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## *Campanula oreodoxa* (Campanulaceae), a new critically endangered species from the Aladagh Mountains, NE Iran

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### Abstract

*Campanula oreodoxa* (Campanulaceae) is described and illustrated as a new sub-alpine species from North Khorassan province, Iran. The new species belongs to *C.* sect. *Oreocodon* based on dehiscence of the capsules with three middle pores at the base and absence of appendages between the calyx lobes. It is compared morphologically with the closely related species including *C. hystricula* and *C. lourica*. The micromorphological characters of seed coat and pollen grains of the new species are presented and compared with the chasmophytic allies in the area. Notes on distribution, habitat characterization, and the associated flora are provided. The new species is assessed as critically endangered (CR) and the conservation value of the habitats in the area is discussed.

**Key words:** conservation, endemism, Khorassan–Kopet-Dagh, micromorphology, new species, *Oreocodon*, *Saxicolae*, taxonomy

### Introduction

The large genus *Campanula* Linnaeus (1753: 163) (Campanulaceae: Campanuloideae) is composed of about 420–450 species worldwide (Lammers 2007, POWO 2019). The species of *Campanula* are distributed mainly in the temperate and subtropical zones of the Northern Hemisphere; however, the hotspots of diversity are found in the Mediterranean region extending to the East Caucasus (Borsch *et al.* 2009, Park *et al.* 2006). *Campanula* consists of annual, biennial, and perennial species growing in different habitats such as forests, woodlands, grasslands, and mountain slopes. There are several species of *Campanula* which are local or narrow endemics and specialized chasmophytes adapted to the microclimate and edaphic conditions of the higher mountains (Park *et al.* 2006, Khansari *et al.* 2012).

The Iranian Plateau is an important center of diversity of *Campanula* species in SW Asia. Rechinger & Schimann-Czeika (1965) recorded 57 species of *Campanula* from the Flora Iranica area. Based on the current data, there are 45 species of *Campanula* (including 13 endemics) in Iran classified in five subgenera: *Campanula* (32 species), *Rapunculus* (Boiss.) Charadze (eight species), *Megalocalyx* Damboldt (three species), *Roucela* (Dumort.) Damboldt (one species), and *Brachycodonia* (Fedorov) Damboldt (one species) (Rechinger & Schimann-Czeika 1965, Damboldt 1978, Aghabeigi & Assadi 2008, Aghabeigi 2010, Khansari *et al.* 2012, Advay & Maroofi 2015).

During field studies in the sub-alpine zone of the Aladagh Mountains in northeastern Iran, we collected a distinct chasmophyte species of *Campanula* not described before and believed to be new to science. At the first glance, the new species may be confused with *Asyneuma* Grisebach & Schenk (1852: 335) species by its corolla divided about  $\frac{3}{4}$  and unappendaged sinuses of calyx. However, in *Asyneuma* the corolla is divided nearly to the base, appearing choripetalous

(not clearly sympetalous) (Lammers 2007). The type locality belongs to the western parts of the Khorassan–Kopet-Dagh (KK) province in the Irano-Turanian floristic region. Being part of the Irano-Anatolian mountain system, the KK floristic province is recognized as one of the 35 biodiversity hotspots in the World (Mittermeier *et al.* 2011, Memariani *et al.* 2016a, Memariani 2020). In this paper, we aim to describe and illustrate the new species with notes on its micromorphology and taxonomy and provide data on habitat, vegetation, and conservation status.

## Material and Methods

Specimens of the new species were collected from Aladagh Mountains, North Khorassan province (Iran) during field trips in July 2018. We reviewed and consulted the descriptions and identification keys in the relevant literature including Flora Iranica (Rechinger & Schimann-Czeika 1965), Flora of Iran (Aghabeigi 2010), Flora of Turkey (Damboldt 1978), and Flora of the USSR (Fedorov 1957). The features of gross morphology of the specimens were examined under a binocular stereomicroscope and compared with the specimens at FUMH and virtual herbaria of K, MA, MW, P, and W. For scanning electron microscopy (SEM), selected mature seeds and pollen grains were placed on aluminum stubs using a double-sided adhesive tape, sputter-coated with gold using an Emiteck K550, and then examined using the FEI Quanta 250 FEG and JEOL Neoscope JCM-5000 scanning electron microscope. We used the geographical range of the new species in the form of the extent of occurrence (EOO) and area of occupancy (AOO) to categorize the threat status using the GeoCAT tool (IUCN 2016, Bachman *et al.* 2011).

## Description of the new species

*Campanula oreodoxa* Arjmandi & Memariani, *sp. nov.* (Fig. 1–2)

**Type**:—IRAN. North Khorassan: W Bojnord, Aladagh Mountains, Darkesh & Haver area, in alpine communities, 2385 m, 3 July 2018 (in flower), *Memariani & Arjmandi 46390* (holotype FUMH!).

Perennial, densely retrorse-strigose, ascending to decumbent, up to 10 cm high. Rootstocks woody, shortly branched. Stems herbaceous, leafy, up to 7 cm long, covered by leaf remains at the base, with numerous ascending branches, ending in usually 1(–3)-flowered racemes. Basal leaves in rosettes, densely retrorse-strigose, 20–30 (33) × 1–2 mm, sessile; cauline leaves ± similar to the basal leaves but smaller, 10–18 × 1–1.5 mm, sessile, entire, acute. Flowers subsessile, erect to suberect, terminal, rarely axillary, densely retrorse-strigose outside, long-hairy inside. Calyx without appendages, 4–5 mm long; calyx lobes 2–2.5 mm long and 1 mm broad, triangular, acute; calyx tube 2–3 mm long. Corolla campanulate-rotate, blue to purple, 6–9 mm long, divided about  $\frac{3}{4}$ ; tube 1.5–2 mm long; lobes 5–7 mm long, retrorse, lanceolate, acute, long-hairy beneath. Stamens 4–6 mm; filaments white to yellow, dilated at base, 2–2.5 mm long, densely hairy at the base; anthers yellow, 2–3 mm long. Style slightly exerted from the corolla, 7–10 mm long. Capsule triangular, 4–6 × 3–5 mm, dehiscence with three pores at the base. Seeds ellipsoid to oblong, 0.7 mm long, shiny brown.

**Phenology**:—Flowering in late June to mid-July. Fruiting is completed from late July to mid-August.

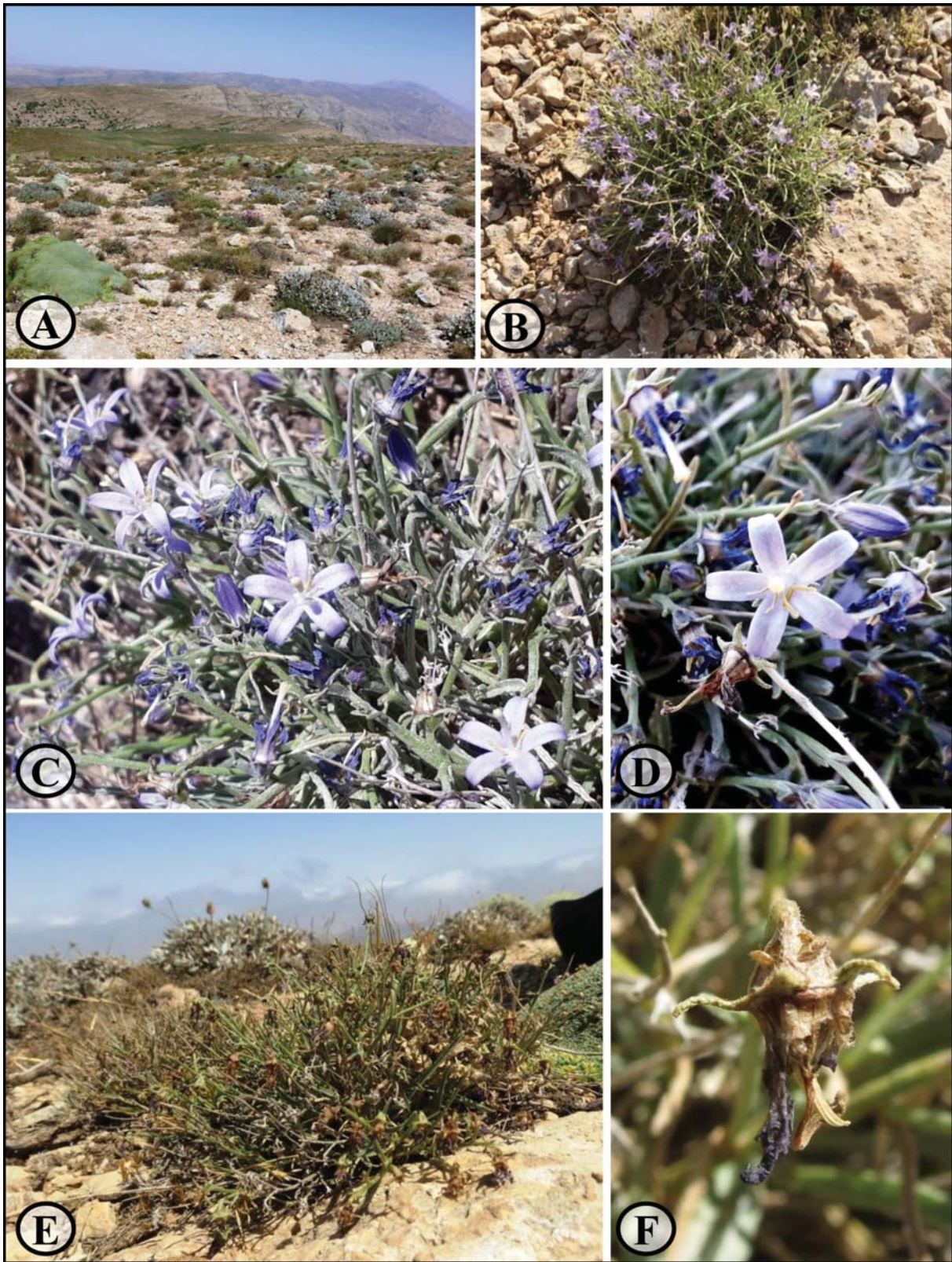
**Additional specimens examined (paratypes)**:—IRAN. North Khorassan: W Bojnord, Aladagh Mountains, Darkesh & Haver area, Barfandil summit, in alpine communities, 2385 m, 24 July 2018 (in fruit), *Memariani & Arjmandi 46404* (FUMH!).

**Etymology**:—The specific epithet “*oreodoxa*” means “glory of the mountain” and refers to the high mountain habitat of the new species.

**Taxonomic relationships**:—*Campanula oreodoxa* belongs to *C.* subgen. *Campanula* sect. *Oreocodon* (Fedorov) Oganessian (1995: 293) [= *C.* sect. *Saxicolae* (Boiss.) Charadze]. The species of *C.* sect. *Oreocodon* are mainly perennial, with pauciflorous stems, and without appendages between calyx lobes (Rechinger & Schimann-Czeika 1965, Mansion *et al.* 2012). They resemble mostly the species of *C.* sect. *Rupestres* (Boiss.) Charadze by their life-form, occurrence in crevices of rocks, and dehiscence of capsules with three middle or basal pores (Fig. 2); however, calyces are appendiculate in *C.* sect. *Rupestres*. *Campanula* sect. *Oreocodon* is represented by 11 species in Iran, of which 9 species are endemic to the country. *Campanula oreodoxa* seems to be related to *C. hystricula* Pau in Pau & Vicioso (1918: 37), an endemic species to the central Zagros Mountains, but differs from the latter by its shorter stems



FIGURE 1. Holotype of *Campanula oreodoxa* (46390 FUMH).



**FIGURE 2.** *Campanula oreodoxa* in its natural habitat. **A.** habitats dominated by *Cousina edmondsonii* and other cushion plants; **B.** plant in the flowering stage; **C–D.** close-up view of the flowers, **E.** plant in the fruiting stage with *Cousina edmondsonii* in background; **F.** the fruiting stage showing the dehiscence of the capsule by basal pores.

(up to 10 cm), shorter corolla tube (1.5–2 mm), longer corolla lobes (5–7 mm), and the style position which is slightly exerted. In a revision of Pau's types of plants, Rechinger (1990) accepted *C. hystricula* and completed its original description. *Campanula oreodoxa* differs from *C. lourica* Boissier (1849: 70), endemic to Alborz and Khorassan–Kopet-Dagh Mountains, by the shape and size of its leaves and corolla (Table 1). The molecular data is needed to realize the relationships and phylogenetic position of the new species within *C.* sect. *Oreocodon*.

**Seed coat micromorphology:**—Seeds in *C. oreodoxa* are fusiform to oblong, 1.60–1.86 mm long and 0.56–0.86 mm wide. The testa sculpture is striate with elongate cells and a narrow lumen (Fig. 3). This type of seed coat belongs to Type I of testa in Campanulaceae which is generally characterized by a striate, interrupted striate, or faintly striate testa; however, the striate-reticulate pattern is common in Type II (Akcin 2009, Alçitepe 2010). The seed coat of *C. oreodoxa* differs from that of the closely related *C. lourica* by its striate surface pattern with anticlinal walls extremely or relatively thick and rod-like in surface view (Subtype Ia), not smooth with an interrupted striate or faintly striate surface (Subtype Ib) (Saeidi-Mehrvarz & Kashi 2015).

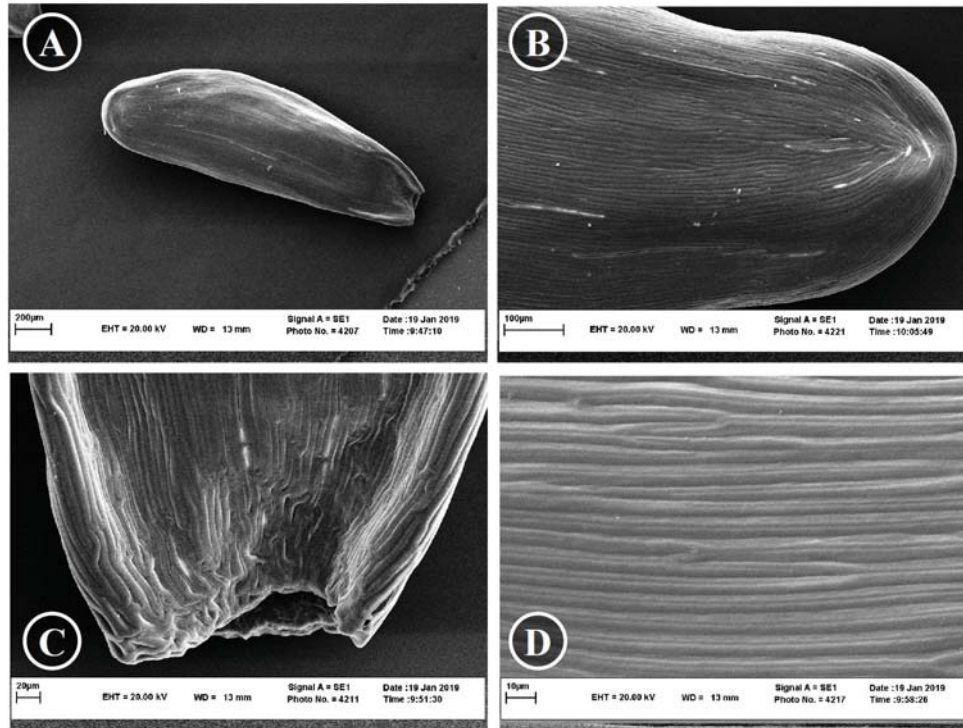


FIGURE 3. Scanning electron micrographs of *Campanula oreodoxa* seeds and details of testa sculpture.

TABLE 1. Comparison of morphological characters of *Campanula oreodoxa* with two related species in *C.* sect. *Oreocodon*.

Taxa/characters	<i>C. oreodoxa</i>	<i>C. hystricula</i> *	<i>C. lourica</i>
Stem length (cm)	up to 10	up to 20	up to 15
Leaves shape	linear	linear-lanceolate	lanceolate-spathulate
Leaf colour	green	glaucous	green
Basal leaves size (mm)	20–30(33) × 1–2	12 × 2.5	4–10 × 2–6
Calyx length (mm)	4–5	5–6	4–7
Calyx lobes length (mm)	2–2.5	3	2–5
Corolla shape	campanulate	campanulate	campanulate-tubulate
Corolla length (mm)	6–9	10–12	5–12
Calyx length/corolla length	1/3	1/2	1/3
Corolla tube length (mm)	1.5–2	5–7	3–7
Corolla lobes length (mm)	5–7	1–5	2–4
Style	slightly exerted	equal to exerted	equal to exerted

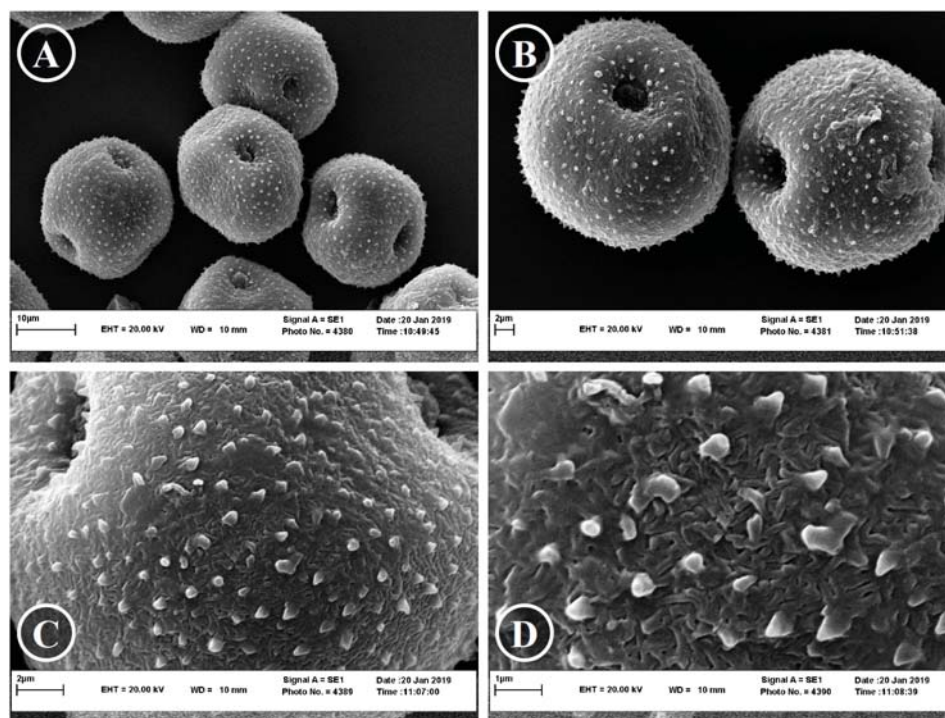
\* Based on the original (Pau & Vicioso 1918) and extended description (Rechinger 1990) of the species.

**Pollen micromorphology:**—Pollen grains of *Campanula oreodoxa* are radially symmetrical, oblate-spheroidal to spheroidal, or rarely prolate-spheroidal in shape (Fig. 4). The polar axis is (19–) 21.21 ± 1.24 (–23.55) µm and the equatorial axis is (22–) 23.61 ± 1.06 (–25.17) µm with the shape index (P/E) of 0.90. The pollen grains are mainly tri-porate, rarely up to penta-porate. Previous studies have revealed that species of *C.* sect. *Oreocodon*, with pollen grains rather smaller than in the species of other sections, have most frequently three pores (Khansari *et al.* 2012). In Table 2, the main pollen morphological features of *C. oreodoxa* are summarized and compared with the other chasmophytic species of *Campanula* in Khorassan–Kopet-Dagh Mountains. Pollen grains of *C. oreodoxa* can be distinguished by their smaller size and P/E ratio. The endemic species *C. khorasanica* (Rech.f. & Aellen) Rechinger in Rechinger & Schimann-Czeika (1965: 17) (sect. *Rupestres*) differs from *C. oreodoxa* and *C. lourica* (sect. *Oreocodon*) by its rather larger pollen grains, and shorter and denser echinae on pollen surface.

**TABLE 2.** Details of pollen morphological characters in *Campanula oreodoxa* (present study) and two other chasmophytic species of *Campanula* (Khansari *et al.* 2012) in Khorassan–Kopet-Dagh Mountains.

Taxa / characters	Polar axis (µm)	Equatorial axis (µm)	P/E	Echinae length (µm)	Ground sculpture	Echinae density*	Pore number
<i>C. oreodoxa</i> (sect. <i>Oreocodon</i> )	(19–)21.21 ±1.24(–23.55)	(22)23.61 ±1.06(–25.17)	0.90	(0.62–)0.7 ±0.1(–0.75)	Rugulate	13	3(–5)
<i>C. lourica</i> (sect. <i>Oreocodon</i> )	(26–)26.75 ±0.5(–27)	(27–)27.75 ±0.5(–28)	0.96	(0.5–)0.65 ±0.1(–0.8)	Rugulate	12	3
<i>C. khorasanica</i> (sect. <i>Rupestres</i> )	(27)29.50 ±1.73(–31)	(31–)31.50 ±0.57(–32)	0.94	(0.26–)0.32 ±0.09(–0.4)	Rugulate	23	3

\* Per sample area of 5 µm × 5 µm.



**FIGURE 4.** Scanning electron micrographs of *Campanula oreodoxa* pollen grains.

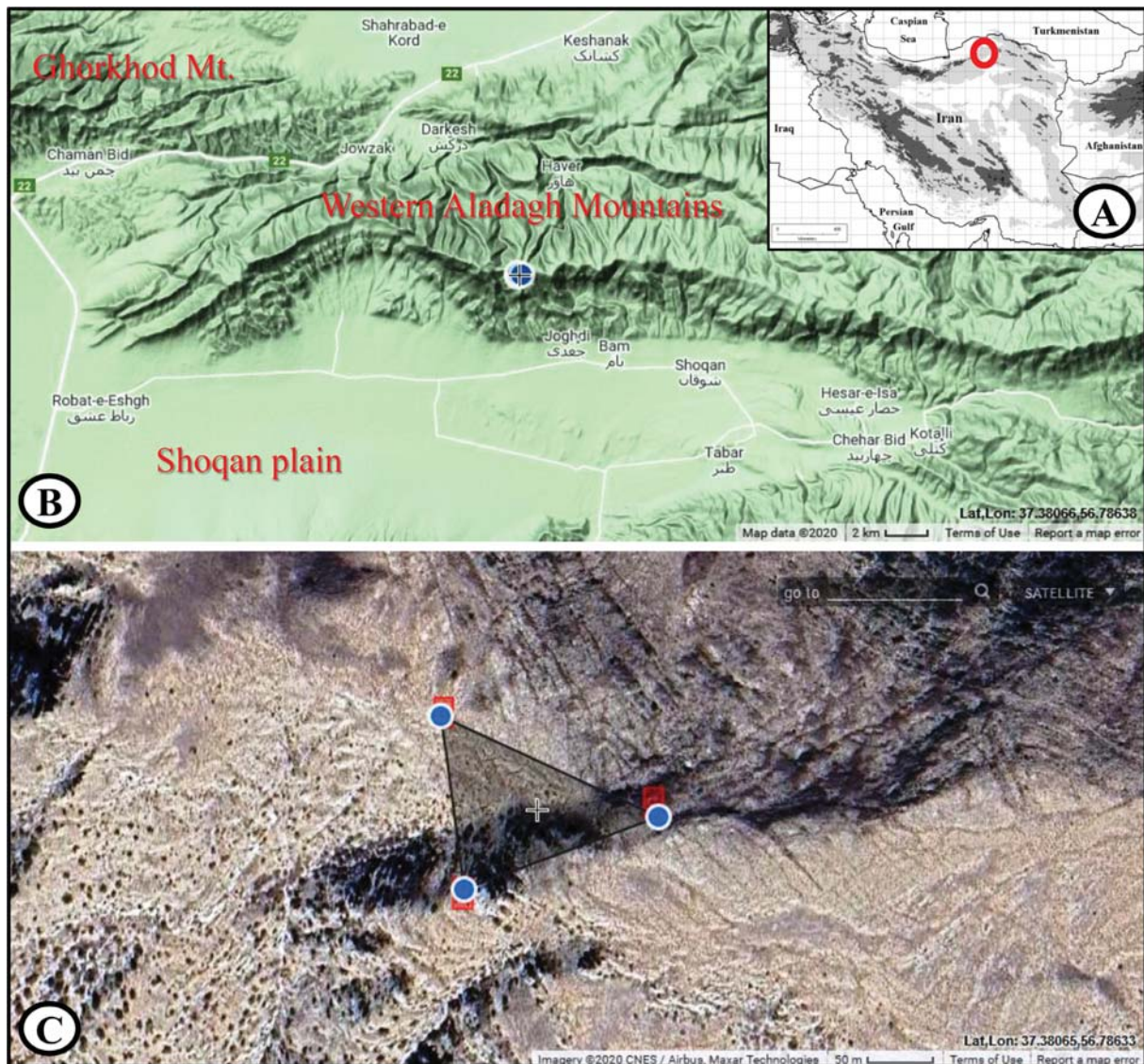
**Distribution and habitat:**—*Campanula oreodoxa* is a local endemic restricted to the sub-alpine zone of western Aladagh mountain ranges, in Khorassan–Kopet-Dagh floristic province of the Irano-Turanian region (Fig. 5A–B). The new species occurs only in crevices of dolomite rocks at the summit of Barfandil Mount, at elevations of 2300–2400

m a.s.l. The habitat is mainly dominated by *Cousinia edmondsonii* Rechinger (1972: 321), hitherto known only from Ghorkhod summit in the northwest of the study area (Memariani *et al.* 2016c). The species associated with *C. oreodoxa* are listed in Table 3 based on three phytosociological relevés in the type locality.

**Conservation status:**—Based on the current data, the new species is restricted to a small area of 1.1 ha (EOO=0.011km<sup>2</sup>, AOO=0.001km<sup>2</sup>) with *ca.* 25 individuals (Fig. 5C). Following the IUCN Red List criteria, *C. oreodoxa* is evaluated as critically endangered (CR; B1+B2ab(iii)+C2a(i)). A very small extent of occurrence, area of occupancy and population size, as well as the global warming and grazing effects in southern slopes of the area, near the Barfandil summit, may bring the new species under extremely high risk of extinction. Moreover, the area has a high conservation value due to the presence of six threatened species endemic to Khorassan–Kopet-Dagh (30% endemism rate), as well as some sub-endemic or range-restricted plants (Table 3).

**TABLE 3.** Species associated with *Campanula oreodoxa* in three 25 m<sup>2</sup> phytosociological relevés in the type locality based on Braun-Blanquet cover-abundance. The chorotypes are based on Memariani *et al.* (2016b, 2016c).

Relevé Number		1	2	3
Elevation (m)		2310	2330	2385
Aspect		W	SW	SW
Slope		20°	20°	10°
Total cover (%)		40	40	65
<b>Species</b>	<b>Chorotype</b>			
1 <i>Cousinia edmondsonii</i> Rech.f.	IT <sup>KK</sup>	3	3	2
2 <i>Dianthus orientalis</i> Adams	IT	2	1	1
3 <i>Elymus longearistatus</i> (Boiss.) Tzvelev	IT <sup>C</sup>	1	-	-
4 <i>Festuca valesiaca</i> Gaudin	IT- ES	1	1	1
5 <i>Sabulina lineata</i> (Boiss.) Dillenb. & Kadereit	IT <sup>KK-Alborz</sup>	1	-	1
6 <i>Onobrychis cornuta</i> (L.) Desv.	IT	1	1	1
7 <i>Poa araratica</i> Trautv.	IT	1	-	-
8 <i>Prunus pseudoprostrata</i> (Pojark.) Rech.f.	IT <sup>KK-Alborz</sup>	1	-	-
9 <i>Stachys turcomanica</i> Trautv.	IT <sup>KK-Alborz</sup>	1	1	-
10 <i>Thymus transcaspicus</i> Klokov	IT <sup>KK</sup>	1	1	1
11 <i>Acantholimon erinaceum</i> (Jaub. & Spach) Lincz.	IT <sup>C</sup>	1	-	-
12 <b><i>Campanula oreodoxa</i> Arjmandi &amp; Memariani</b>	IT <sup>KK</sup>	+	+	1
13 <i>Alyssum lanigerum</i> DC.	IT <sup>C</sup>	+	+	-
14 <i>Allium aladaghense</i> Memariani & Joharchi	IT <sup>KK</sup>	-	+	+
15 <i>Alyssum murale</i> Waldst. & Kit.	IT- ES	-	1	+
16 <i>Erysimum ischnostylum</i> Freyn & Sint.	IT <sup>KK-Afgh.</sup>	-	+	+
17 <i>Gypsophila aretioides</i> Boiss.	IT <sup>C</sup>	-	1	1
18 <i>Silene crispans</i> Litw.	IT <sup>KK</sup>	-	+	+
19 <i>Asperula oppositifolia</i> Regel & Schmalh. subsp. <i>rechingeri</i> F.Ghahreman, Joharchi & Aydani	IT <sup>KK</sup>	-	-	1
20 <i>Aethionema carneum</i> (Banks & Sol.) B.Fedtsch.	IT	-	-	+



**FIGURE 5.** A. Geographical position of the study area in northeastern Iran. B. Distribution map of the *Campanula oreodoxa* in the western Aladagh Mountains. C. Location of the populations of *C. oreodoxa* and the estimation of EOO and AOO in geoCAT based on IUCN Red List criteria.

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