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Authors: Mahmoodi, Mohammad, Maassoumi, Ali-Asghar, and Noroozi, Jalil

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MOHAMMAD MAHMOODI^{1*,2}, ALI-ASGHAR MAASSOUMI¹ & JALIL NOROOZI^{3,4}

A new alpine species and a new record of *Astragalus* sect. *Stereothrix* (*Fabaceae*) from Iran, with comments on the phylogeography of the section

Abstract

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Astragalus issatissensis, a new species of *A.* sect. *Stereothrix* (*Fabaceae*), is described and illustrated from the alpine zone of Shirkuh mountain, Yazd province, in C Iran. It is compared with its presumed closest relative, *A. bavanatensis*. Furthermore, *A. hakkariensis*, also in *A.* sect. *Stereothrix*, is recorded for the first time from West Azerbaijan province in NW Iran. An updated list of species of *A.* sect. *Stereothrix* is presented, distribution maps of all species are given and the distribution patterns in the section are discussed.

Additional key words: alpine flora, *Astragalus bavanatensis*, *Leguminosae*, taxonomy, Turkey

Introduction

Astragalus L. (*Fabaceae*) is probably the largest genus of flowering plants containing up to 3000 species (Lock & Simpson 1991). It is the largest genus in both Iran and Turkey, with species distributed in various habitats. Iran and Turkey are considered as major centres of diversity of the genus (Maassoumi 1998). Approximately 80 species of *Astragalus* are known to grow at alpine areas in Iran, and almost 90 % of these are considered to be endemic to the country (Noroozi & al. 2008).

Astragalus sect. *Stereothrix* Bunge (1868) has undergone many changes since its original description, and there is no constant consensus about its circumscription. Many taxa that were once considered to belong in this section have since been transferred to other sections,

mostly to *A.* sect. *Hypoglottidei* DC. and *A.* sect. *Malacothrix* Bunge (e.g. *A. brachypetalus* Trautv., *A. coodei* D. F. Chamb. & V. A. Matthews and *A. nabelekii* Czeaczott to *A.* sect. *Hypoglottidei*; *A. saganlugensis* Trautv., *A. hirtus* Bunge and *A. stridii* Kit Tan to *A.* sect. *Malacothrix*; *A. autranii* Baldacci to *A.* sect. *Baldaccia* Sytin & Podlech; *A. kurnet-es-saudae* Eig to *A.* sect. *Hololeuce* Bunge; and *A. robertianus* Kit Tan & Sorger to *A.* sect. *Onobrychoidei* DC.).

On the other hand, many new species have recently been described in *Astragalus* sect. *Stereothrix*, which has almost doubled in size over the past 20 years. According to Flora iranica (Podlech & al. 2010, 2012), the section had 12 species in Iran. After the preparation of Flora iranica, *A. montismishoudaghi* Sheikh Akbari Mehr & al. (2011) was published. Counting the new species and new

1 TARI Herbarium, Research Institute of Forests and Rangelands, P.O. Box 13185-116, Tehran, Iran; *e-mail: mahmoodi@rifr-ac.ir (author for correspondence); maassoumi@rifr-ac.ir

2 Department of Plant Biology, Faculty of Biological Sciences, Kharazmi University, 43 Mofatteh Avenue, 15719-14911 Tehran, Iran.

3 Department of Conservation Biology, Vegetation and Landscape Ecology, University of Vienna, Rennweg 14, 1030 Vienna, Austria; e-mail: noroozi.jalil@gmail.com

4 Department of Plant Biology, Faculty of Natural Science, University of Tabriz, Tabriz, Iran.

record published in the present paper, the number of species in the section in Iran has increased to 15. A recent synopsis of *A. sect. Stereothrix* (Ranjbar & al. 2013), in which two further species were described, *A. andabilensis* Ranjbar & Mahmoudian and *A. savanatensis* Ranjbar & al., shows deep contradictions with the treatment of *A. sect. Stereothrix* in *Flora iranica* and we do not agree with its conclusions. We have doubts that the two new species are distinct, but we have not yet had the opportunity to examine the types. Until we can ascertain their status, we prefer to exclude them from the present work.

For Turkey, there is no new revision of *Astragalus* sect. *Stereothrix*. Based on *Flora of Turkey* (Chamberlain & Matthews 1970; Davis & al. 1988; Guner & al. 2000) and counting the more recently published species *A. subhanensis* F. Ghahrem. & Behçet (Ghahremaninejad & Behçet 2003), *A. mahmutlarensis* Podlech (Podlech & Ekici 2008) and *A. chamardiensis* Podlech (2009) and considering changes made in the last version of the checklist of Old World *Astragalus* (Podlech 2011), the number of Turkish species has reached 11. Species of the section also occur in Armenia, Iraq, Syria and Ukraine (one species each). The total number of species in the section currently stands at 25 (see Table 2). All species are hemicyptophytes.

Material and methods

The new species was discovered during a botanical expedition conducted by the first (MM) and third (JN) authors in early July 2012 to the alpine zone of Mt Shirkuh (highest summit 4075 m) in central Iran. After detailed examination of the samples collected and the materials in the herbarium TARI, we concluded that our samples represent a new species. Furthermore, among older materials in TARI, we found *Astragalus hakkariensis* Podlech as a new record for the flora of Iran. In order to provide a preliminary picture of the distribution patterns in *A. sect. Stereothrix*, an up-to-date checklist of accepted names in the section is provided using *Flora Iranica* (Podlech & al. 2010, 2012), *Flora of Turkey* (Chamberlain & Matthews 1970; Davis & al. 1988; Güner & al. 2000), *Flora USSR* (Komarov 1965) and other monographs, revisions and recent articles (Maassoumi 1989, 1998, 2005; Podlech 1999, 2004, 2009, 2011; Ghahremaninejad & Behçet 2003; Podlech & Ekici 2008; Sheikh Akbari Mehr 2011). The locations of records of all species were georeferenced and the distributions were mapped by Diva-GIS (Hijmans & al. 2005). Finally, by grouping of species with similar distributions, the distribution patterns of *A. sect. Stereothrix* were determined. These georeferenced observations include literature records, all herbarium specimens in TARI and some of our personal field observations. Herbarium codes used follow Thiers (2008+).

Results and Discussion

New species

Astragalus issatissensis Maassoumi & Mahmoodi sp. nov. – Fig. 1, 2.

Holotype: Iran, Yazd province, Taft, Deh-e Balla village, Mt Shirkuh, 31°37'04"N, 54°03'55"E, 3800–3900 m, 4 Jul 2012, Mahmoodi & Noroozi 98654 (TARI).

Diagnosis — Haec species *Astragalo bavanatensi* Zarre & Podlech similis, sed petiolis pedunculisque dense ascendenter vel patenter duplicato-pilosis (nec adpresse unicato-pilosis), pilis manifeste basifixis (nec valde asymmetricice medifixis), foliis 9–13(–16)-jugis, imbricatis vel approximatis, complicatis (nec 4- vel 5-jugis, remotiusculis, applanatis), petalis luteolis, dense violaceo-paralleliveniis, in sicco atroviolaceis (nec albido-luteis), vexilli lamina rectangulari (nec orbiculari), alis c. 10 mm (nec c. 7 mm) longis, alarum laminis c. 6.5 × 3 mm (nec c. 3 × 2.5 mm), carina c. 7 mm (nec c. 6 mm) longa, differt.

Description — *Plants* hemicyptophytes, subcaulescent, prostrate, 8–10 cm tall; *caudex* diffusely branched, with short subterranean stolons; *stems* to 2 cm long, densely covered with ± confusedly ascending to spreading rigid hairs 0.2–0.3 mm long. *Leaves* 2–6 cm long; *stipules* narrowly triangular, c. 8 mm long, adnate to petiole for 1.5–2 mm, very shortly vaginate-connate behind stem, rather densely covered with spreading to ascending white hairs to 0.2 mm long; *petiole* 1–2.5 cm long, with two kinds of basifixed hairs: densely covered with confusedly spreading white short hairs to 0.2 mm long mixed with few long hairs to 0.7 mm long; *leaflets* in 9–13(–16) pairs, imbricate or approximate, folded, elliptic, 7–8 × 5–8 mm, both surfaces densely covered with confusedly ascending to nearly spreading hairs 0.3–1 mm long, apex obtuse to rounded. *Peduncle* often recurved, 5–7 cm long, sulcate, like petiole rather densely covered with basifixed ascending white short and long rigid hairs; *raceme* densely many-flowered, 2–2.5 cm wide; *bracts* narrowly triangular, 3.5–4 mm long, covered with white hairs to 1 mm long; *pedicels* very short. *Calyx* funnel-shaped, c. 10 mm long, rather densely covered with confusedly ascending to spreading white hairs 1–1.5 mm long; teeth subulate, c. 6 mm long, hairy on inner surface. *Petals* pale yellow with dense parallel violet veins, in dry state dark violet; *standard* c. 11 × 6 mm, base gradually narrowed with a cuneate claw, blade rectangular, distally gradually narrowed, apex widely retuse to emarginate; *wings* c. 10 mm long, claw c. 4 mm long, auricle c. 0.5 mm long, blade oblong, c. 6.5 × 3 mm, apex rounded; *keel* c. 7 mm long, claw c. 3.5 mm long, auricle absent, blade obliquely obovate, distally with widely rectangular-curved lower edge and minutely concave upper edge, c. 2.5 × 3.5 mm, apex subacute. *Stamen tube* truncate at mouth. *Ovary* sessile, white hairy; *style* glabrous; *stigma* punctate. *Legume* unknown.

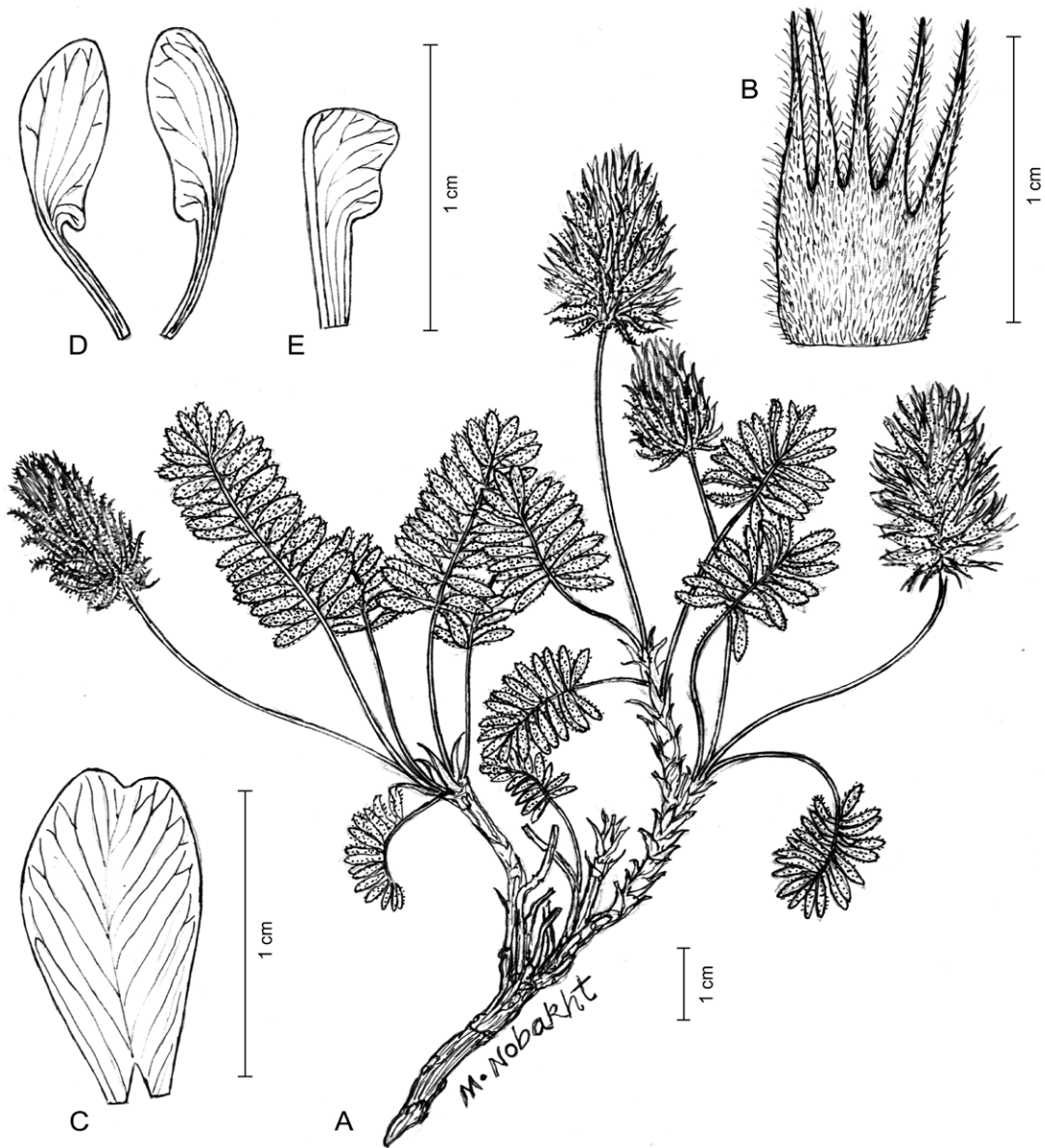


Fig. 1. *Astragalus issatissensis* – A: habit; B: calyx; C: standard; D: wings; E: keel. – Drawn by M. Nobakht from the holotype.

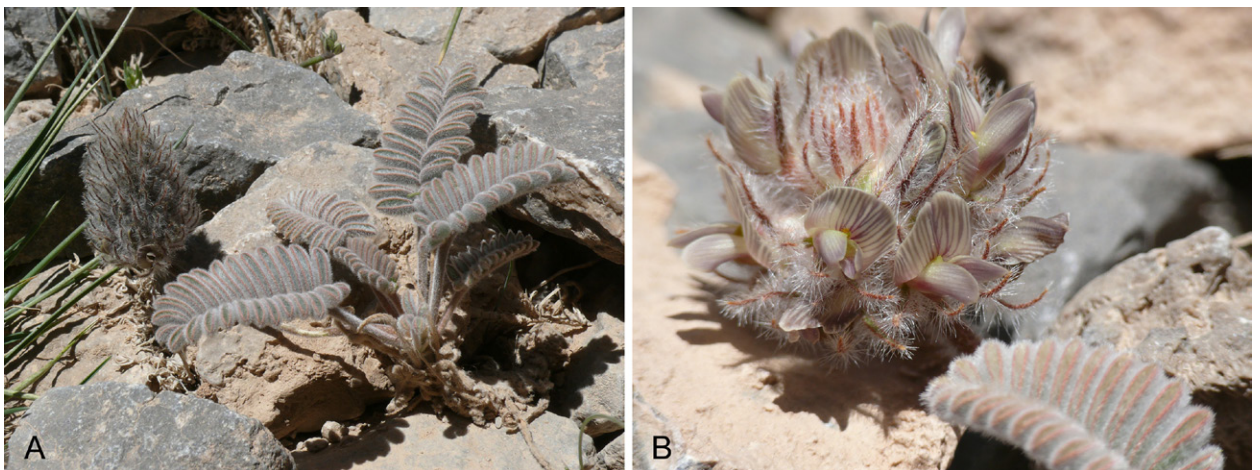


Fig. 2. *Astragalus issatissensis* – A: habit of an individual; B: inflorescence and leaf. – Photographs taken at the type locality, 4 Jul 2012, by J. Noroozi.

Table 1. Morphological differences between *Astragalus issatissensis* and *A. bavanatensis*.

| <i>Morphological characters</i> | <i>Astragalus issatissensis</i> | <i>Astragalus bavanatensis</i> |
|---------------------------------|--|--|
| Stem length | to 2 cm | 1.5–5 cm |
| Stem indumentum | dense ± confusedly ascending to spreading rigid hairs 0.2–0.3 mm long | dense subappressed hairs to 0.5 mm long |
| Leaf length | 2–6 cm | 2–3 cm |
| Stipule length | c. 8 mm | 4–8 mm |
| Stipule connectivity | adnate to petiole for 1.5–2 mm | free from petiole |
| Stipule indumentum | rather densely hairy | laxly hairy |
| Petiole length | 1–2.5 cm | 1–1.5 cm |
| Petiole and peduncle indumentum | densely covered with 2 types of basifixed hairs: short hairs mixed with few long hairs | covered with 1 type of very asymmetrical medifixed hairs |
| Leaflets | 9–13(–16) pairs, imbricate or approximate, folded | 3 or 4 pairs, somewhat remote, flattened |
| Leaflet dimensions | 7–8 × 5–8 mm | 7–12 × c. 3 mm |
| Leaflet indumentum | confusedly ascending to nearly spreading hairs 0.3–1 mm long | ± appressed hairs c. 1 mm long |
| Peduncle length | 5–7 cm | c. 3 cm |
| Bract length | 3.5–4 mm | 2–2.5 mm |
| Calyx indumentum | hairs 1–1.5 mm long | hairs 0.5–1.2 mm long |
| Petal colour | pale yellow with dense parallel violet veins, in dry state dark violet | whitish yellow |
| Standard shape | base gradually narrowed, blade rectangular | base constricted, blade orbicular |
| Standard dimensions | c. 11 × 6 mm | c. 8 × 3 mm |
| Wing length | c. 10 mm | c. 7 mm |
| Wing lamina shape | oblong | narrowly obovate |
| Wing lamina dimensions | c. 6.5 × 3 mm | c. 3 × 2.5 mm |
| Keel length | c. 7 mm | c. 6 mm |
| Ovary indumentum | white hairy | glabrous |

Phenology — Flowering in late June and early July.

Distribution and ecology — Endemic to the alpine zone of Mt Shirkuh (Fig. 3D), growing on screes at 3800–3950 m (possibly up to 4075 m) in altitude.

Conservation status — The new species is known so far only from the highest elevations of Mt Shirkuh above 3800 m. The highest summit of this mountain is about 4075 m. Therefore, both the altitudinal range and geographical distribution of this species are very narrow. With regard to ongoing climate change and its effect on cold-adapted species, the new species could be very vulnerable as there is no possibility of migration to higher elevations. Consequently, following the IUCN Red List criteria (IUCN, 2012) *Astragalus issatissensis* is categorized as Critically Endangered: CR B1ab(iii)+2ab(iii).

Etymology — *Astragalus issatissensis* is named after Issatiss, the old name of the city Yazd in C Iran.

Remarks — The new species is morphologically close to *Astragalus bavanatensis*, which is endemic to the S Zagros mountains, but there are clear differences in pu-

bescence, stipule length, peduncle length, bract length, petal colour, shape, and length and ovary hairs. The morphological characters of these two species are compared in Table 1.

Additional specimen seen (paratype) — IRAN: Yazd province, Taft, Deh-e Balla village, Mt Shirkuh, 3950 m, 24 Jun 2012, A. Dehghani-Esmatabadi. 3520 (Herbarium of Mazandaran University).

New record

Astragalus hakkariensis Podlech in Sendtnera 6: 168. 1999 (*A. sect. Stereothrix*).

Holotype: Turkey, Hakkâri province, 5 km W of Esendere toward Yüksekova, 1720 m, 24 Jul 1983, M. Nydegger 18427 (MSB; isotype: BASBG).

Material examined: Iran, West Azerbaijan province, Urmiye, Nazlu, 16 Jun 1981, Tarighi & Amini 1351 (TARI).

This specimen was determined as *Astragalus barbatus* Lam. by Maassoumi (1989), before the publication of *A. hakkariensis*, and later as *A. pseudocapito* Podlech by

Table 2. Checklist of species of *Astragalus* sect. *Stereothrix* including their distribution, altitudinal range and number of records. All species listed are hemicyptophytes. Asterisks (*) indicate new treatments after Flora iranica (Podlech & al. 2010; 2012). – Country codes: AM = Armenia; IR = Iran; IQ = Iraq; SY = Syria; TR = Turkey; UA = Ukraine.

| Species | Distribution | Altitudinal range [m] | No. of records |
|---|--------------|-----------------------|----------------|
| <i>Astragalus altimontanus</i> Podlech & Maassoumi | IR | c. 2250 | 1 |
| <i>Astragalus barbatus</i> Lam. | AM, TR | 1900–3100 | 5 |
| <i>Astragalus bavanatensis</i> Zarre & Podlech | IR | 1800–2200 | 2 |
| <i>Astragalus capito</i> Boiss. & Hohen. | IR | 2250–3850 | 10 |
| <i>Astragalus chamardiensis</i> Podlech | TR | c. 1400 | 1 |
| <i>Astragalus chamberlainianus</i> Sümbül | TR | 1300–1400 | 1 |
| <i>Astragalus damghanensis</i> Podlech | IR | c. 1450 | 1 |
| <i>Astragalus doshman-ziariensis</i> Maassoumi & Podlech | IR | 1900–2500 | 1 |
| <i>Astragalus hakkariensis</i> Podlech* | IR, TR | 1720–2500 | 5 |
| <i>Astragalus hispidus</i> Labill. (= <i>A. nanus</i> DC.) | SY, TR | 1100–2350 | 10 |
| <i>Astragalus issatisensis</i> Maassoumi & Mahmoodi* | IR | 3800–3950 | 2 |
| <i>Astragalus koelzii</i> Barneby | IR | c. 2000 | 1 |
| <i>Astragalus ledinghamii</i> Barneby | IR | 420–2800 | 27 |
| <i>Astragalus leucothrix</i> Freyn & Bornm. | TR | 800–2300 | 4 |
| <i>Astragalus mahmutlarensis</i> Podlech | TR | c. 1270 | 1 |
| <i>Astragalus mahneshanensis</i> Maassoumi & Moussavi | IR | c. 2950 | 1 |
| <i>Astragalus montismishoudaghi</i> Sheikh Akbari Mehr & al.* | IR | c. 1930 | 1 |
| <i>Astragalus montis-varvashti</i> Podlech | IR | 3500–4100 | 1 |
| <i>Astragalus podosphaerus</i> Boiss. & Hauskn. | IR | 2200–3350 | 3 |
| <i>Astragalus pseudocapito</i> Podlech | IR | 1700–1900 | 2 |
| <i>Astragalus setosulus</i> Gontsch. | UA | c. 1200 | 1 |
| <i>Astragalus sorgerae</i> Hub.-Mor. & D. F. Chamb. | TR | 1150–1600 | 2 |
| <i>Astragalus sparsipilis</i> Hub.-Mor. & D. F. Chamb. | TR | c. 1800 | 2 |
| <i>Astragalus sphaeranthus</i> Boiss. | IQ, IR, TR | c. 3320 | 8 |
| <i>Astragalus subhanensis</i> F. Ghahrem. & Behçet | TR | c. 2300 | 1 |

Podlech & al. (2010). However, we examined the specimen carefully and found that its characters match exactly the description of *A. hakkariensis*. Among the species of *A.* sect. *Stereothrix*, *A. hakkariensis* is the only one with a very long standard. This species was previously considered endemic to SE Turkey (Podlech 1999). The new locality in Iran is only c. 40 km from the type locality (Fig. 4A).

Phytogeography of *Astragalus* sect. *Stereothrix*

With 25 species, *Astragalus* sect. *Stereothrix* is a medium-sized section in the genus (Mahmoodi & al. 2012). A list of the species accepted in this section is presented in Table 2. For convenience, authors of the names are omitted in the following notes but may be found in Table 2.

The distribution of *Astragalus* sect. *Stereothrix* is almost entirely confined to Iran and Turkey. Exceptions are *A. setosulus*, known only from the type locality in the Crimean Peninsula, Ukraine; *A. barbatus* and *A. hispidus*,

two Turkish subendemics each also with one record from Armenia and Syria, respectively; and *A. sphaeranthus*, recorded from NE Iraq as well as from SE Turkey and Iran. Most of the species are local endemics and many of them are well-adapted to high elevations (Mahmoodi & al. 2009). Outlining the exact phytogeographical status of *A.* sect. *Stereothrix* is very difficult due to the deficit of data. More than half of the species are recorded only from the type localities and only five species have more than five records. The most-recorded species is *A. ledinghamii* with 27 records. The circumscription of *A.* sect. *Stereothrix* is not stable, and the boundaries between *A.* sect. *Hololeuce*, *A.* sect. *Hypoglottidei*, *A.* sect. *Malacothrix* and *A.* sect. *Stereothrix* are not definitely clear. Without intending to draw any phytogeographical conclusions, based on the available data, the species of *A.* sect. *Stereothrix* can be categorized in five distributional groups, as follows:

1. *Distribution in the Alborz Mountains with an extension to the west* (Fig. 3A–C) — There are four endemic

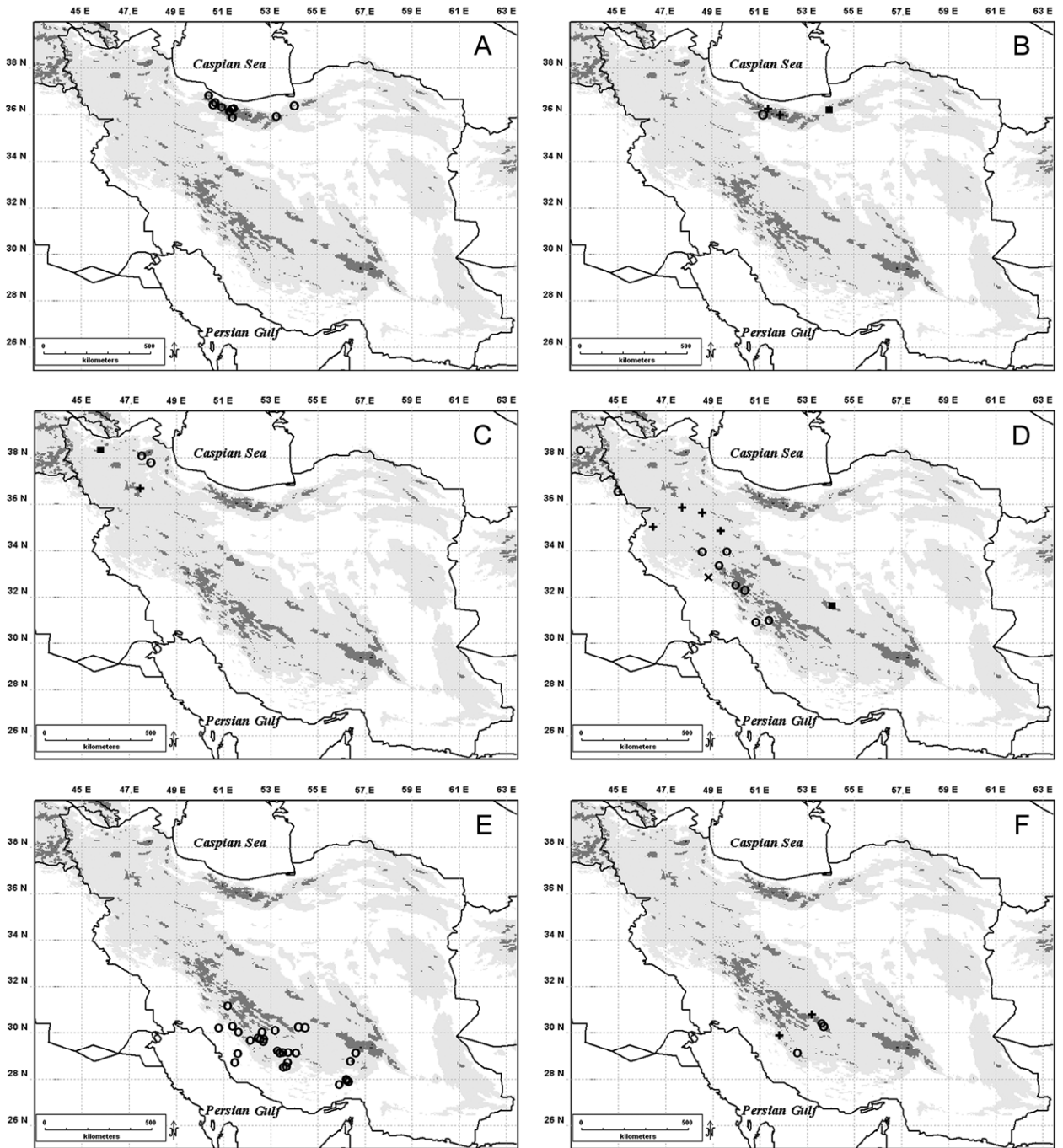


Fig. 3. Distribution of endemic and subendemic species of *Astragalus* sect. *Stereothrix* in Iran – A–C: species distributed in the Alborz Mountains with an extension to the west: A: *A. capito* (○); B: *A. altimontanus* (○), *A. damghanensis* (■) and *A. montis-varvashti* (+); C: *A. mahneshanensis* (+), *A. montismishoudaghi* (■) and *A. pseudocapito* (○); D: species distributed in the C and N Zagros Mountains extending to NE Iraq and SE Turkey: *A. issatisensis* (■), *A. koelzii* (×), *A. podosphaerus* (+) and *A. sphaeranthus* (○); E, F: species distributed in the S Zagros Mountains; E: *A. ledinghamii* (○); F: *A. bavanatensis* (○) and *A. doshman-ziariensis* (+).

species in the C Alborz Mountains (Fig. 3A, B), each belonging to a certain altitudinal zone. They are *Astragalus damghanensis* (montane zone), *A. altimontanus* (sub-alpine zone), *A. capito* and *A. montis-varvashti* (alpine and subnival zones). The distribution extends from the Alborz Mountains to Iranian Azerbaijan (Fig. 3C) with *A. mahneshanensis*, *A. montismishoudaghi* and *A. pseu-*

dopapito. Although *A. capito* has been reported from the E Anatolian mountains (Chamberlain & Matthews 1970), the presence of this species in Turkey is doubtful, and we follow Podlech & al. (2010), who recently considered it as endemic to the Alborz Mountains. All species of this group are local endemics and most have been recorded only from the type localities. Nearly all species

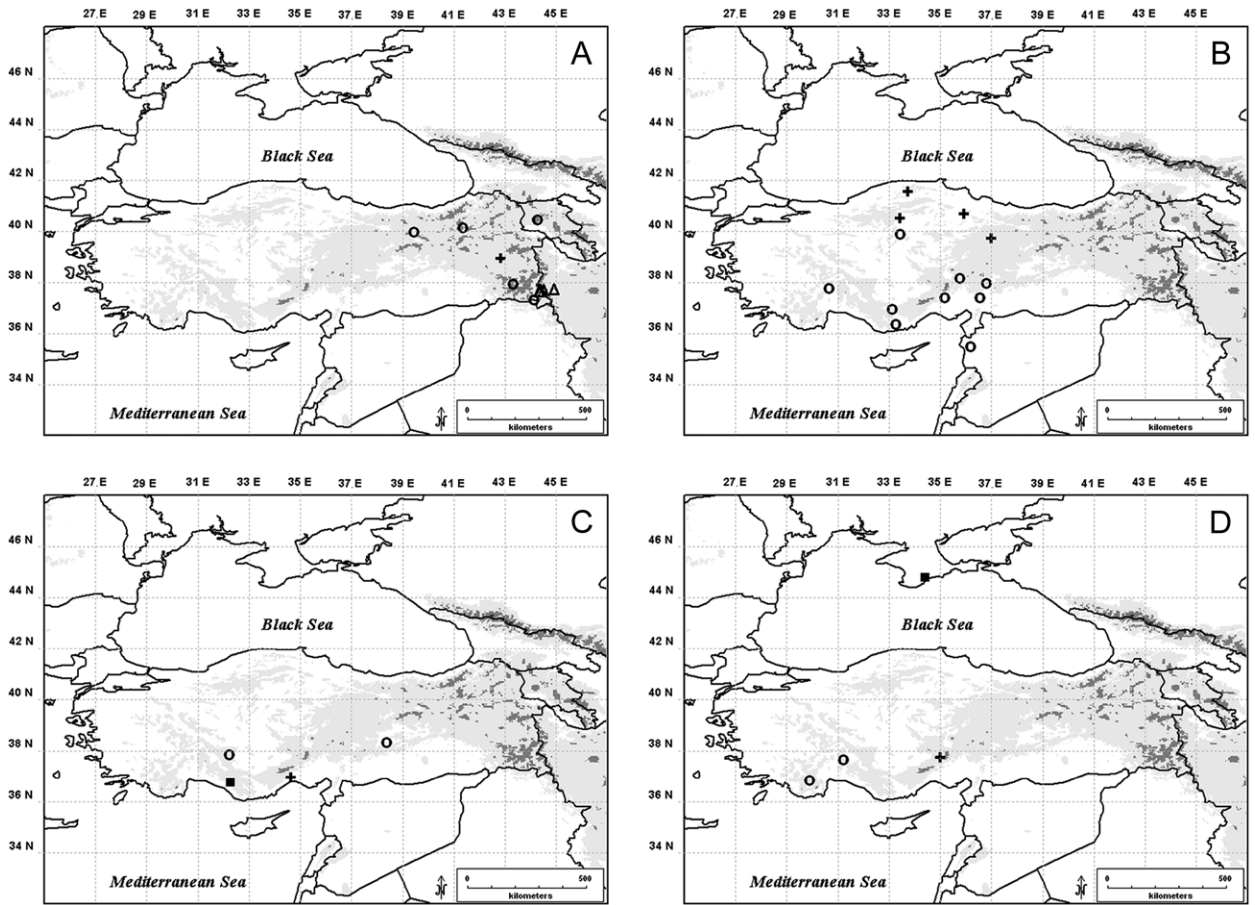


Fig. 4. Distribution of endemic and subendemic species of *Astragalus* sect. *Stereothrix* in southeastern Europe and Turkey – A: species distributed in E Anatolia: *A. barbatus* (○), *A. hakkariensis* (△) and *A. subhanensis* (+); B–D: species distributed in C Anatolia; B: *A. hispidus* (○) and *A. leucothrix* (+); C: *A. chamberlainianus* (+), *A. mahmutlarensis* (■) and *A. sparsipilis* (○); D: *A. chamardiensis* (+), *A. setosulus* (■) and *A. sorgerae* (○).

are morphologically close to each other. The exception is *A. montismishoudaghi*, which is somewhat close to *A. ledinghamii*, with a large geographical disjunction between the two species (Sheikh Akbari Mehr & al. 2011). Based on unpublished molecular data, these two species are distinct (Kazempour Osaloo, pers. comm.).

2. *Distribution in the C and N Zagros Mountains extending to NE Iraq and SE Turkey* (Fig. 3D) — There are four species in this group. *Astragalus issatissensis*, described here, is endemic to the C Zagros Mountains; *A. podosphaerus* is known from only four localities in the N Zagros Mountains; and *A. sphaeranthus* is rather widespread in the C Zagros Mountains extending to NE Iraq and SE Turkey. The remaining species in this group is *A. koelzii* which, despite numerous attempts by the second of the present authors (Maassoumi), has not been recorded since the type specimen was collected.

3. *Distribution in the S Zagros Mountains* (Fig. 3E, F) — There are three related species, *Astragalus bavanatensis*, *A. doshman-ziariensis* and *A. ledinghamii* restricted to the S part of the Zagros Mountains. Among these, *A.*

ledinghamii has the widest distribution of *A. sect. Stereothrix* in Iran (Fig. 3E) and represents the southern limit of the section. Unlike other Iranian species in *A. sect. Stereothrix*, the species of this group grow at relatively low altitudes (average altitude: 1550 m).

4. *Distribution in E Anatolia* (Fig. 4A) — This group comprises three species: *Astragalus barbatus*, *A. hakkariensis* and *A. subhanensis*. The most abundant is *A. barbatus*, the type specimen of which is from Armenia. The other two species were recently described from the S part of E Anatolia, and *A. hakkariensis* is recorded here from adjacent NW Iran.

5. *Distribution in C Anatolia* (Fig. 4B–D) — One of the most important centres of diversity in *Astragalus* sect. *Stereothrix* is C Anatolia, which has the following seven species: *A. chamardiensis*, *A. chamberlainianus*, *A. hispidus*, *A. leucothrix*, *A. mahmutlarensis*, *A. sorgerae* and *A. sparsipilis*. Almost all the species in this area have been recorded from low altitudes (1100–1800 m). *Astragalus hispidus* (*A. nanus* DC.) is widespread in the S part of C Anatolia (Fig. 4B) and its type is from NW

Syria. In contrast, the N part of the area is occupied by *A. leucothrix* (Fig. 4B). The other five species, each with one or two records, are locally endemic within a range of about 2° latitude in the S part of C Anatolia (Fig. 4C, D). *Astragalus setosulus* is the only representative of the section in Europe, described from the Crimean Peninsula on the Black Sea coast of Ukraine. It is an isolated species representing the northern limit of the distribution of *A.* sect. *Stereothrix* (Fig. 4D). In this paper, the latter species is considered as a member of the C Anatolian distribution group.

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