Phytotaxa 538 (1): 045–054
https://www.mapress.com/pt/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

https://doi.org/10.11646/phytotaxa.538.1.4

Allium parhamii (Amaryllidaceae, Allioideae), a new species from Central Kopet Dagh Mountains, NE Iran

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Abstract

Allium parhamii is described and illustrated as a new species from the Kopet Dagh mountain range, North Khorassan province in Iran. Based on morphological features, the new species belongs to *A.* sect. *Asteroprason*. It differs from the closely related species *A. monophyllum* in several floral and leaf characters as well as the micromorphological characters of seed coat and karyotype. The new species is illustrated and Red-Listed as critically endangered and notes on habitats and distribution are provided.

Keywords: *Asteroprason*, conservation, endemism, karyology, micromorphology, new species, taxonomy

Introduction

Allium Linnaeus (1753: 294) (Amaryllidaceae, Allioideae) is mainly a perennial geophytic genus with currently accepted 1006 species (Govaerts *et al.* 2021). As one of the largest genera among the monocots, it is widely distributed over Holarctics and adapted to diverse habitats from the Mediterranean Basin to Central Asia (Friesen *et al.* 2006, Fritsch 2012). The Irano-Turanian floristic region is known as a main center of diversity of the genus *Allium* where it displays a high level of specific endemism (Matin 1992, Memariani *et al.* 2016a, 2016b). Of over 155 *Allium* species growing naturally in Iran (Dolatyari *et al.* 2020), about 42 species are native to the northeastern corner of the country, which is known as Khorassan-Kopet Dagh (KK) floristic province, with 36% of endemism in the genus (Memariani 2020). Moreover, the phytogeographical position of the KK has made it an area with disjunct distribution of several *Allium* species from the surrounding areas, especially Middle Asia (Memariani *et al.* 2007).

Allium subg. *Melanocrommyum* (Webb & Berthelot 1848: 347) Rouy (1910: 378) is the second-largest subgenus of *Allium* and comprises ten sections with about 83 species in Iran (Dolatyari *et al.* 2020). Several members of this subgenus have been listed as ornamental plants (Fritsch & Abbasi 2013). *Allium* sect. *Asteroprason* R.M.Fritsch in Fritsch *et al.* (2010: 184) is a section endemic to Khorassan-Kopet Dagh (KK) floristic province and Central-Eastern Alborz Mountains. Within it, *A.* subsect. *Christophiana* Tscholokaschvili (1975: 52) is narrowly endemic to the KK (Memariani *et al.* 2012). The species are typical xerophilous plants growing on rocky and stony exposed slopes with more or less flat star-like flowers, patent or later somewhat recurved and after anthesis longitudinally enrolled tepals.

During botanical excursions in Central Kopet Dagh Mountains in northeastern Iran, we collected a peculiar and distinct *Allium* that mostly resembles *A. monophyllum* Vvedensky (1934: 128) and believed to be a species new to science. In this paper, we aim to describe and illustrate this new species with notes on its seed coat micromorphology, chromosome number and karyotype, habitat, and conservation status.

Material and methods

We examined the living and dried *Allium* specimens collected from Kopet Dagh Mountains and consulted the descriptions and identification keys in the relevant literature including Vvedensky (1935), Wendelbo (1971), Memariani *et al.* (2012),

Accepted by Lorenzo Peruzzi: 8 Feb. 2022; published: 3 Mar. 2022

Fritsch (2012), and Fritsch & Abbasi (2013). The features of gross morphology of the specimens were examined under a binocular stereomicroscope and compared with the specimens at FUMH, LE, and W herbaria (acronyms follow Thiers, 2022). 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 (IUCN 2019), using the GeoCAT tool (Bachman *et al.* 2011). For micromorphological analysis, we placed the selected mature seeds on aluminum stubs using a double-sided adhesive tape, sputter-coated them with gold using an Emiteck K550, and then examined the seeds using the FEI Quanta 250 FEG and JEOL Neoscope JCM-5000 scanning electron microscope.

For karyotype analysis, the seeds were germinated at 4 °C for 6 months. Five to ten root tips of species were pretreated with 8-hydroxyquinoline (0.002 M) for three hours at room temperature. Then, they were fixed in Carnoy's solution (3:1 absolute ethanol – glacial acetic acid) for 24–48h at 4°C. The fixed root tips were hydrolyzed in 1N HCl at 60°C for 6–9 min followed by washing them in distilled water. Then they were stained with aceto-orcein (1% w/v) for 2 h. Finally, the root tips were squashed in acetic acid 45%. The metaphase chromosomes were counted for at least 10 cells of each seedling root. The examined metaphase plates were photographed using Olympus BX52 microscope with automatic camera. The numerical values were measured including total chromosome length (TCL) and arm ratio (AR) for each chromosome. Arm ratio (AR) was calculated according to Kutarekar & Wanjari (1983) by the formula AR = S/L (Short arm length of the chromosome/Long arm length of the chromosome). Furthermore, chromosomes were identified based on Levan *et al.* (1964). The idiogram was presented based on the data related to the chromosome length. Two parameters were used to determine the karyotype asymmetry including Coefficient of Variation of Chromosome Length ($CV_{CL} = A_2 \times 100$) and Mean Centromeric Asymmetry ($M_{CA} = A \times 100$). A is degree of karyotype asymmetry (Watanabe *et al.* 1999) and A_2 is the interchromosomal asymmetry index (Romero Zarco 1986). Both parameters provide the most suitable methods for estimating karyotype asymmetry (Peruzzi & Eroğlu, 2013). We used the chromosome data (long arms and short arms) of *Allium monophyllum* calculated by Fritsch (2018) to compare karyological parameters (CV_{CL} and M_{CA}) of two related species. We also obtained Stebbins' categories (Stebbins 1971) to detect a symmetric karyotype.

Description of the new species

Allium parhamii Memariani, ***sp. nov.*** (Figs. 1–2, 3A)

Similar to *Allium monophyllum* in shape and color of flowers, but distinguished from it by its dense and many-flowered inflorescence, usually 2 leaves with much wider blades, and larger habit, capsules, and seeds.

Type:—IRAN. North Khorassan: NE Shirvan, 6 km east of Namanlu towards Bajgiran, southern slopes of Sivak Mount, 2135 m, 8 June 2013, *Joharchi* & *Memariani 45135* (holotype: FUMH!; isotypes: FUMH!, W!).

Bulbs subovoid to subglobose, 1.5–2 cm in diameter, tunics greyish. Leaves (1–)2, oblong, almost thick and fleshy, basally enclosing the scape, the upper side sulcate, green and basally purplish, after flowering usually with wide reddish stripes in margin and surface, margin and sometimes in lower side scabrous, 10–20 cm long, 1.5–2.5(–3) cm wide. Scape cylindrical, erect, shorter than leaves, app. 2 cm above soil, 3–5 mm in diameter, pale green. Spathe membranous, splitting into 2–3 acuminate parts with brownish nerves. Umbel semi-globose, contracted, many-flowered, 3.5–4(–5) cm in diameter. Pedicels straight, up to 20 mm long, pale purple. Flowers flat funnel-like. Tepals long-triangular, longitudinally folded, acute, 6–7(–8) mm long, basally 1.5–2 mm wide, violet, pink to pale purple, with darker purple mid-vein, after anthesis convolute but not prickly stiff. Filaments 2/3 to 3/4 as long as tepals, whitish purple, subulate, basally connate. Anthers 1.5–2 mm long, yellow. Ovary subglobose- pyriform with three furrows, 2.5–3 mm in diameter, whitish green, coarsely tuberculate on surface. Style conical, 3–4 mm long, green to purplish, stigma undivided. Capsule depressed tripartite with furrows, 4–6 mm in diameter, in fresh state whitish green, in dry state brownish. Seeds one per locule, ovate, 2–2.3 mm long, 1.3–1.5 mm wide, 1 mm thick, shiny black.

Additional specimen examined (paratype):—IRAN. North Khorassan: NE Shirvan, *ca.* 5 km east of Namanlu towards Bajgiran, in *Juniperus polycarpos* woodland, 2040 m, 9 June 2008, *Memariani & Zangooei 40733-A* (FUMH).

Eponymy:—The specific epithet of the new species is commemorated to the late Saied Parham, an Iranian nature conservationist in North Khorassan province who was killed by the poachers on December, 1st 2010 when he was on his official duties in Sarani Protected Area. The type locality of *Allium parhamii* (Sivak Mount) is located at the

southeastern borders of Sarani Protected Area which has been protected since 1973. The area is a part of the Kopet Dagh Biosphere Reserve which was designated as one of the UNESCO worldwide inscribed areas in the Man and the Biosphere Programme (MAB) in 2018.

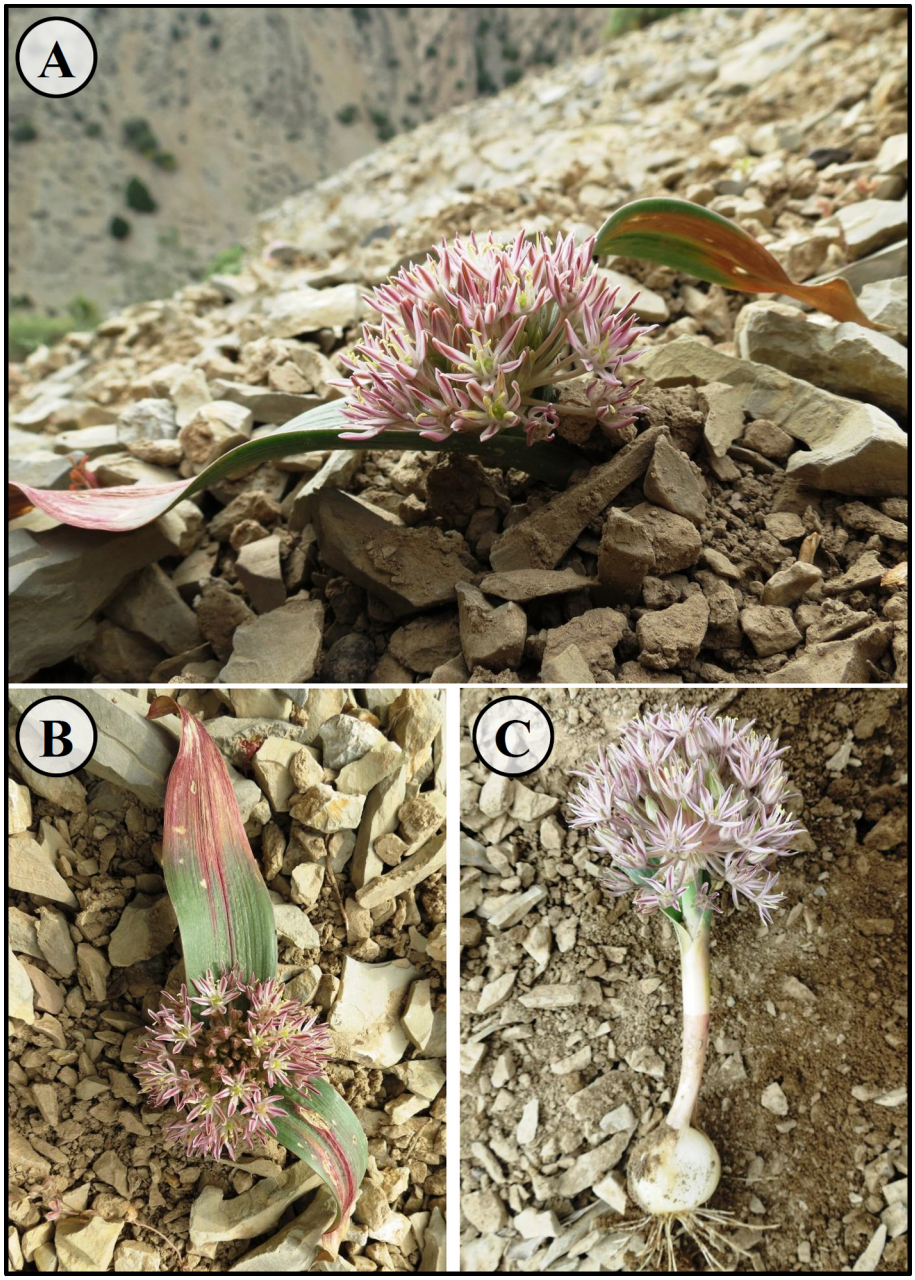

FIGURE 1. *Allium parhamii* in its natural habitat on exposed stony slopes. **A–B.** habit in early flowering stage with compact stature showing semi-globose inflorescence and two leaves, **C.** sub-globose bulbs and the grazed leaves by the livestock.

Phenology:—An ephemeroid species, leaf sprouting is initiated in mid-May, flowering and fruiting is completed in mid-June.

Distribution and habitat:—So far, *A. parhamii* was found in higher elevations of Sivak Mt. in Central Kopet Dagh Mountains, NE Iran. It grows on south facing stony slopes, between 2000–2200 m a.s.l., in mountain steppes and very open *Juniperus polycarpos* var. *turcomanica* (B.Fedtsch.) R.P.Adams woodlands.

Conservation status:—According to IUCN Red List Categories and Criteria (IUCN 2019), *A. parhamii* is Critically Endangered (CR, B1+2ab(iii)). Its extent of occurrence is not more than 10 km^2 and the area of occupancy is less than 5 km^2. The small populations are located at the borders between Sarani Protected Area and Gharajagheh P. A. It is highly recommended to extend the borders of these protected areas more southwards to the Aq-Kamar Mount which inhabits several narrow and regional endemic plants; however, the area is under high grazing by the livestock of local nomads which may enter illegally to the adjacent protected areas (Fig. 1C). Very peculiar habitats of fragmented populations of the new species in subalpine zone may be sensitive to climate change and global warming.

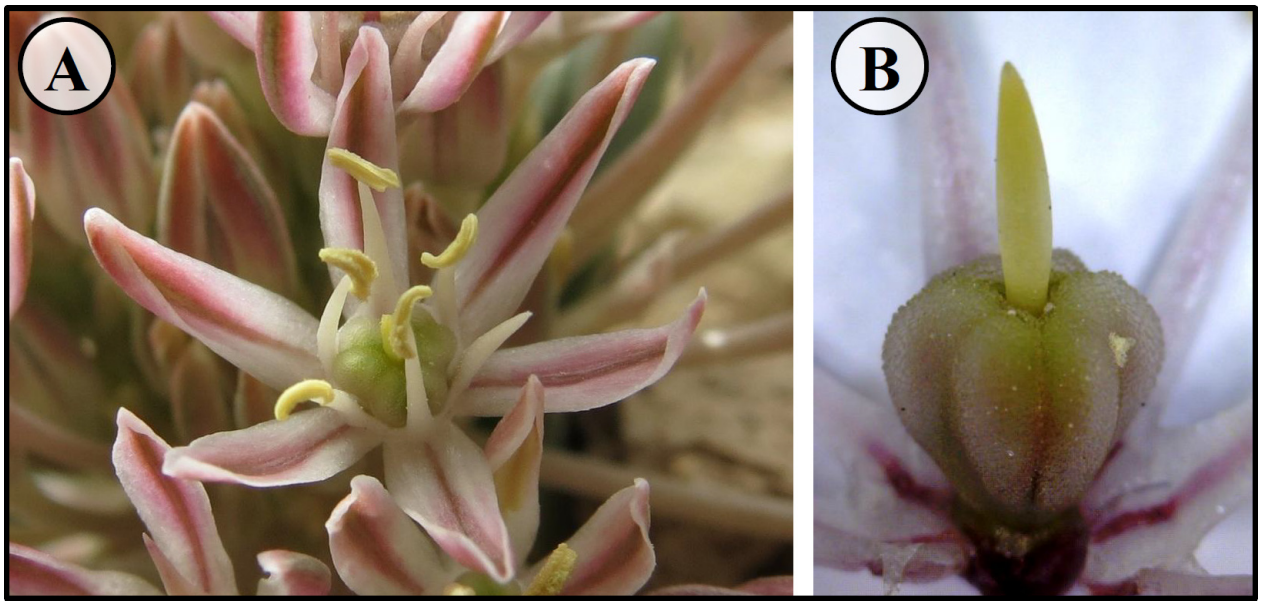

FIGURE 2. Flower details in *Allium parhamii.* **A.** close-up view of a flower; **B.** coarsely tuberculate ovary, conical style, and undivided stigma.

Taxonomic relationships:—Based on nuclear and plastid molecular markers, *Allium* sect. *Asteroprason* constitute a distinctive subgroup within *A.* subg. *Melanocrommyum* (Fritsch *et al.* 2010, Gurushidze *et al.* 2010). Morphologically, the new *Allium* species belongs to *A.* sect. *Asteroprason* subsect. *Asteroprason* which differs from the species of *A.* subsect. *Christophiana* i.e. *A. cristophii* Trautvetter (1884: 268) and *A. ellisii* Hooker (1903: t.7875) by its compact stature and crumpled and not prickly tepals in the fruiting stage. *Allium parhamii* is more similar to *A. monophyllum* especially in the shape and color of the flowers; however, it can be distinguished from the latter by its dense and many-flowered inflorescence, usually 2 leaves with considerably wider blades, and larger habit, capsules, and seeds (Fig. 3, Table 1). In dried herbarium specimens, several diagnostic characters of living material may be lost. So, *A. parhamii* may be confused with *A. aladaghense* Memariani & Joharchi in Memariani *et al.* (2012: 29) in dried material; however, it differs from the latter by its yellow (not violet) anthers (Fig. 2A, Table 1).

Seed coat micromorphology:—The seeds of the new species are oval-spherical, 1.3–1.5 mm wide and 2.0–2.3 mm long. The most frequent shape of testa cells is elliptic. The periclinal walls are convex with verrucate and granulate sculpture and the anticlinal walls are loosely undulated (Fig. 4). Based on Neshati & Fritsch (2009), the closely related *A. monophyllum* has different seed coat micromorphology with penta- to hexagonal testa cells, and very shallow S-undulation in anticlinal walls.

Chromosome number and karyotype:—The diploid chromosome number of 2n = 16 was found in *Allium parhamii*. The karyogram presented six pairs of metacentric chromosomes (m) and two pairs of satellited submetacentric chromosomes (sm) as well as one relatively long B chromosome (Fig. 5, Table 2). Fritsch (2018) reported the same chromosome number and symmetric karyotype for the closely related *A. monophyllum*; however, it differs from *A. parhamii* by its longer chromosome length, very short to invisible satellites, and absence of B chromosomes. Different ploidy levels i.e. 2n = 16, 32, 48, and 64 have been reported for *Allium* species; however, most of taxa are diploid (Pastor *et al.* 1995, Fritsch & Astanova 1998, Peruzzi *et al.* 2017). Analysis of somatic metaphase spreads in *A. parhamii* confirmed the previous reports on the basic chromosome number of x = 8, a uniform karyotype, and presence of satellites and B chromosomes in *Allium* subg. *Melanocrommyum* (Fritsch & Astanova 1998, Genç *et al.* 2013). Table 3 shows the evaluation parameters for karyotype asymmetry in *A. parhamii* and *A. monophyllum*. According to Stebbins' categories (Stebbins 1971), the new species is placed in the class 2A, while *A. monophyllum* in 1A. Therefore, these results indicate a symmetric karyotype for both species. Genç *et al.* (2013) reported a similar symmetric karyotype in *Allium* subg. *Melanocrommyum* from Turkey. Based on the results, the karyotype of *A. parhamii* is more interchromosomally (CV_{CL} = 17.70) and intrachromosomally (M_{CA} = 13.41) asymmetric than that of *A. monophyllum* (Table 3).

TABLE 1. Morphological comparison of *Allium parhamii* with two closely related or similar species of *A.* sect. *Asteroprason.*

	A. parhamii	*A. monophyllum*	*A. aladaghense*
Leaves	(1–)2, 10–20 cm long, 1.5–2.5(–3) cm wide	1(–2), 6–15 cm long, 0.3–1.1 cm wide	1–2, 7–20 cm long, 1.5–3 cm wide
Inflorescence	commonly ± 60 flowers	±20 flowers	± 50 flowers
Flowers	funnel-star like	funnel-star like	flat-star like
Tepals	6–7(–8) mm long, at base 1.5–2 mm wide, pink to pale purple (mid-vein dark purple)	5–7 mm long, at base 1–1.2 mm wide, dark violet, rose to pink (mid-vein purple)	5–7 mm long, at base 0.5–1 mm wide, white (mid-vein brownish)
Filaments	2/3 to 3/4 as long as tepals, whitish purple	2/3 to 3/4 as long as tepals, white to rose	4/5 to nearly as long as tepals, violet with white base
Anthers	yellow	yellow	violet
Style	green to purplish, 3–4 mm long	yellow ± purplish, 2–4 mm long	whitish violet, 3–4 mm long
Capsule (diameter)	4–6 mm	2–3 mm	5–6 mm
Seed length	2–2.3 mm	1.4–2 mm	2–2.5 mm

TABLE 2. Mean of satellites and arm length (μm) of the chromosomes in *Allium parhamii*.

Chromosome pair No.	Short arm (S)	Long arm (L)	Satellite length	Total length	Arm ratio (L/S)	Chromosome type
1	2.37	5.58	3.37	11.33 ± 0.23	2.35	sm/SAT
2	2.92	5.35	2.56	10.84 ± 0.18	1.83	sm/SAT
3	4.32	6.17	-	10.49 ± 0.26	1.43	m
4	4.52	5.48	-	10.00 ± 0.06	1.21	m
5	4.53	5.30	-	9.83 ± 0.02	1.17	m
6	4.54	5.08	-	9.62 ± 0.23	1.12	m
7	4.45	4.64	-	9.09 ± 0.06	1.04	m
8	4.36	4.47	-	8.84 ± 0.82	1.02	m
9	-	-	-	3.82 ± 0.01	-	B

TABLE 3. Karyotype symmetric indices calculated for *Allium parhamii* and *A. monophyllum*; CV_{CL}: coefficient of variation of chromosome length, and M_{CA}: mean centromeric asymmetry. The karyotype formula and chromosome data for calculating the indices for *A. monophyllum* are from Fritsch (2018).

Symmetric indices	Stebbins	CV_{CL}	M_{CA}	Karyotype formula
Allium parhamii	2A	17.70	13.41	2n = 2x = 16 = 12m + 4sm(4SAT) + 1B
Allium monophyllum	1A	11.04	11.83	2n = 2x = 16 = 13m + 3sm(2SAT)

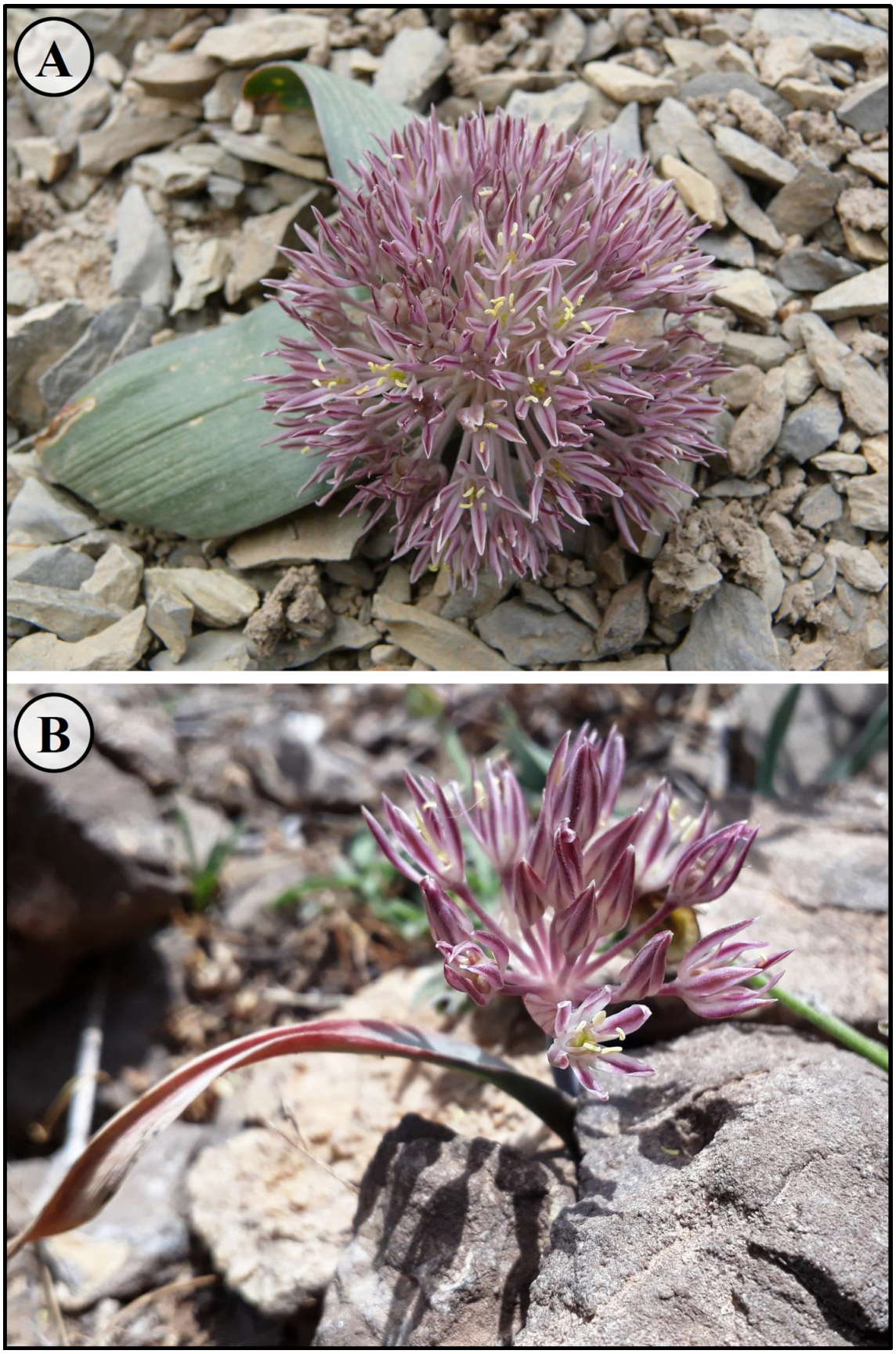

FIGURE 3. A. *Allium parhamii* with dense many-flowered inflorescence and two wider leaves. **B.** the closely related species, *A. monophyllum*, with lower number of flowers in inflorescence and a single narrow leaf. Both species are endemic to Kopet Dagh Mountains, NE Iran.

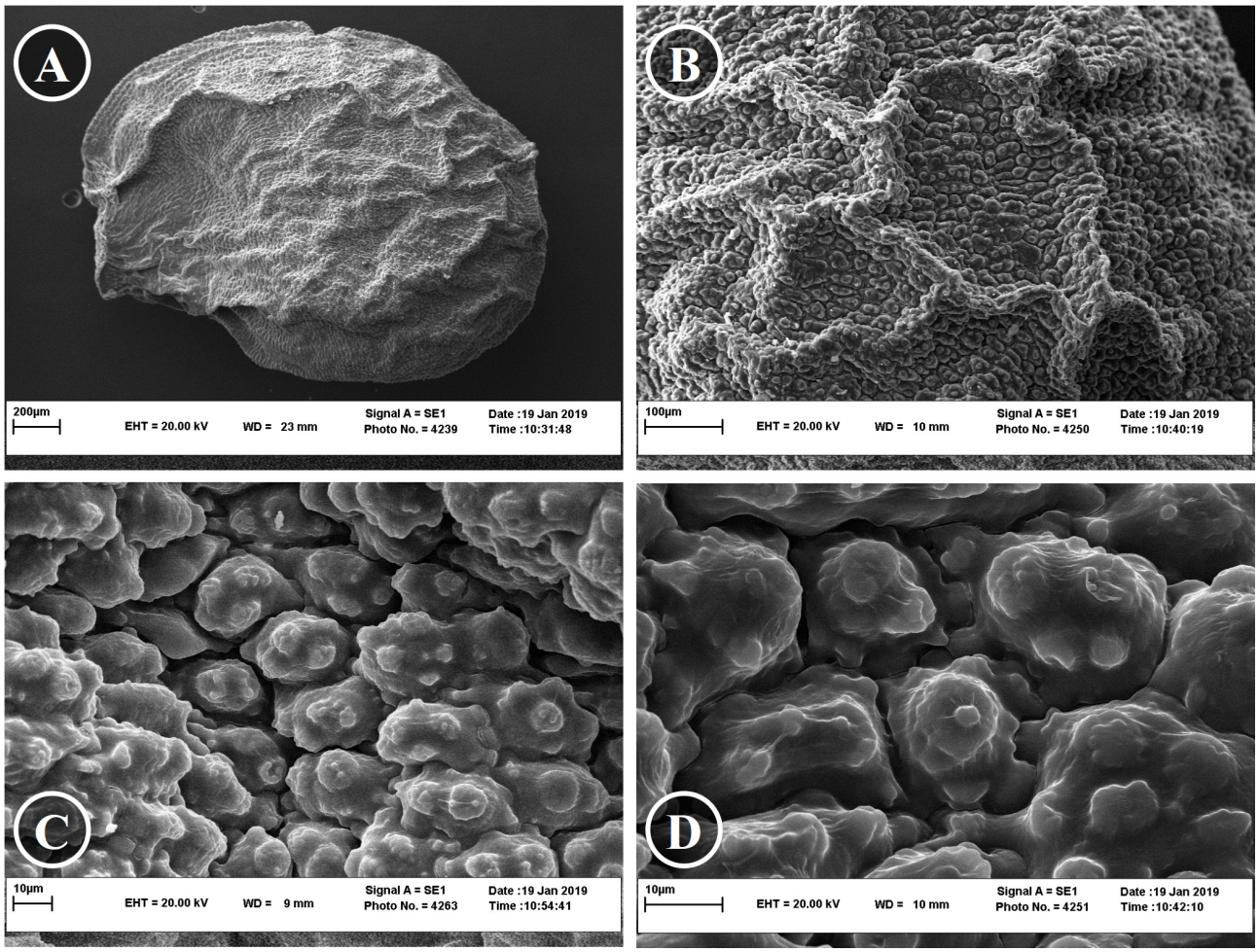

FIGURE 4. A–D. Scanning electron micrographs of *Allium parhamii* seeds and details of testa sculpture.

Identification key to *Allium* sect. *Asteroprason*

A revised and updated identification key to the species of *Allium* sect. *Asteroprason* (after Memariani *et al.* 2012) is provided here to facilitate identification of nine species of this section.

1. Plants of compact stature; tepals in fruiting stage crumpled and not prickly; leaves glabrous (Subsect. *Asteroprason*) 2
- Plants of larger stature; tepals in fruiting stage stiff and prickly; leaves hairy or glabrous (Subsect. *Christophiana*) 8
2. Scape stout, thickened, up to 10 mm in diameter; tepals after anthesis recurved; pedicels in fruiting stage up to 9 cm long; leaves in upper part spirally twisted .....***Allium helicophyllum***
- Scape weak, up to 8 mm in diameter; tepals after anthesis patent; pedicels in fruiting stage not more than 4.5 cm long; leaves not twisted.....3
3. Tepals ± dark violet, after anthesis not much changing; leaves 0.3–1.1 cm wide; plants smaller in habit .... ***Allium monophyllum***
- Tepals violet, purple, pink, lilac, white, after anthesis longitudinally enrolled; leaves up to 8 cm wide; plants larger in habit..... 4
4. Pedicels up to 4.5 cm long; scape up to 15(–20) cm long 5
- Pedicels up to 2.5 cm long; scape up to 8 cm long.....6
5. Ovary surface glass-like glossy and colorless; filaments 3/5 to 2/3 as long as tepals.....***Allium elburzense***
- Ovary with coarse surface; filaments nearly as long as tepals ..... ***Allium pseudobodeanum***
6. Leaves 1.5–3 cm wide 7
- Leaves 5–8 cm wide ..... ***Allium kuhsorkhense***
7. Flowers flat-star like; tepals white, at base 0.5–1 mm wide; anthers violet in early anthesis.....***Allium aladaghense***
- Flowers funnel-star like; tepals violet, pink to pale purple, at base 1.5–2 mm wide; anthers yellow in anthesis..... ..... ***Allium parhamii***
8. Leaves hairy, rarely subglabrous; pedicels up to 11 cm long; filaments 1/2 as long as tepals.....***Allium cristophii***
- Leaves glabrous; pedicels up to 6 cm long; filaments 2/3 as long as tepals ..... ***Allium ellisii***

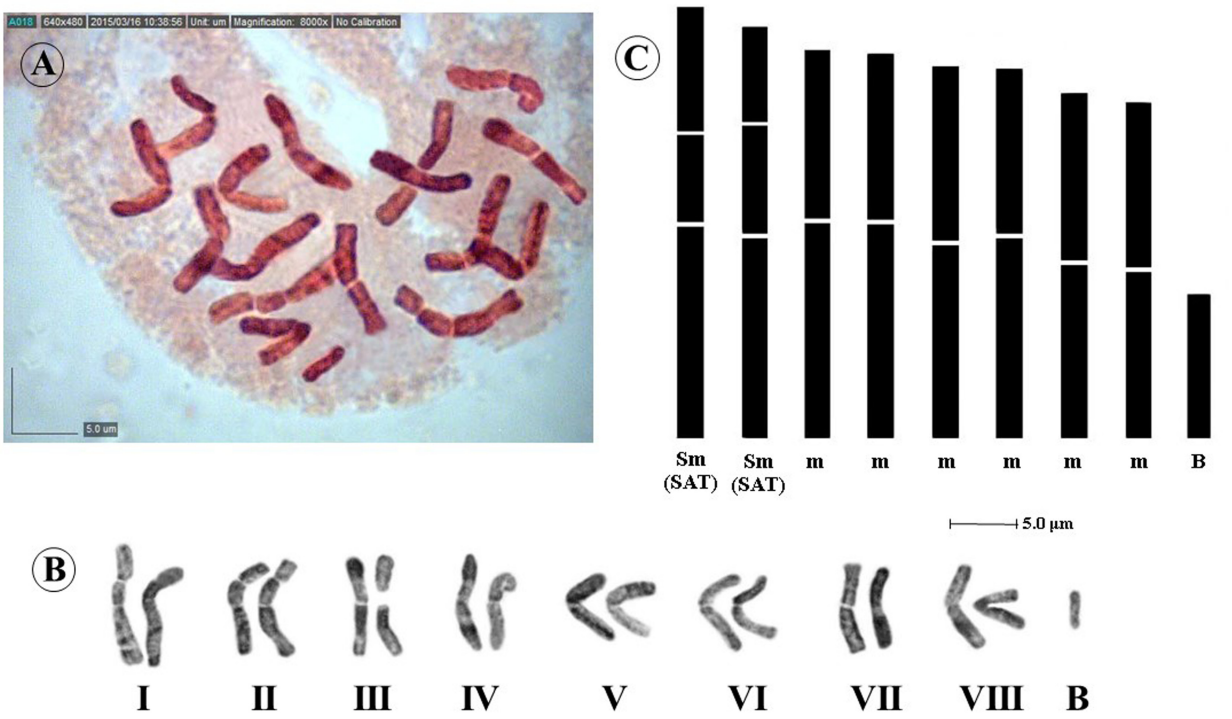

FIGURE 5. Karyotype and idiogram of *Allium parhamii*. **A–B.** Metaphasic plate, showing 2n = 16 + 1B with two satellite chromosomes (I & II). **C.** Haploid idiogram based on the data of Table 2.

Acknowledgements

We gratefully acknowledge FUMH, LE, and W herbaria for helping to access to plant specimens. We also thank Hassan Zangooei (FUMH) for field assistance. Maryam Behroozian was partially supported by a grant from Ferdowsi University of Mashhad (No. FUM-14002794075).

References

Bachman, S., Moat, J., Hill, A.W., de la Torre, J. & Scott, B. (2011) Supporting Red List threat assessment with GeoCAT: geospatial conservation assessment tool. *ZooKeys* 150: 117–126. https://doi.org/10.3897/zookeys.150.2109

Dolatyari, A., Moazzeni, H., Hosseini, S., Blattner, F. & Fritsch, R.M. (2020) *Allium schisticola*, a new species with peculiar morphological characters and an unexpected phylogenetic position. *Phytotaxa* 450: 246–256. https://doi.org/10.11646/phytotaxa.450.3.1

Friesen, N., Fritsch, R.M. & Blattner, F.R. (2006) Phylogeny and new intrageneric classification of *Allium* (Alliaceae) based on nuclear ribosomal DNA ITS sequences. *Aliso* 22: 372–395. https://doi.org/10.5642/aliso.20062201.31

Fritsch, R.M. (2012) Illustrated key to the sections and subsections and brief general circumscription of *Allium* subg. *Melanocrommyum*. *Phyton (Horn)* 52: 1–37.

Fritsch, R.M. (2018) *Allium monophyllum* (Amaryllidaceae) is a diploid species. *Phytotaxa* 333: 298–300. https://doi.org/10.11646/phytotaxa.333.2.16

Fritsch, R.M. & Astanova, S.B. (1998) Uniform karyotypes in different sections of *Allium* L. subg. *Melanocrommyum* (Webb & Berth.) Rouy from Central Asia. *Feddes Repertorium* 109: 539–549. https://doi.org/10.1002/fedr.19981090710

Fritsch, R.M., Blattner, F.R. & Gurushidze, M. (2010) New classification of *Allium* L. subg. *Melanocrommyum* (Webb. & Berthel.) Rouy

(Alliaceae) based on molecular and morphological characters. *Phyton (Horn, Austria)* 49: 145–220.

Fritsch, R.M. & Abbasi, M. (2013) A taxonomic review of *Allium* subg. *Melanocrommyum* in Iran. Leibniz-Institut für Pflanzengenetik und Kulturpflanzenforschung, 240 pp.

Genç, I., Özhatay, N. & Cevri, M. (2013) A karyomorphological study of the genus *Allium* (sect. *Melanocrommyum*) from Turkey. *Caryologia* 66: 31–40.
https://doi.org/10.1080/00087114.2013.780439

Govaerts, R., Kington, S., Friesen, N., Fritsch, R.M., Snijman, D.A., Marcucci, R., Silverstone-Sopkin, P.A. & Brullo, S. (2021) World checklist of Amaryllidaceae. Facilitated by the Royal Botanic Gardens, Kew. Available at: https://wcsp.science.kew.org/incfamilies.do (accessed 4 September 2021).

Gurushidze, M., Fritsch, R.M. & Blattner, F.R. (2010) Species-level phylogeny of *Allium* subgenus *Melanocrommyum*: Incomplete lineage sorting, hybridization and *trn*F gene duplication. *Taxon* 59: 829–840.
https://doi.org/10.1002/tax.593012

Hooker, J.D. (1903) *Allium ellisii*, native of Khorassan. *Curtis's Botanical Magazine* 129: t7875.

IUCN (2019) Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Subcommittee. Available at: http://www.iucnredlist.org/ documents/RedListGuidelines.pdf (accessed 25 July 2021).

Kutarekar, D.R. & Wanjari, K.B. (1983) Karyomorphological studies in some of the varieties of Bengal Gram (*Cicer arietinum* L.). *Cytologia* 48: 699–705.
https://doi.org/10.1508/cytologia.48.699

Levan, A., Fredga, K. & Sandberg, A.A. (1964) Nomenclature for centromeric position on chromosomes. *Hereditas* 52: 201–220.
https://doi.org/10.1111/j.1601-5223.1964.tb01953.x

Linnaeus, C. (1753) *Species Plantarum*, Vol. 1. Laurentius Salvius, Stockholm.

Matin, F. (1992) The genus *Allium* in Iran, diversity, distribution and endemism. *In*: Hanelt, P., Hammer, K. & Knüpffer, H. (eds.) *The genus Allium - Taxonomic Problems and Genetic Resources*. (Proc. Int. Symp. Gatersleben, June 11–13, 1991). IPK, Gatersleben, pp. 193–194.

Memariani, F. (2020) The Khorassan-Kopet Dagh Mountains. *In:* Noroozi, J. (Ed.) *Plant Biogeography and Vegetation of High Mountains of Central and South-West Asia*. Springer Nature Switzerland AG, Cham, pp. 93–116.
https://doi.org/10.1007/978-3-030-45212-4_3

Memariani, F., Joharchi, M.R. & Khassanov, F.O. (2007) *Allium* L. subg. *Rhizirideum sensu lato* in Iran, two new records and a synopsis of taxonomy and phytogeography. *Iranian Journal of Botany* 13: 12–20.

Memariani, F., Joharchi, M.R. & Arjmandi, A.A. (2012) *Allium aladaghense* (Amaryllidaceae, Allieae), a new species of section *Asteroprason* from northeast of Iran. *Phytotaxa* 56: 28–34.
https://doi.org/10.11646/phytotaxa.56.1.7

Memariani, F., Zarrinpour, V. & Akhani, H. (2016a) A review of plant diversity, vegetation, and phytogeography of the Khorassan-Kopet Dagh floristic province in the Irano-Turanian region (northeastern Iran– southern Turkmenistan). *Phytotaxa* 249: 8–30.
https://doi.org/10.11646/phytotaxa.249.1.4

Memariani, F., Akhani, H. & Joharchi, M.R. (2016b) Endemic plants of the Khorassan-Kopet Dagh floristic province in Irano-Turanian region: diversity, distribution patterns and conservation status. *Phytotaxa* 249: 31–117.
https://doi.org/10.11646/phytotaxa.249.1.5

Neshati, F. & Fritsch, R.M. (2009) Seed characters and testa sculpture of some Iranian *Allium* L. species (Alliaceae). *Feddes Repertorium* 120: 322–332.
https://doi.org/10.1002/fedr.200911112

Pastor, J.E., Diuosdado, J.C. & Cabezudo, B. (1995) A karyological study of *Allium rouyi* Gautier (Liliaceae), a recently rediscovered endemic species from the south of Spain. *Botanical Journal of the Linnean Society* 117: 255–258.
https://doi.org/10.1111/j.1095-8339.1995.tb00455.x

Peruzzi, L. & Eroğlu, H. (2013) Karyotype asymmetry: again, how to measure and what to measure? *Comparative Cytogenetics* 7: 1–9.
https://doi.org/10.3897/compcytogen.v7i1.4431

Peruzzi, L., Carta, A. & Altinordu, F. (2017) Chromosome diversity and evolution in *Allium* (Allioideae, Amaryllidaceae). *Plant Biosystems* 151: 212–220.
https://doi.org/10.1080/11263504.2016.1149123

Romero Zarco, C. (1986) A new method for estimating karyotype asymmetry. *Taxon* 35: 526–530.
https://doi.org/10.2307/1221906

Rouy, G. (1910) *Flore de France; ou, Description des Plantes qui Croissent Spontanément en France, en Corse et en Alsace-Lorraine*. Vol. XII. Paris.

Stebbins, G.L. (1971) *Chromosomal Evolution in Higher Plants*. Edward Arnold, London.

Thiers, B. (2022) *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 5 February 2022)

Trautvetter, E.R. von (1884) Incrementa florae phanerogamae rossicae, fascic. IV. *Trudy Imperatorskago S. –Peterburgskago Botanicheskago Sada* 9: 221–642.

Tscholokaschvili, N.B. (1975) Ad cognitionem systematis generis *Allium*. *Zametki po Sistematike i Geografii Rastenii (Tbilisi)* 31: 36–54.

Vvedensky, A.I. (1934) Descriptiones Alliorum novorum. *Byulleten' Sredne-Aziatskogo Gosudarstvennogo Universiteta* 19: 119–130.

Vvedensky, A.I. (1935) *Allium* L. *In:* Komarov, V.L. (Ed.) *Flora of the U.S.S.R.*, vol. IV. Izdatel'stvo Akademii Nauk SSSR, Leningrad, pp. 87–280.

Watanabe, K., Yahara, T., Dendam, T. & Kosuge, K. (1999) Chromosomal evolution in the genus *Brachyscome* (Asteraceae, Astereae): statistical tests regarding correlation between changes in karyotype and habit using phylogenetic information. *Journal of Plant Research* 112: 145–161.
https://doi.org/10.1007/PL00013869

Webb, P.B. & Berthelot, S. (1844–1850) *Histoire naturelle des Isles Canaries* 3 (2). Phytographia canariensis, sectio 3. Paris, Béthune etc., 479 pp., tab. 137–252.

Wendelbo, P. (1971) Alliaceae. *In*: Rechinger, K.H. (ed.) *Flora Iranica.* No. 76. Akademische Druck- und Verlagsanstalt, Graz, 100 pp.