Stipa richteriana (Poaceae) and Galium songaricum (Rubiaceae): two new additions of the Central Asian species to the flora of Iran

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Abstract. Stipa richteriana and Galium songaricum are newly recorded species for the flora of Iran, collected from Binalood and Hezar-Masjed Mountains in Razavi Khorasan Province. The geographical distribution of both species is mainly confined to the Middle Asia. Morphological characters of two newly recorded species are compared with their close relatives. Notes on taxonomy, ecology, phytogeography, and conservation status of both species are provided.

Keywords. biodiversity, conservation, Khorassan-Koped Dagh, phytogeography, taxonomy

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**INTRODUCTION**

The Khorassan-Kopet Dagh floristic province (KK) is situated mostly in the mountains of northeastern Iran and partly extending to the neighboring parts of southern Turkmenistan. The area encompasses very diverse flora and vegetation types. As a transitional zone, KK is a corridor connecting different phytogeographical units of the Irano-Turanian region such as Central Iranian, Afghan, Aralo-Caspian, and the Middle/Central Asian, as well as the Hycranian province of the Euro-Siberian region. Moreover, the presence of a local center of plant endemism has made the area a unique and separate biogeographical entity (Memariani et al., 2016a). A comprehensive analysis of the plant diversity showed that the level of endemism in KK is about %14 (Memariani et al., 2016b), which is higher than the average in neighboring Central Asia (Sennikov, 2016). 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).

In growing seasons of 2017-2018, during ecological studies on selected endemic plants in Khorassan- Kopet Dagh, we recorded and collected some unknown plant specimens, in phytosociological relevés, belonging to the genera *Stipa* and *Galium*. Using the identification keys in the relevant Floras and monographs (Tzvelev, 1976; Freitag, 1985; Pobedimova, 2000; Ehrendorfer et al., 2005). We consulted the images of the type and representative specimens of newly recorded species and their close relatives in B, MW, and W herbaria in order to confirm their identity (herbarium codes based on Thiers, 2018). The plant specimens are preserved in the Herbarium of Ferdowsi University of Mashhad (FUMH). We produced a distribution map for both species using collection data of the herbarium specimens in ArcGIS 10.3 software. The threat status of the species was determined based on the IUCN Red List categories and criteria (IUCN, 2016).

**RESULTS AND DISCUSSION**

**New records**

*Stipa richteriana* Kar. & Kir., Bull. Soc. Imp. Nat. Moscow 14 (4): 862 (1841). (Fig. 1, 2 A-D)

Type: E. Kazakhstan, in lapidosis mont. Arganaty, 1840, Karalen 907 (LE).

Perennial, caespitose, densely tufted, basal branching intravaginal, with few culms and many vegetative shoots; culms 59-60 (-70) cm, 3-noded, densely pubescent below the nodes; leaf-sheaths densely pubescent, outer margin hairy, at the junction with the blades densely bearded; ligules obscure, up to 0.2 mm long, ciliate at the margin; blades at the culm leaves up to 7 (-8) cm long, at the vegetative shoots up to 15 (-20) cm long, usually involute, 0.3-0.5 mm diam., upper surface densely pubescent, beneath pubescent at the base; panicle (15-) 20-25 × (1-) 2 cm, open, linear, exserted or embraced at base by subtending leaf, the branches ascending with 1-5 spikelets; spikelets 10-15 mm long, glumes persistent, subequal, acuminate, margins and tip hyaline, setose along the primary vein, the lower 3-5-nerved, the upper 7-nerved; anthecium 6-7 mm long; callus 0.6-0.8 mm long, densely bearded; lemma lanceolate, coriaceous,

In this paper, we aim to document the new records of *Stipa* and *Galium* species for the flora of Iran as well as revised descriptions of both species based on collected specimens from Binalood and Hezar-Masjed mountains in Razavi Khorasan Province. We also provide additional notes on their taxonomy, ecology, and biogeography.

**MATERIALS AND METHODS**

The plant specimens were collected during 2017-2018 field excursions in Khorassan-Kopet Dagh Mountains and vegetation data were recorded in phytosociological relevés. The herbarium specimens were examined using identification keys and species descriptions in relevant Floras and monographs (Tzvelev, 1976; Freitag, 1985; Pobedimova, 2000; Ehrendorfer et al., 2005).
Fig. 1. Herbarium specimen of *Stipa richteriana* (Memariani & Behroozian 46440, FUMH).
without keel, with 0.5 mm long ascending hairs, only the marginal hairs almost reaching the top, the top with a crown of 0.5-1.5 mm long hairs; awn bigeniculate, (5-) 6-7 cm long, minutely pubescent throughout, columnum densely twisted, with 0.2 mm long hairs, seta falcate with 0.5 mm long hairs; palea equalling lemma in length, glabrous, with a tuft of a few hairs at the apex; lodicules 3, 1.5 mm long, glabrous; anthers 3, 3-4 mm long, yellow; ovary glabrous, with 2 stigmas; caryopsis fusiform.

Specimen seen: Razavi Khorassan province: NW Neyshabur, Bargish (Baharkish), above Oghbaei garden, 2210 m, 36° 41′ 41.9″N, 58° 40′ 6.9″E, Memariani & Behroozian 46440 (FUMH).

General distribution: Central Asiatic, mainly in Kazakhstan, Uzbekistan, Western China, and Eastern Afghanistan, and also in NE Iran (in the present work).

Taxonomy: Stipa richteriana belongs to section Stipa, species group of “Eriostipa” (Freitag, 1985). S. bungeana Trin. is another Central Asiatic species which is known as one of the close relatives of S. richteriana. Freitag (1985) recorded S. richteriana from Afghanistan on the basis of a specimen from higher mountains of Hindukush in Ghazni Province, which was misidentified by Bor (1970) as S. bungeana. The latter species can be distinguished from S. richteriana by some morphological characters such as its shorter anthecium, glabrous awn, and different leaf and lemma indumentum (Table 1). S. richteriana can be confused with S. haussknechtii Boiss. (sect. Lasioagrostis (Link) Hackel), which is an endemic feather grass to Iran. However, it clearly differs from the latter by its contracted linear vs. very loose ovate panicle, among other characters (Table 1). The Central Asiatic S. breviflora Griseb. is separated from S. richteriana by its longer awns (over 9 cm long) and longer hairs on seta (1-2 mm long) (Nobis et al., 2016).

Galium songaricum Schrenk ex Fisch. & C.A.Mey., Enum. Pl. Nov. 1: 57 (1840) (Fig. 2E).

Annual; roots thin, thread-like, reddish or brown; stems fragile, prostrate, thin, branched, (3-) 5-20 cm long, glabrous, rarely with scattered, long hairs, quadrangular; leaves 2, arranged in a whorl with two smaller leaf-like stipules, (2.5-) 5-15 (-23) mm long, (1.5-) 2.5-5 (-8) mm wide, lowest leaves obovate to

Fig. 2. A-D. Some details of morphological characters in Stipa richteriana (Memariani & Behroozian 46440, FUMH), scale bars = 1 mm. A. the minutely pubescent awn with twisted columna. B. the entire lemma apex with a crown of hairs. C. the densely pubescent culm below the nodes. D. the collar showing the short membranous and ciliolate ligule with densely pubescent leaves on upper surface. E. the dwarf Galium songaricum plant (Joharchi & Behroozian 46259, FUMH).
spatulate, other leaves elliptic to lanceolate-elliptic, obtuse to slightly acute, 1-nerved, thin, glabrous on both sides, less commonly covered with scattered, upright hairs, petiole 0.5-1.5 mm long; inflorescence as axillary cymes, 1-2(-3)-flowered; pedicels glabrous, thin, (3-) 12-20 (-40) mm long, longer than leaves, often with a pair of small bracts somewhat above the middle of the pedicel, rarely 2-3 flowers on short pedicel, usually horizontally directed, corolla white, sometimes with purplish lobes, rotate, (0.2-) 0.5-1 mm in diameter, lobes 4 (rarely 3), wide, ovate-triangular, acute; stamens 4 (-5)-lobed, anthers yellow; style two-parted almost from the middle; ovary glabrous to rarely hispid; Mericarps 2, globular to reniform, less commonly with one mericarp, 0.2×0.2-2.5 mm, glabrous or covered with long, hooked-curved, white hairs.

Specimen seen: Razavi Khorasan province: N Mashhad, SW Balghour, 2150 m, 36° 49' 58.3"N, 59° 35' 54.7"E, Joharchi & Behroozian 46259 (FUMH).

**General distribution:** Central Asia, Western Siberia, Western Himalaya, Turkmenistan (Central Kopet Dagh), and NE Iran (in the present work).

**Taxonomy:** *Galium songaricum* belongs to sect. *Depauperata* Pobed. subsect. *Quadrifolia* Pobed., which includes only annual taxa having two leaves with usually two smaller leaf-like stipules, resembling four-leaf whorls. *Galium* sect. *Depauperata* includes few closely related species such as the North American *G. bifolium* S.Watson and the Himalayan *G. exile* Hook.f. (= *G. handelii* Cufod.) (Ehrendorfer et al. 2005; Chen & Ehrendorfer, 2011). There are several morphological characters which differentiate *G. songaricum* from the closely related species *G. exile* and another similar perennial species i.e. *G. triflorum* Michx. (Table 2).

### Table 1. Morphological and chorological comparison of *Stipa richteriana* with its closely relates species.

<table>
<thead>
<tr>
<th>Character</th>
<th><em>Stipa bungeana</em></th>
<th><em>Stipa haussknechtii</em></th>
<th><em>Stipa richteriana</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ligule</td>
<td>Eciliate</td>
<td>Eciliate</td>
<td>ciliate</td>
</tr>
<tr>
<td>Leaf-blade state</td>
<td>conduplicate</td>
<td>involute</td>
<td>involute</td>
</tr>
<tr>
<td>Leaf-blade width</td>
<td>0.76-1.3 mm</td>
<td>2-3 mm</td>
<td>0.3-0.5 mm</td>
</tr>
<tr>
<td>Leaf-blade surface</td>
<td>glabrous</td>
<td>glabrous</td>
<td>pubescent</td>
</tr>
<tr>
<td>Panicle shape</td>
<td>lanceolate</td>
<td>ovate</td>
<td>linear</td>
</tr>
<tr>
<td>Upper glume</td>
<td>3-5-veined</td>
<td>3-veined</td>
<td>7-veined</td>
</tr>
<tr>
<td>Anthecium</td>
<td>4.5-5 mm long</td>
<td>7 mm long</td>
<td>6-7 mm long</td>
</tr>
<tr>
<td>Column of lemma awn</td>
<td>scabrous</td>
<td>puberulous</td>
<td>puberulous</td>
</tr>
<tr>
<td>Lemma surface hairy</td>
<td>below</td>
<td>all along</td>
<td>all along</td>
</tr>
<tr>
<td>Lemma apex shape</td>
<td>entire</td>
<td>Dentate</td>
<td>entire</td>
</tr>
<tr>
<td>Palea apex</td>
<td>undifferentiated</td>
<td>undifferentiated</td>
<td>ciliate</td>
</tr>
<tr>
<td>Geographical distribution</td>
<td>Middle/Central Asia</td>
<td>Endemic to Iran (C, SW, S)</td>
<td>Middle/Central Asia, E Afghanistan, NE Iran (new record)</td>
</tr>
</tbody>
</table>

### Table 2. Morphological comparison between *Galium songaricum* and its closely related species.

<table>
<thead>
<tr>
<th>Character</th>
<th><em>Galium songaricum</em></th>
<th><em>Galium exile</em></th>
<th><em>Galium triflorum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth form</td>
<td>annual</td>
<td>annual</td>
<td>perennial</td>
</tr>
<tr>
<td>Stem height</td>
<td>(3-)5-30 cm</td>
<td>4-20 cm</td>
<td>(15-)25-80(-120) cm</td>
</tr>
<tr>
<td>Stem state</td>
<td>branched</td>
<td>somewhat branched</td>
<td>somewhat branched</td>
</tr>
<tr>
<td>Leaf number in a whorl</td>
<td>4</td>
<td>4</td>
<td>4 to 6(-8)</td>
</tr>
<tr>
<td>Leaf shape</td>
<td>elliptic</td>
<td>ovate or oblanceolate</td>
<td>narrowly ovate to broadly oblone-lanceolate</td>
</tr>
<tr>
<td>Leaf size</td>
<td>(7-)12-15(-23) × (2-)5(-8) mm</td>
<td>(2-)3.5-10(-12)</td>
<td>(15-)20-25(-45)</td>
</tr>
<tr>
<td>Petiole size (in fruit)</td>
<td>short or elongate</td>
<td>short</td>
<td>short or subssesile</td>
</tr>
<tr>
<td>Cymes</td>
<td>1 or 2(-3)-flowered</td>
<td>1-flowered</td>
<td>3 to several-flowered</td>
</tr>
<tr>
<td>Corolla lobes number</td>
<td>4</td>
<td>3(4)</td>
<td>4</td>
</tr>
</tbody>
</table>
Notes on ecology and biogeography of the newly recorded species

*Stipa richteriana* is widely distributed in Aralo-Caspian lowlands to the montane and subalpine steppes and shrublands of Pamir-Alai and Eastern Tianshan Mountains (Freitag, 1985; Nobis *et al*., 2016). It grows on stony and clay slopes, rarely on sands and pebbles (Tzvelev, 1976). Based on the data collected from the habitats in NE Iran, it grows in high montane steppes of the western parts of Binalood mountain range, on northwest-faced slopes at the elevations around 2200 m a.s.l., which is dominated by dwarf shrubs and thorn-cushion plants such as *Astragalus verus* Olivier and *Acantholimon erinaceum* (Jaub. & Spach.) Lincz., respectively. The habitats of *S. richteriana* in the area are also co-dominated by *Dianthus polylepis* Bien. ex Boiss. subsp. *binaludensis* (Rech.f.) Vaezi & Behrooz, which is known as a vulnerable plant and endemic to Khorassan-Kopet Dagh (Farsi *et al*. 2013, Memariani *et al*., 2016b).

The new records of *Stipa richteriana* and *Galium songaricum* extend the distribution range of these Eastern Irano-Turanian species more south-westward to NE Iran (Fig. 3), which belongs to Khorassan-Kopet Dagh (KK) floristic province. In KK, about 100 plant species (ca. 3.7% of the flora) have a distribution pattern such as that of the newly recorded species, which is well known as Khorassan-Kopet Dagh/Eastern Irano-Turanian chorotype (IT).
Their distribution ranges are restricted mainly to the lowlands and/or mountains of the Middle/Central Asia with a disjunction in KK and some of them are connected to KK through the north of Afghanistan (Memariani et al., 2016a). A number of these plant species have been discovered and recorded for the flora of Iran during the last 15 years, such as Galatella itinivinii Novopokr. (Aydani et al., 2006), Anemone tscrnjaelevii Regel (Joharchi & Akhani, 2006), Allium barsczewskii Lipsky and A. tenuicaule Regel (Memariani et al., 2007), Allium turcomanicum Regel (Fritsch & Maroofi, 2010), Festuca karatavica (Bunge) B.Fedtsch. (Memariani & Arjmandi, 2013), Primula fedtschenkoi Regel (Joharchi & Nejati, 2015), Piptatherum latifolium (Rohev.) Nevski (Memariani et al. 2016c), and Rosa kochanica (Regel) Regel ex Juz. (Arjmandi et al., 2016).

According to the dwarf habit of G. songaricum and difficultly distinguishable specimens of S. richteriana in their habitats, it is highly probable that these plants have been overlooked by the Iranian field botanists. Therefore, searching more for them may result in finding additional habitats and a wider distribution range in Iran. Concerning the insufficient information on their distribution, and in order to avoid placing more taxa in DD (Data Deficient) category, we refer to the criterion D2 of the IUCN Red List categories and criteria which deals with very small or restricted populations for some taxa with few numbers of known locations (IUCN, 2016). Based on this criterion, the conservation status of S. richteriana and G. songaricum is provisionally evaluated as VU (Vulnerable) in Iran.

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