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چکیده. گزارش جدیدی از دو گونه Stipa richteriana و Galium songaricum برای فلور ایران در این مطالعه ارائه می شود. گستره پراکندگی جغرافیایی این گونههای این گونههای بینالود و هزار مسجد در استان خراسان رضوی جمع آوری شدهاند، به طور عمده مربوط به آسیای مرکزی است. ریخت شناسی این گونههای جدید برای ایران با گونههای خویشاوندشان مقایسه و اطلاعاتی درباره آرایه شناسی، بوم شناسی، جغرافیای گیاهی و وضعیت حفاظتی آنها ارائه می شود.

واژه های کلیدی. آرایه شناسی، تنوع زیستی، جغرافیای گیاهی، حفاظت، خراسان-کپهداغ

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 Khorassan 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-Kopet Dagh, phytogeography, taxonomy

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 Hyrcanian 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 (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 socalled 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 releves, belonging to the genera *Stipa* and *Galium*. Using the identification keys in the relevant Floras, they were determined as two new species not previously recorded from Iran.

Stipa L. is one of the largest genera in the family Poaceae. Based on the narrow taxonomic concept, it comprises over 150 species in temperate regions of the Old World (Barkworth & Everett, 1987; Nobis, 2014). Central Asia is an important center of diversity of Stipa with ca. 70 species (Nobis et al., 2013, 2017). According to Bor (1970), in Flora Iranica, this genus is represented by 18 species in Iran. In the monograph of Stipa in the southwest and south Asia, Freitag (1985) recorded 22 species from Iran. Based on published works, 13 species of Stipa are recognized for the flora of Khorassan in northeastern Iran (Freitag, 1985; Joharchi et al., 2007; Ghahremaninejad et al., 2012; Memariani et al., 2016c).

Galium L., with about 667 species distributed worldwide, is the largest genus of the tribe Rubieae in the family Rubiaceae (Yang et al., 2018). It is a taxonomically problematic genus and its species groups are often poorly differentiated morphologically and geographically. In the Flora Iranica, 45 Galium species are recorded for Iran (Ehrendorfer et al., 2005). Based on current data, 12 Galium species occur in Khorassan provinces (Joharchi et al., 2007; Ghahremaninejad et al., 2010).

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 Khorassan 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 releves. 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). 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, Karelin 907 (LE).

Perennial, caespitose, densely tufted, 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-) $20-25 \times (1-) 2$ 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, setulose 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,



Fig. 1. Herbarium specimen of Stipa richteriana (Memariani & Behroozian 46440, FUMH).

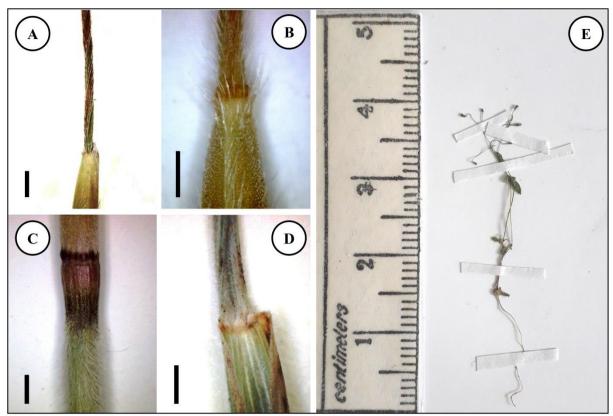


Fig. 2. A-D. Some details of morphological characters in *Stipa richteriana* (Memariani & Behroozian 46440, FUMH), scale bars = 1 mm. **A.** the minutely pubescent awn with twisted columna. **B.** the entire lemma apex with a crown of hairs. **C.** the densely pubescent culm below the nodes. **D.** the 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).

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, columna 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. Lasiagrostis (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

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

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

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 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, $0.2-2 \times 0.2-2.5$ mm, glabrous or covered with long, hooked-curved, white hairs.

Specimen seen: Razavi Khorassan 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, four-leaf whorls. resembling Galium 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 2. Morphological comparison between *Galium songaricum* and its closely related species.

Character	Galium songaricum	Galium exile	Galium triflorum
Growth form	annual	annual	perennial
Stem height	(3-)5-30 cm	4-20 cm	(15-)25-80(-120) cm
Stem state	branched	somewhat branched	somewhat branched
Leaf number in a whorl	4	4	4 to 6(-8)
Leaf shape	elliptic	ovate or oblanceolate	narrowly ovate to broadly
_	_	to linear-elliptic	oblong-lanceolate
Leaf size	(7-)12-15(-23)	(2-)3.5-10(-12)	(15-)20-25(-45)
	\times (2-)5(-8) mm	\times 1-3.5(-5) mm	\times (6-)7-8(-15) mm
Petiole size (in fruit)	short or elongate	short	short or subsessile
Cymes	1 or 2(-3)-flowered	1-flowered	3 to several-flowered
Corolla lobes number	4	3(4)	4

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 codominated 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 distribution range of Gailum songaricum is mainly confined to the Central Asian spruce and juniper forests. The closest habitat to the Iranian recorded locality is the high mountains of Kopet Dagh in southern Turkmenistan (Pobedimova, 2000). Based on our recorded locality in NE Iran, it occurs on northwest-faced slopes at the elevations above 2100 m a.s.l. in Hezar-Masjed Mountains. The habitat is a montane steppe which is mainly dominated by thorn-cushion *Onobrychis cornuta* (L.) Desv. and inhabited by another endemic taxon, i.e. *Dianthus polylepis* subsp. *polylepis*.

The new records of *Stipa rechteriana* and *Galium songaricum* extend the distribution range of these Eastern Irano-Turanian species more southwestward 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 KK-E).

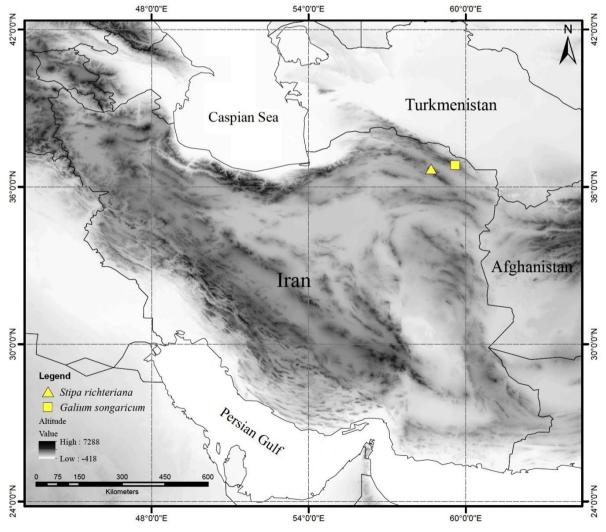


Fig. 3. Distribution map of the newly recorded species *Stipa richteriana* and *Galium songaricum* in Iran.

Their distribution ranges are restricted mainly to lowlands and/or mountains 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 litvinovii Novopokr. (Aydani et al., 2006), Anemone tschernjaewii 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 (Roshev.) Nevski (Memariani et al. 2016c), and Rosa kokanica (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, conservation status of S. richteriana and G. songaricum is provisionally evaluated as (Vulnerable) in Iran.

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