha* Boiss., He, IT. ***Brassicaceae* (*Cruciferae*):** *Alliaria petiolata* (M. Bieb.) Cavara & Grande, Th, ES-IT-M. *Anchonium elichrysifolium* (DC.) Boiss. subsp. *persicum* (DC.) Cullen & Coode, He, IT. *Arabis caucasica* Willd. subsp. *caucasica*, He, IT. *A. gerardii* Besser, He, ES-IT. *A. Sagittata* (Bertol.) DC., He, ES-IT-M. *Barbarea plantaginea* DC., He, IT. *Cardaria draba* (L.) Desv. subsp. *draba*, He, IT. *Clastopus erubescens* Hausskn., He, IT [End.]. *Conringia persica* Boiss., He, IT. *Draba nemorosa* L., He, ES-IT. *Sisymbrium irio* L., Th, IT. ***Campanulaceae*:** *Asyneuma amplexicaule* (Willd.) Hand. – Mazz. subsp. *amplexicaule*, He, IT [End.]. *A. mazanderanicum* Rech. f., He, IT [End.]. *Campanula glomeratra* L., He, ES-IT. *C. lourica* Boiss. He, IT [End.] *C. stevenii* M. Bieb., He, IT. ***Caryophyllaceae*:** *Arenaria gypsophiloides* L. var. *gypsophiloides*, He, IT. *Dianthus orientalis* Adams subsp. *gorganicus*, Rech. f., Ch, IT. *D. orientalis* Adams subsp. *stenocalyx* (Boiss.) Rech. f., Ch, IT. *Gypsophila aretioides* Boiss., Ch, IT. *Minuartia lineata* Bornm., Ch, IT [End.]. *M. recurva* (All.) Schinz et Thell subsp. *oreina* (Mattf.) Mc Neill, Ch, IT. *Silene* sp., He. ***Chenopodiaceae*:** *Camphorosma monspeliaca* L., Ch, ES-IT-M. ***Crassulaceae*:** *Sedum gracile* C. A. Mey., Ge, IT. *S. pilosum* M. Bieb., He, ES-IT. *Sempervivum iranicum* Bornm. & Gauba, He, IT [End.]. ***Cupressaceae*:** *Juniperus excelsa* M. Bieb., Ph, IT. ***Cyperaceae*:** *Carex orbicularis* Boott subsp. *kotschyana* (Boiss. & Hohen.) Kukkonen, He, IT. *Eleocharis quinqueflora* (Hartmann) O. Schwarz, He, Cosm. ***Dipsacaceae*:** *Cephalaria kotschyi* Boiss. & Hohen., He, IT. ***Euphorbiaceae*:** *Euphorbia bungei* Boiss., Ch, IT. ***Fabaceae*:** *Astragalus aureus* Willd., Ch, IT [End.]. *A. capax* Maassoumi, Ch, IT [End.]. *A. citrinus* Bunge subsp. *citrinus*, He, IT [End.]. *A. magistratus* Maassoumi, Ghahreman & Mozzaffarian, Ch, IT [End.]. *A. oxyglottis* M. Bieb., He, IT [End.]. *A. submitis* Boiss. & Hohen. subsp. *maassoumii* Tietz & Zarre, Ch, IT [End.]. *Astragalus* sp., He. *Onobrychis cornuta* (L.) Desv., Ch, IT. *Trifolium* sp., He. *Vicia canescens* Labill. subsp. *gregaria* (Boiss. & Heldr.) P.H. Davis, He, IT. *V. sojakii* Chrtková, He, IT. ***Fumariaceae*:** *Corydalis* sp., Ge. ***Gentianaceae*:** *Gentiana septemfida* Pall., He, IT. *Swertia*

aucheri Boiss., He, IT. ***Geraniaceae*: *Geranium tuberosum*** L., Ge, ES-IT-M. ***Hypericaceae* (*Guttiferae*): *Hypericum armenum*** Jaub. & Spach, He, IT. *H. scabrum* L., He, IT-M. ***Iridaceae*: *Iris acutiloba*** C. A. Mey., Ge, IT. *Iris barnumae* Baker & Foster subsp. *demavendica* (Bornm.) Mathew & Wendelbo, Ge, IT [End.]. ***Lamiaceae* (*Labiatae*): *Ajuga chamaecistus*** Ging. ex Benth., He, IT [End.]. *Betonica nivea* Steven subsp. *mazandarana* (Bornm.) Rech. f., He, IT [End.]. *Leonurus cardiaca* L. subsp. *persicus* (Boiss.) Rech., f. He, IT [End.]. *Marrubium astracanicum* Jacq., He, IT. *Mentha longifolia* (L.) Hudson var. *chlorodictya* Rech. f., Ge, PL. *Nepeta racemosa* Lam., He, IT. *N. sintenisii* Bornm., He, IT. *Phlomis anisodonta* Boiss., He, IT [End.]. *Salvia staminea* Montbr. & Aucher ex Benth., He, IT. *S. xanthocheila* Boiss. ex. Benth., He, IT. *Scutellaria pinnatifida* A.Ham. subsp. *alpina* (Bornm.) Rech. f., He, IT. *Stachys byzantina* K. Koch, He, IT. *S. lavandulifolia* Vahl, He, IT-M. *Thymus kotschyanus* Boiss. & Hohen., Ch, IT. *T. pubescens* Boiss. & Kotschy ex Celak, Ch, IT. *Ziziphora clinopodioides* Lam. subsp. *elbursensis* (Rech. f.) Rech. f., Ch, IT. ***Liliaceae*: *Allium erubescens*** K. Koch, Ge, ES-IT. *Gagea gageoides* (Zucc.) Vved. Ge, IT. *Ornithogalum balansae* Boiss., Ge, ES-IT. *O. bungei* Boiss., Ge, ES-IT. *O. gussonei* Ten. (*O. tenuifolium* Guss.), Ge, ES-IT. *Tulipa biflora* Pall., Ge, IT. *Tulipa* sp., He. ***Linaceae*: *Linum nervosum*** Waldst. & Kit. var. *bungei* (Boiss.) Sharifinia, He, IT [End.]. *Linum nervosum* Waldst. & Kit. var. *nervosum*, He, IT [End.]. ***Ophioglossaceae*: *Botrychium lunaria*** (L.) SW., He, PL. ***Orchidaceae*: *Dactylorhiza umbrosa*** (Kar. & Kir.) Nevski, He, PL. ***Orobanchaceae*: *Orobanche pulchra*** Gilli, Ge, IT [End.]. ***Papaveraceae*: *Papaver armeniacum*** (L.) DC., He, IT. *P. bracteatum* Lindl. He, ES-IT. ***Poaceae*: *Agropyron cristatum*** (L.) Gaertn. subsp. *pectinatum* (M. Bieb.) var. *pectinatum*, He, ES-IT-M. *Agrostis gigantea* Roth, He, PL. *Alopecurus textilis* Boiss., He, IT. *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl. & C. Presl, He, ES-IT-M. *Brachypodium sylvaticum* (Huds.) P. Beauv., He, ES-M. *Bromus tomentellus* Boiss., He, IT. *Calamagrostis parsana* (Bor) M. Dogan, He, IT. *Dactylis glomerata* L. subsp. *glomerata*, He, ES-IT-M. *Elymus elongatiformis* (Drobov) Assadi, Ge, IT. *Festuca ovina* L., He, Cosm. *Hordeum bulbosum* L., Ge, IT. *H .violaceum* Boiss. & Hohen., He, IT-M. *Melica jacquemontii* Decne. subsp. *jacquemontii*, He, IT. *Phleum iranicum* Bornm. & Gauba, He, IT [End.]. *Poa bulbosa* L., Ge, IT-M. *Poa nemoralis* L., He, PL. *Poa supina* Schrad., He, Es-IT. *Psathyrostachys fragilis* (Boiss.) Nevski, He, IT. *Stipa barbata* Desf., He, ES-IT. *Trisetum flavescens* (L.) P. Beauv., He, ES-IT. ***Plantaginaceae*: *Plantago atrata*** Hoppe, He, ES-IT. ***Plumbuginaceae*: *Acantholimon demavendicum*** Bornm., Ch, IT [End.]. *A. hohenackeri* (Jaub. & Spach) Boiss., Ch, IT. ***Polygalaceae*: *Polygala anatolica*** Boiss. & Heldr., He, ES-M. ***Polygonaceae*: *Polygonum alpestre*** C. A. Mey., He, ES. *P. rottboellioides* Jaub. & Spach, He, IT. *Rumex elbursensis* Boiss., He, IT [End.]. ***Primulaceae*: *Primula auriculata*** Lam., He, IT. *P. macrocalyx* Bunge, He, ES-IT. ***Ranunculaceae*: *Ficaria kochii*** (Ledeb.) Iranshahr & Rech. f., He, IT. *Ranunculus amblyolobus* Boiss. & Hohen., He, IT [End.]. ***Rosaceae*: *Alchemilla gigantodus*** Frohner, He, ES. *A. persica* Rothm., He, ES IT. *Cotoneaster nummularioides* Pojark., Ph, IT. *Potentilla canescens* Besser, He, ES-IT. *Rosa canina* L., Ph, IT. ***Rubiaceae*: *Crucianella gilanica*** Trin. subsp. *hirsuta* (Ehrend.) Ehrend. & Schönb.-Tem., He, IT. *Cruciata taurica* (Pall. ex Willd.) Ehrend. subsp. *persica* (DC.) Ehrend., He, IT. *Galium ghilanicum* Stapf, Th, IT. *Galium verum* L. subsp. *verum* f. *verum*, Th, IT. ***Salicaceae*: *Salix aegyptiaca*** L., Ph, ES-IT. ***Scrophulariaceae*: *Linaria genistifolia*** (L.) Mill. subsp. *genistifolia*, He, ES. *Pedicularis sibthorpii* Boiss., He, IT. *Scrophularia elbursensis* Bornm., He, IT [End.]. *Verbascum cheiranthifolium* Boiss. var. *transcaspicum* Murb., He, IT. *V. gossypinum* M. Bieb., He, ES. *Veronica anagallis-aquatica* L., Ge, IT-M. *Veronica* sp., He. ***Urticaceae*: *Urtica dioica*** L. subsp. *dioica*, He, Cosm. ***Valerianaceae*: *Valeriana sisymbriifolia*** Vahl, He, ES-IT. ***Violaceae*: *Viola rupestris*** F. W. Schmidt, Th, ES.

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