



Typification and an emended description of *Astragalus moussavii* (Fabaceae, Papilionoideae)

FARROKH GHahremaninejad^{1,4*}, ATIYE NEJAD FALATOURY^{2,5} & FARSHID MEMARIANI^{3,6}

¹Department of Plant Sciences, Faculty of Biological Sciences, Kharazmi University, Postal Code 15719-14911, Tehran, Iran.

²Iranian Research Institute of Plant Protection, Agricultural Research, Education and Extension Organization (AREEO), 19858-13111, Tehran, Iran.

³Herbarium FUMH, Department of Botany, Research Center for Plant Sciences, Ferdowsi University of Mashhad, Mashhad, Iran.

⁴✉ ghahremaninejad@khu.ac.ir; <https://orcid.org/0000-0001-5860-9976>

⁵✉ a.falatoury@areeo.ac.ir; <https://orcid.org/0000-0003-3522-3717>

⁶✉ memariani@um.ac.ir; <https://orcid.org/0000-0001-5478-1859>

*Author for correspondence.

Abstract

Type materials of *Astragalus moussavii* (Fabaceae) are designated as a lectotype and four isolectotypes. An epitype for the species is designated here too. An emended description of *A. moussavii* is provided with illustrations and information on several morphological characters not indicated in the protologue, including the size and shape of the terminal leaflet, petals characteristics, fruit and seed features. Based on field observations, a brief description of the habitat and data on ecology and biogeography of the species are provided and its conservation status is evaluated.

Keywords: gypsophyte, Iran, Leguminosae, nomenclature, Papilionaceae, section *Dissitiflorii*, section *Xiphidium*

Introduction

Astragalus L. (“Gævæn” in Persian language) is the largest genus of the plant kingdom, with approximately 3000 species including more than 8000 valid and invalid names (based on International Plant Names Index, IPNI 2019). If we accept the estimated number of 295,383 species for the angiosperms (Christenhusz & Byng 2016), then the huge genus *Astragalus* alone represents a little more than one percent of the flora of angiosperms in the world. It is also the major genus of flowering plants in the territory of Iran, with more than 60% endemism (Bidarlord *et al.* 2016). This genus is a member of the legume family or Fabaceae and is generally ordered in the tribe Galegeae (Bronn.) Torr. & Gray. *Astragalus* comprises around 10.5 percent of the flora of Iran (Ghahremaninejad 2015). The number of known (published and valid) species of *Astragalus* in Iran is around 840 up to today (Ghahremaninejad & Joharchi 2020).

Sometimes it is not possible to define the range of characteristics of a species, by using the published descriptions, and it is necessary to study multiple herbarium specimens and records of their habitats. The example of this case is *Astragalus moussavii* Maassoumi, F.Ghahrem. & Ghahr. (2000: 353). At first, it seemed that Memariani’s newly collected specimens of Sorkheh (*Memariani 46538*) to be a new species and close relative to *A. moussavii*. But with further studies, it became clear that Memariani’s specimens do not necessarily belong to a new species, although it does not fit perfectly with the original description of *A. moussavii*. It is worth noting that one of the authors of the present work has been one of the authors of *A. moussavii*. Therefore, after observing other specimens and studying in its environment, it was revealed that the description of *A. moussavii* needs to be emended.

Here we attempt to provide a more complete description for *Astragalus moussavii*. Morphological evidence such as bifurcated hairs, free stipules, imparipinnate leaves, absence of the bracteoles, cylindrical calyx (not becoming inflated), glabrous petals, bilocular and coriaceous pod longer than the calyx, support taxonomic placement of this species in *Astragalus* sect. *Dissitiflori* DC. (1825: 284). This section is a bifurcated-hair taxon which comprises 166 species with 21 species in Iran, of which more than half are endemic (estimated from data in Podlech & Zarre 2013). The section is the largest bifurcated-hair section of the genus *Astragalus*. The center of diversity of section *Dissitiflori* is the Turkestanian and Armeno-Iranian floristic provinces of the Irano-Turanian region (Takhtajan 1986). Its vast

distribution covers a wide range from Europe over all the former Soviet Union, from Turkey to the Near East, Iraq, Iran, Afghanistan, Pakistan, India, China and Mongolia (Podlech & Zarre 2013).

Material and methods

The present study was carried out through analysis and examination of specimens kept in the herbaria FAR, FUMH, IRAN, T, TARI and W (herbaria acronyms follow Thiers 2019+) using the relevant literature (Maassoumi *et al.* 2000, Podlech *et al.* 2010, Podlech & Zarre 2013, Maassoumi 2018). The threat status of the species was determined based on the IUCN Red List categories and criteria (IUCN 2016).



FIGURE 1. The lectotype of *Astragalus moussavii* Maassoumi, F.Ghahrem. & Ghahr.; M. Moussavi & M. Tehrani s.n. (58014/3-IRAN!).



FIGURE 2. The epitype designated for *Astragalus moussavii*: M. Moussavi, F. Termeh & M. Tehrani s.n. (55308-IRAN!) and a close view of a fruit.

Results and discussion

Typification of *Astragalus moussavii*

Astragalus moussavii Maassoumi, F.Ghahrem. & Ghahr. (2000: 353) was first described from Iran (Semnan) based on two herbarium specimens collected by M. Moussavi & M. Tehrani in 1993. In protologue, it had mentioned that the holotype is deposited at IRAN herbarium and the isotype at TARI herbarium. But in recent visiting IRAN by the authors, we found three specimens (Fig. 1, 4 A, B). Therefore, we designated here *M. Moussavi* & *M. Tehrani* s.n. (58014/3-IRAN) as lectotype specimen and two other sheets of these specimens deposited in IRAN (58014/1,2-IRAN), one specimen in TARI and another in W as isolectotypes.

The type materials of *A. moussavii* do not have ripened fruit. The fruit features are important for separation of many species in the genus *Astragalus* and usually are used in the identification keys (i.e. Brullo *et al.* 2012, Estrada Castellón *et al.* 2020). For this species, it is more significant, because in the literature the descriptions have not mentioned the mature fruit status. The fruit characteristics are always beneficial in section *Dissitiflori*. Thus, according to the article 9.9 of the International Code of Nomenclature for algae, fungi, and plants (ICN) (Turland *et al.* 2018), an epitypification is needed for this species. We designate here *M. Moussavi*, *F. Termeh* & *M. Tehrani s.n.* (55308-IRAN!) specimen (including ripe fruits) (Fig. 2) as an epitype for *A. moussavii*.

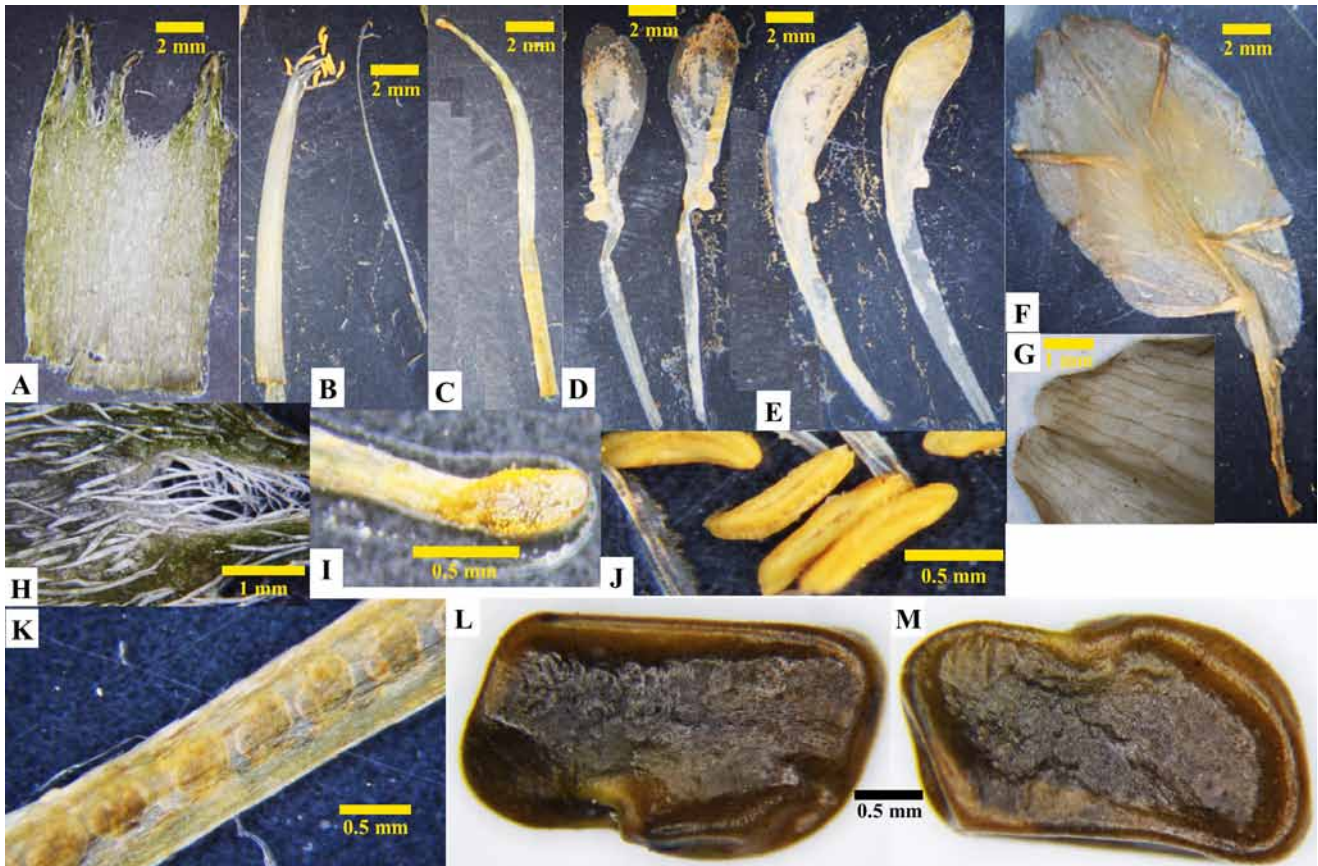


FIGURE 3. *Astragalus moussavii*. A. Calyx; B. Stamens; C. Carpel; D. Wings; E. Keel; F. Standard; G. Apex of standard; H. Indumentum of calyx; I. Stigma; J. Anthers; K. Ovules in ovary; L, M. Side view of a seed.

Emended description of *Astragalus moussavii*

There are several descriptions for this species. The first is the original description which was written by considering two specimens (holotype: IRAN!, isotype: TARI!). The second one is in “Flora Iranica” (Podlech *et al.* 2010: 248), the third in “A taxonomic revision of the genus *Astragalus* L.” (Podlech & Zarre 2013: 1915) and the fourth one in “Flora of Iran” (Maassoumi 2018: 643-644).

The most complete description in English language up to now is published by Podlech & Zarre (2013: 1915). It is an almost precise description. Here we use the data from lectotype, isolectotypes, other specimens in IRAN, TARI and newly collected plant specimens in FUMH and T herbaria.

Recollecting and photography of *A. moussavii* revealed to us more details from this species, e.g. its petals’ color in the living form which is pink, white, and yellow (Fig. 7) and after drying the color of petals converts to yellow and brown (Figs. 1, 2, 3), and the variations in size of plant parts and in shape of flower parts and terminal leaflets (Fig. 3). The emended description is prepared by using several specimens that are mentioned, and have been broadly based on the detailed description of the species in Podlech & Zarre (2013).

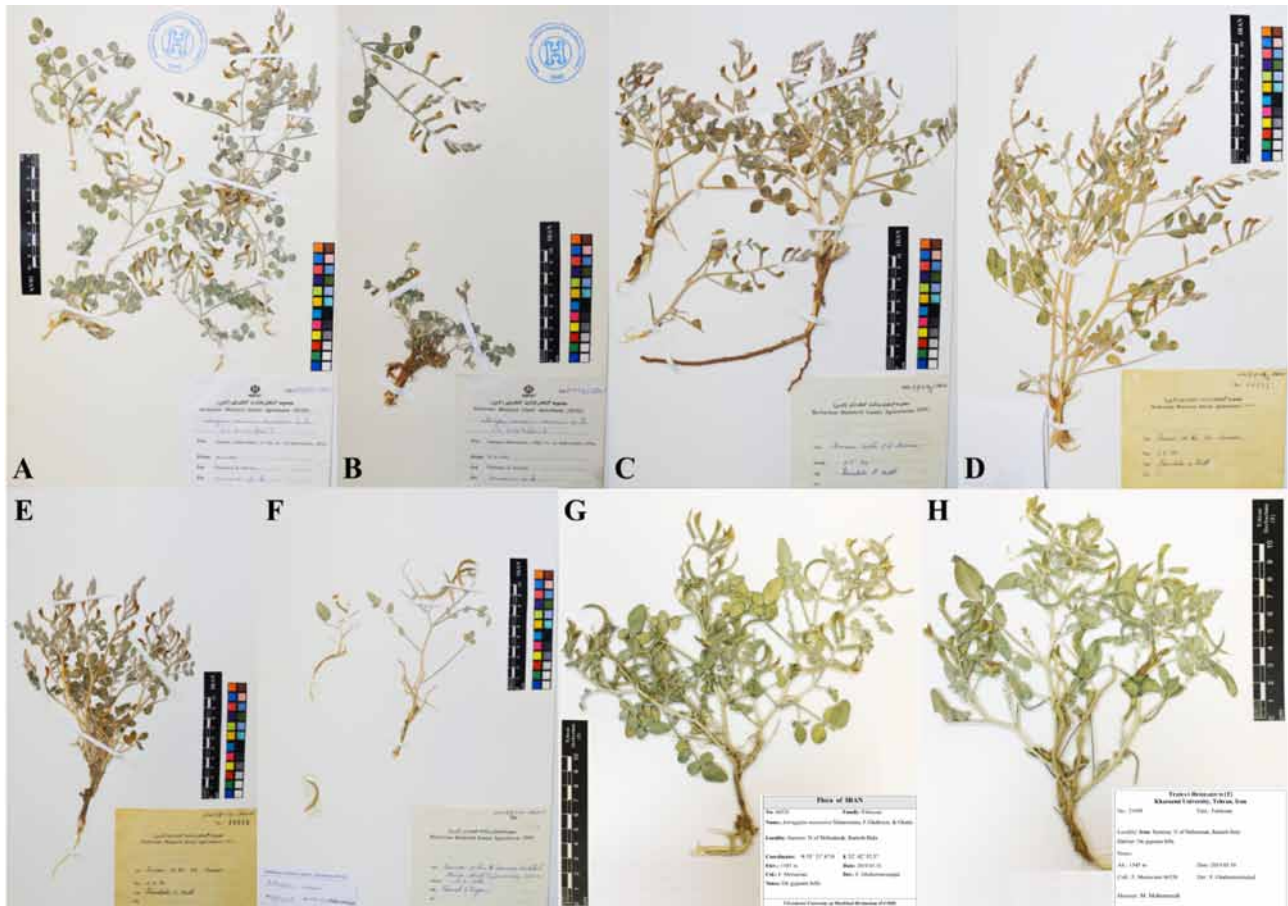


FIGURE 4. *Astragalus moussavii*. A. 58014/1-IRAN (isolectotype); B. 58014/2-IRAN! (isolectotype). C, D. *M. Iranshahr & H. Riedl 40881-E* (58014/1,2-IRAN!); E. *M. Iranshahr & H. Riedl 16046* (58015-IRAN!); F, F. *Termeh & A. Zargani 41144* (58010-IRAN!); G, H. *F. Memariani 46538* (FUMH!, 21999-T!).

Astragalus moussavii Maassoumi, F.Ghahrem. & Ghahr., *Nordic Journal of Botany* 20: 353 (2000) emend. F.Ghahrem.

Lectotype (designated here):—IRAN. Prov. Semnan, 13 km South of Rokn-Abad, 890 m, 28 May 1993, *M. Moussavi & M. Tehrani s.n.* (58014/3-IRAN!) (Fig. 1).

Isolectotypes (designated here):—IRAN. Prov. Semnan, 13 km South of Rokn-Abad, 890 m, 28 May 1993, *M. Moussavi & M. Tehrani s.n.* (58014/1,2-IRAN!, TARI!, W!) (Fig. 4 A, B).

Epitype (designated here):—IRAN. Prov. Semnan, Momen-Abad, 5 km W of Momen-Abad, 1100-1130 m, 31 May 1995, *M. Moussavi, F. Termeh & M. Tehrani s.n.* (55308-IRAN!) (Fig. 2).

Plants 15-40 cm tall. Stems 2-25 cm, branched, densely to very densely covered with medifixed, appressed white hairs (0.5-)0.6-1 mm. Stipules 2-5 mm, from wide base narrowly triangular acuminate, adnate to the petiole for 1-1.5 mm, with sparsely to loosely appressed white hairs, sometimes with a few black hairs mixed in, at the margins also with basifixed hairs. Leaves imparipinnate or very rarely simple; (3)4-10 cm; petiole 1-4 cm, like the rachis stout, loosely to rather densely hairy like the stem. Leaflets in 1-4(5) pairs, remote, orbicular, elliptic to obovate, 6-20 × 5-13 mm, the terminal one larger, (10-)15-30 × 7-15 mm, all subacute to widely rounded and often minutely mucronulate, on both sides loosely to rather densely covered by 0.8-1.2 mm long appressed white hairs. Peduncles 0.3-7 cm, strong, loosely to rather densely hairy like the stem. Racemes 3.5-12 cm long, loosely 6-18-flowered, elongated in fruit; axis white hairy like the peduncle. Bracts yellowish-membranous, 0.5-5 mm long, narrowly ovate-triangular, covered with appressed white hairs, sometimes with few black hairs mixed in, at the margins also with basifixed hairs. Pedicels c. 1 mm, hairy. Calyx 15-21 mm, tubular, rather densely covered with symmetrically to slightly asymmetrically bifurcate, appressed white hairs 0.8-1 mm, sometimes with few short black hairs mixed in; teeth subulate, 1-5(-6) mm, densely covered with thin, flexuose white hairs on the inner side. Petals yellow to brown in dry form; standard pink, pinkish-

purple, pinkish-white, greenish-yellow to white in natural state; wing and keel white to yellow-green in natural state. Standard 19-23 mm; blade obovate to elliptic, 8-11 mm wide, slightly emarginate, at the base gradually narrowed into the short, cuneate claw. Wings 19-21 mm; blades obovate, obtuse, $7.5-8 \times 3-4$ mm; auricle round, c. 1 mm, claw 11-13 mm. Keel 18-21 mm; blades obliquely elliptic, with widely curved lower edge and sigmoid upper edge, acute, $7.5-9 \times 2.5-3$ mm; auricle indistinct up to 1 mm long, claw 10-12 mm. Stamen-tube 20-21 mm, truncate at the mouth. Ovary with a stipe 1-3 mm, linear, hairy; style glabrous to hairy at the base. Legumes linear, curved, bilocular, acute, 4-5 cm long, 2.5-3.2 mm wide, with 1.5-3 mm beak, valves with appressed white hairs. Seeds oblong, olive-brown, ca. 3.1×1.7 mm.



FIGURE 5. Distribution map of *Astragalus moussavii*.

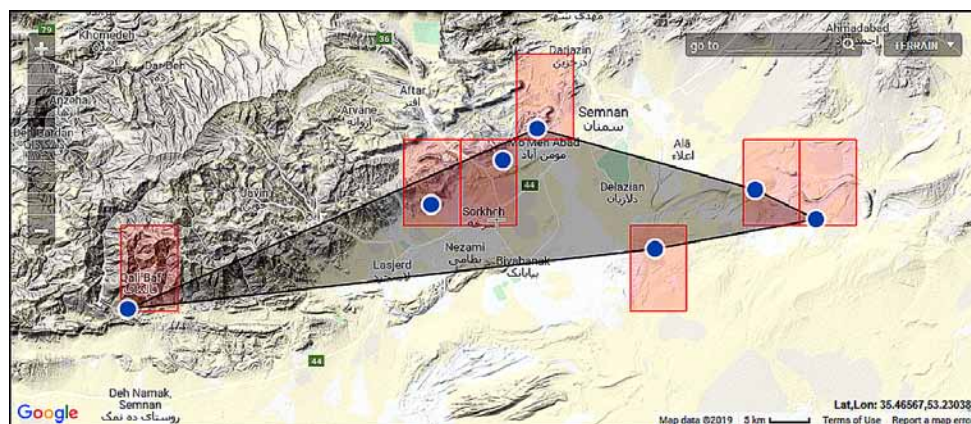


FIGURE 6. Local distribution map of *Astragalus moussavii* and estimation of the extent of occurrence (EOO) and the area of occupancy (AOO) based on the IUCN Red List criteria.

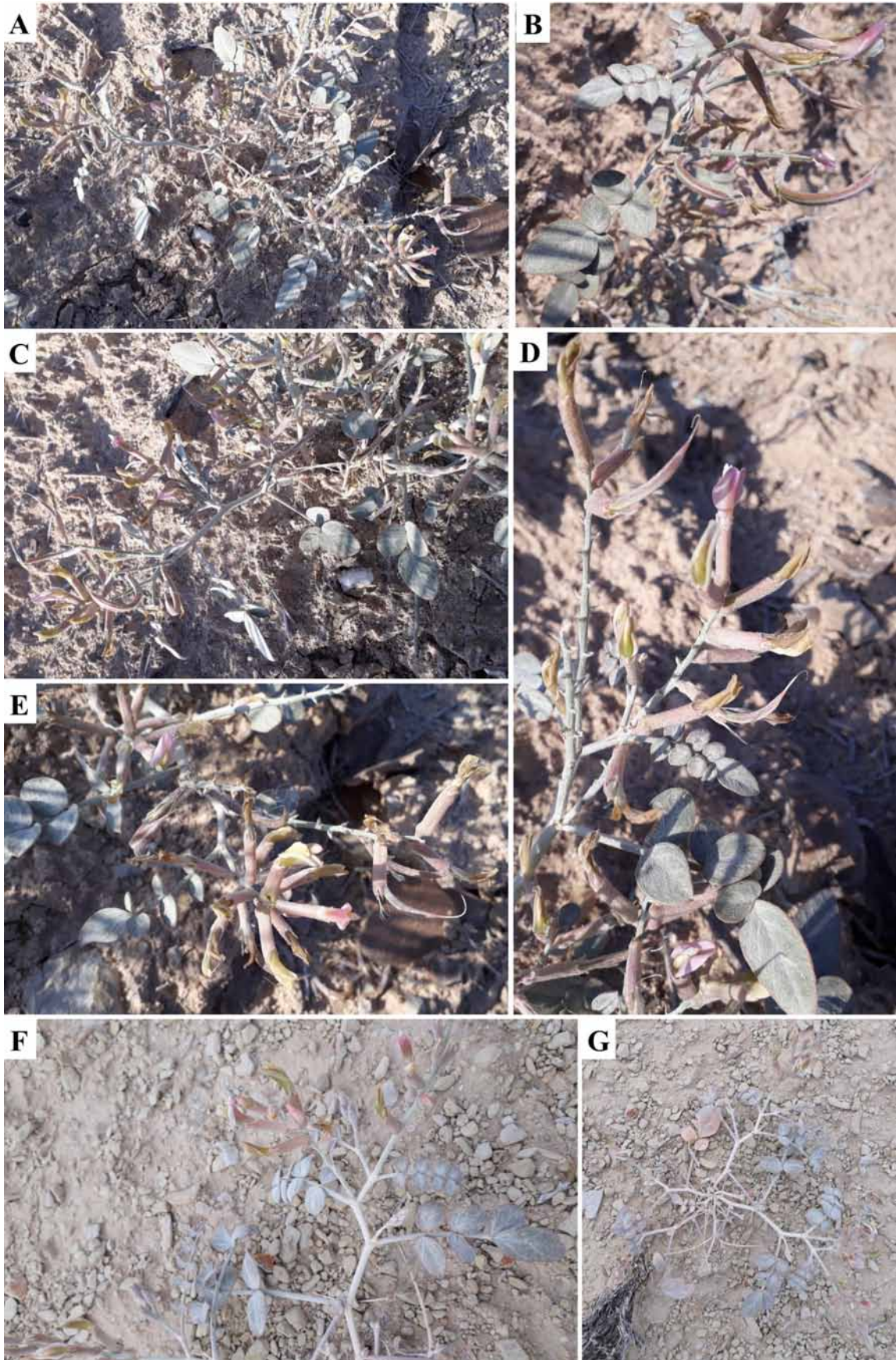


FIGURE 7. *Astragalus moussavii* in natural habitat. A–E. Semnan, N Dehnamak, Rameh-Bala, on gypsum hills, N35° 21' 47.0" E52° 42' 52.5", 1545 m, 16 May 2019, Photo by *F. Memariani*; F–G. Semnan, NW Sorkheh, near Sahand gypsum mine, on gypsum hills, N35° 28' 56.6", E53° 08' 22.1", 1365 m, 17 May, Photos by *F. Memariani*.

Ecology and biogeography: *Astragalus moussavii* is a narrowly endemic plant known only from a few locations on foothills of Central Alborz Mountains southeast, south, and west-southwest of Semnan, Iran (Fig. 1, 2). It is a gypsophyte growing mainly on gypsum hills with high soil gypsum content usually more than 25 percent. The elevation of the distribution area ranges between 900-1600 m a.s.l. The area is covered mainly by lower montane steppe vegetation and dominated by thorny-cushion like xerophyte and dwarf shrubs including the well-known gypsum plant species *Acantholimon cymosum* Bunge, *Astragalus fridae* Rech.f., *Astragalus semnanensis* Bornm. & Rech.f., *Diploaxis harra* (Forssk.) Boiss., *Gypsophila mucronifolia* Rech.f., and *Moltkia gypsacea* Rech.f. & Aellen.

Based on the IUCN Red List categories and criteria (IUCN 2016), *Astragalus moussavii* has a restricted extent of occurrence (EOO=771 km²) and area of occupancy (AOO=534 km²) with the maximum distance of 90 km between any pair of population localities (Fig. 5, 6). According to the very peculiar habitats of gypsum hills, severe grazing pressure, and also very fragmented populations, this endemic species is globally evaluated as Endangered [EN, B1ab (i, iii)]. The urgent conservation practices are highly recommended to protect the unique gypsum ecosystems in the area inhabited by several endemic gypsophytes, in accordance as already undertaken in other endangered ecosystems worldwide for *in situ* conservation (Hanski 2011, Maes *et al.* 2012, Perrino *et al.* 2013, Perrino *et al.* 2014).

Specimens examined

—IRAN. Prov. Semnan, 20 km SE Semnan, 02 May 1974, *M. Iranshahr & H. Riedl 40881-E* (58014/1,2-IRAN!); 30 km SE Semnan, 02 May 1974, *M. Iranshahr & H. Riedl 16046* (58015-IRAN!); 31 km W of Semnan, Sorkheh, Momen-Abad (gypsum), 1200-1350 m, 19 May 1982, *F. Termeh & A. Zargani 41144* (58010-IRAN!); 13 km South of Rohn-Abad, 890 m, 28 May 1993, *M. Moussavi & M. Tehrani s.n.* (Lectotype: 58014/3IRAN; Isolectotypes: 58014/1,2-IRAN!, TARI!, W!); Momen-Abad, 5 km W of Momen-Abad, 1100-1130 m, 31 May 1995, *M. Moussavi, F. Termeh & M. Tehrani s.n.* (55308-IRAN!); N of Dehnamak, Rameh-Bala, on gypsum hills, N35° 21' 47.0" E52° 42' 52.5", 16 May 2019, 1545 m, *F. Memariani 46538* (FUMH!, T!) (Figs. 1,2,4,7).

Acknowledgements

The authors appreciate all the following herbaria for helping to access to the plant specimens FAR, FUMH, IRAN, T, TARI, and W. Special thanks to Dr. John Edmondson (Kew, UK) for linguistic correction of the manuscript. We appreciate Mohammad Reza Joharchi (FUMH) for his constructive comments on our work. This study was partly supported by the project H2020-MSCA-RISE-GYPWORLD (funded by the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie Grant Agreement No. 777803) for F. Memariani.

References

- Bidarlord, M., Ghahremaninejad, F. & Maassoumi, A.A. (2016) A new species of the genus *Astragalus* (Leguminosae) from Northwest Iran. *Phytotaxa* 252: 280–284.
<https://doi.org/10.11646/phytotaxa.252.4.4>
- Burillo, S., Giusso del Galdo, G. & Musarella, C.M. (2012) Taxonomic revision of *Astragalus angustifolius* group (Fabaceae). *Bocconea* 24: 19–52.
- Christenhusz, M.J.M. & Byng, J.W. (2016) The number of known plant species in the world and its annual increase. *Phytotaxa* 261 (3): 201–217.
<https://doi.org/10.11646/phytotaxa.261.3.1>
- De Candolle, A.P. (1825) *Astragaleae in Prodromus Systematis Naturalis Regni Vegetabilis* 2: 281–307. Parisii: Sumptibus Sociorum Treuttel et Würtz.
- Estrada Castellón, E., Villarreal Quintanilla, J.A. & Encina Domínguez, J.A. (2020) A new species and a new section of *Astragalus* (Fabaceae: Papilionoideae) from Mexico. *Phytotaxa* 428 (3): 163–172.
<https://doi.org/10.11646/phytotaxa.428.3.1>
- Ghahremaninejad, F. (2015) Notes about *Astragalus* (Leguminosae) in Iran. *Annalen des Naturhistorischen Museums in Wien* 117 B: 279–281.
- Ghahremaninejad, F., Ataei, N. & Nejad Falatoury, A. (2017) Comparison of angiosperm flora of Afghanistan and Iran in accordance with

APG IV system. *Nova Biologica Reperta* 4: 73–97.

<https://doi.org/10.21859/acadpub.nbr.4.1.74>

- Ghahremaninejad, F. & Joharchi, M.R. (2020) 840th species of genus *Astragalus* (Fabaceae) for the flora of Iran from Khorassan Province as a new record: *A. globiceps* Bunge. *Journal of Plant Research* 32 (4): 906–910. [http://plant.ijbio.ir/article_1701.html]
- Hanski, I. (2011) Habitat loss, the dynamics of biodiversity, and a perspective on conservation. *Ambio* 40: 248–255.
<https://doi.org/10.1007/s13280-011-0147-3>
- IPNI. (2019) *The International Plant Names Index*. Royal Botanic Gardens, Kew. Available from: <http://www.ipni.org> (accessed 11 July 2019)
- IUCN. (2016) *Guidelines for Using the IUCN Red List Categories and Criteria. Version 12*. Prepared by the Standards and Petitions Subcommittee. Available from: [http://www.iucnredlist.org/documents/Red List Guidelines.pdf](http://www.iucnredlist.org/documents/Red%20List%20Guidelines.pdf) (accessed 20 July 2019)
- Maassoumi, A.A. (2018) Papilionaceae (*Astragalus* III). In: Assadi, M. & Maassoumi, A.A. (Eds.) *Flora of Iran*, No. 145. Research Institute of Forests and Rangelands of Iran, Tehran, 766 pp.
- Maassoumi, A.A., Ghahremaninejad, F. & Ghahreman, A. (2000) *Astragalus moussavii* (Fabaceae), a new species of *Astragalus* sect. *Xiphidium* from Iran, with supplementary notes on the section. *Nordic Journal of Botany* 20: 353–356.
<https://doi.org/10.1111/j.1756-1051.2000.tb00749.x>
- Maes, J., Paracchini, M.L., Zulian, G., Dunbar, M.B. & Alkemade, R. (2012) Synergies and trade-offs between ecosystem service supply, biodiversity, and habitat conservation status in Europe. *Biological Conservation* 155: 1–12.
<https://doi.org/10.1016/j.biocon.2012.06.016>
- Perrino, E.V., Brunetti, G. & Farrag, K. (2014) Plant communities of multi-metal contaminated soils: a case study in National Park of Alta Murgia (Apulia Region - southern Italy). *International Journal of Phytoremediation* 16 (9): 871–888.
<https://doi.org/10.1080/15226514.2013.798626>
- Perrino, E.V., Tomaselli, V., Costa, R. & Pavone, P. (2013) Conservation status of habitats (Directive 92/43 EEC) of coastal and low hill belts in a Mediterranean biodiversity hot spot (Gargano - Italy). *Plant Biosystems* 147 (4): 1006–1028.
<https://doi.org/10.1080/11263504.2013.860052>
- Podlech, D. & Zarre, Sh. (2013) *A taxonomic revision of the genus Astragalus L. (Leguminosae) in the Old World*. Naturhistorisches Museum, Wien, 2439 pp.
- Podlech, D., Zarre, Sh., Maassoumi, A.A., Ekici, M. & Sytin, A. (2010) Papilionaceae VI, *Astragalus* IV. In: Rechinger K.H. (Ed.) *Flora Iranica*, Lfg. 178. Naturhistorisches Museum, Wien, 430 pp.
- Takhtajan, A.L. (1986) *Floristic regions of the world*. Berkeley, University of California Press, Los Angeles, London, 522 pp.
- Thiers, B. (2019 [Continuously updated]) *Index Herbariorum: A global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. Available from: <http://sweetgum.nybg.org/ih/> (accessed 10 July 2019)
- Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kusber, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A. M., Prado, J., Price, M.J. & Smith, G.F. (Eds.) (2018) *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. Regnum Vegetabile 159. Glashütten: Koeltz Botanical Books.
<https://doi.org/10.12705/Code.2018>