

## Systematic revision of the genus *Gagea* Salisb. (Liliaceae) in Iran

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This paper presents a systematic revision of *Gagea* Salisb. in Iran, which is a genus of bulbous perennials widely distributed in alpine and subalpine regions across Eurasia and North Africa. The plants of many *Gagea* species grow in seasonally moist soils with a high percentage of clay. These studies are based on extensive field work and study of herbarium specimens in all herbaria of Iran and the most important in the United Kingdom. In all, nearly 2000 specimens have been studied. Complete synonymy, descriptions, notes on taxonomy, geographical distribution, conservation status, habitats of species and an enumeration of selected material studied is given for each species. A key for the identification of flowering specimens of the accepted species is provided. The largest mountain ranges of Iran, i.e. Alborz and Zagros, are important centres of diversity for *Gagea*. In Iran, there are 26 species of the genus, of which *G. chanae* Grossh. and *G. commutata* K.Koch are presented here as new records. We consider *G. anonyma* Rech.f., *G. grey-wilsonii* Rech.f., *G. ova* Stapf and *G. tehranica* Gand. to be synonymous with *G. setifolia* Baker, *G. chlorantha* (M.Bieb.) Schult. & Schult. f., *G. stipitata* Merckl. ex Bunge and *G. reticulata* (Pall.) Salisb., respectively. *Gagea perpusilla* Pascher is another new synonym of *G. setifolia*. © 2007 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2007, 154, 559–588

ADDITIONAL KEYWORDS: Alpine – geographical distribution – key – systematic revision – conservation status.

### INTRODUCTION

Richard Anthony Salisbury (1761–1829) separated seven species that had long been placed in the genus *Ornithogalum* (e.g. by Linnaeus, 1753, 1762; and by Pallas, 1773, 1776) into the new genus *Gagea* (Salisbury, 1806) due to their ‘distinction in habit and fructification’. He named it after Sir Thomas Gage (1781–1820) of Hengrave Hall, Suffolk, who was famous for collecting rare European plants and was liberal in distributing them (Dasgupta & Deb, 1983a). Though Salisbury’s new genus was based on species

previously described in the genus *Ornithogalum*, he did not consider priority of earlier specific epithets and created new ones; this was the first source of taxonomic confusion in the genus (Heyn & Dafni, 1971).

For the next hundred years after the description of the new genus by Salisbury, advances in the study of *Gagea* were gradual and not extensive. Schultes & Schultes fil. (1829), Koch (1849) and Boissier (1882) made important contributions, treating especially the species from the Orient (Uphof, 1958). The most important revisions of *Gagea* were undertaken simultaneously and independently by two authors at the beginning of the 20th century: Pascher (1904, 1907) and Terracciano (1905, 1906). Neither of these revisions was ever completely finished, although

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Pascher's interpretation has been considered the more valid of the two (Rechinger, 1986).

Descriptions of many new species have appeared since 1907, especially in the last two decades by Levichev and colleagues (Levichev, 1981, 1988, 1991, 2000, 2001; Dasgupta & Deb, 1983b; Levichev & Navruzshoev, 1997; Zarrei & Zarre, 2005). The compilations of Stroh (1937) and Uphof (1958–1960) are now out of date, and there are more recent revisions for Palestine (Heyn & Dafni, 1971, 1977; Feinburn-Dotham, 1986), India (Dasgupta & Deb, 1983a), Iraq (Wendelbo, 1985), Turkey (Rix, 1984), the Caucasus area (Davlianidze, 1976), and the *Flora Iranica* region (Wendelbo & Rechinger, 1990). A complete revision of *Gagea* is therefore long overdue.

*Gagea* is a Eurasian genus, with a few species in North Africa, and comprises between 70 and 250 species depending on the opinion of various authors (Stroh, 1937; Melchior, 1964; Willis, 1980; Mabberley, 1997; Levichev, 1999a, b; Peruzzi, 2003; Uphof, 1958–1960). According to Wendelbo & Rechinger (1990) and including recent new species described or recorded by other authors (Akhani, 1999; Assadi, 1988; Zarrei, 2001, 2003; Zarrei & Zarre, 2005a), there are 35 species in Iran; we reduce this to 26 in this account.

The systematic treatment of *Gagea* is difficult because of the paucity of distinguishing characters, especially when one is forced to rely solely on herbarium material; these difficulties are shared by many other genera of the Liliaceae (Rechinger, 1986). This paper represents the first stage in the preparation of a monograph of the genus *Gagea*. It is the result of our research during the last 5 years on the species that are distributed in Iran and neighbouring areas.

## MATERIAL AND METHODS

This study is mainly based on examination of nearly 2000 herbarium sheets, including type material from various European and Iranian herbaria, e.g. BM, E, IRAN, K, M, TARI, TUH (acronyms according to Holmgren, Holmgren & Barnett, 1990). This study is based not only on specimens that were collected in Iran, but also specimens from neighbouring countries as well as most European countries. We have taken about 8000 images from herbarium specimens, including the types. About 400 specimens collected by us have been deposited in TUH, and duplicates have been sent to BM, IRAN, K, LE, M and TARI.

In addition, many of the species were studied in the field, noting especially flower colour, basal leaf cross-section, number of bulbs enclosed by the same tunic, bulbils and inflorescence arrangement. These studies have resulted in a better understanding of the range of variation within different populations. Excursions

were made throughout Iran; we were able to take more than 400 high-quality digital pictures. We have also studied the conditions under which *Gagea* species grow and examined the effects of ecological factors on the habit of different species.

All measurements were taken directly from herbarium material. Information that could not be clearly observed on dried material (e.g. flower colour or cross-section of basal leaf) was recorded in the field or herbarium.

## TAXONOMY

*Gagea* Salisb., *Ann. Bot.* 2: 555. 1806.

*Ornithoxanthum* Link, *Handb.* 1: 161. 1829 (LECTOTYPE designated here: *O. minimum* (L.) Link. = *Gagea minima* (L.) Ker Gawl.). *Hornungia* Bernh., *Flora* 23: 392. 1840 (TYPE: *H. circinata* Bernh. = *Ornithogalum circinatum* L.f. = *Gagea circinata* (L.f.) Loudon). *Bulbillaria* Zucc., *Pl. Hort. Bot. Moench.* 3: 229 t. 2. 1843 (TYPE: *B. gageoides* Zucc. = *Gagea gageoides* (Zucc.) Vved.). *Plecostigma* Turcz., *Trautv. Pl. Imag. Fl. Ross.* 9. t. 2. 1844 (TYPE: *P. pauciflorum* Turcz. = *Gagea pauciflora* (Turcz. ex Trautv.) Turcz. ex Ledeb.). *Solenarium* Dulac, *Fl. Hautes Pyr.* 112. 1867 (LECTOTYPE designated here: *S. luteum* (L.) Dulac = *Ornithogalum luteum* L. = *Gagea lutea* (L.) Ker Gawl.).

*Lectotype* (Designated by Uphof, 1958): *G. bracteolaris* Salisb. [= *G. pratensis* (Pers.) Roem. et Schult.].

*English vernacular names:* Yellow star of Bethlehem, *gagea*

*German vernacular names:* Gelbstern, Goldstern

*Persian vernacular names:* Najm-e Talaie, Zardak-e Piazy, Gyab, Nosrek

PLANTS herbaceous, bulbous, perennial (4–) 10–20 (–30) cm tall, solitary or clump-forming. BULBS 4–25 mm in diameter; tunics coriaceous, fibrous or reticulate; neck present, up to 8 cm, or absent; bulbils (on the bulb) present or absent. ROOTS normally thin, occasionally thickened roots present, coiled round the bulb. RADICAL LEAVES one or rarely two, filiform, linear or narrowly lanceolate, up to 30 cm, ciliate or glabrous. CAULINE LEAVES (bracts) verticillate or alternate, glabrous or ciliate; bulbils occasionally present in axil of cauline leaves. BRACTEOLES occasionally present. INFLORESCENCE umbel-like or cymose, few-, many- or occasionally 1-flowered (*G. uliginosa*). PEDUNCLE glabrous or pubescent.

PEDICELS of various lengths, erect or nodding (*G. chomutovae*); pubescent or glabrous. TEPALS 6, free, flat, with a nectar gland at the base, lanceolate, oblanceolate or elliptic, apex obtuse or acute to acuminate, glabrous, villous or ciliate especially at the tip; the inner whorl occasionally shorter than the outer, usually abaxially glossy, yellow, pale yellow or golden yellow and adaxially greenish, occasionally white or with a pink stripe abaxially and adaxially dull greenish, seldom white, with a pink stripe on the back. STAMENS 6, longer to shorter than the style; filaments

filiform, sometimes flattened at the base (4–)5–8(–10) mm; anthers basifixed, spherical to oblong-ellipsoid, yellow, dehiscent longitudinally. OVARY superior, ovoid, obovoid or cylindrical, 3-celled, each cell with many ovules; style elongate, trigonous; stigma capitate, or indistinctly tri-lobed. FRUIT a trigonous thin-walled capsule, many-seeded, as long as or shorter than perianth, loculicidal, cylindrical or ovoid, with a distinct or indistinct stipe. SEEDS spheroid or flattened, pink to brown, with longitudinal and latitudinal ridges; embryo half as long as the endosperm.

DIAGNOSTIC KEY TO THE GENUS *GAGEA* IN IRAN

1. Bulbils present in axils of cauline leaves or bracts.....2
- 1'. Bulbils absent (from axils of cauline leaves or bracts).....6
2. Bulbils present in axils of lower cauline leaves, bracts without bulbils.....3
- 2'. Bulbils present in axils of lower cauline leaves as well as of bracts.....4
3. Inflorescence umbel-like; tepals (9-)12–15(18) mm long; radical leaves 1–3 mm broad, linear.....15. *G. villosa*
- 3'. Inflorescence cymose; tepals 6–7 mm long; radical leaves 0.4–0.6 mm broad, filiform.....26. *G. tenera*
4. Bulbils in clusters in the axils of cauline leaves and bracts; tepals 4–7 mm; radical leaf usually absent.....
- .....17. *G. gageoides*
- 4'. Bulbils solitary in the axils of cauline leaves and bracts; tepals longer than 10 mm; radical leaf usually present.....5
5. Inflorescence umbel-like; cauline leaves whorled and bracteose; tepal apices acuminate.....12. *G. bergii*
- 5'. Inflorescence cymose; cauline leaves alternate; tepal apices acute.....16. *G. bulbifera*
6. Radical leaf hollow, fistulose.....7
- 6'. Radical leaf terete, semicircular, circular or flat in cross-section.....8
7. Inflorescence cymose.....14. *G. chomutovae*
- 7'. Inflorescence umbel-like.....13. *G. fistulosa*
8. Radical leaves flattened.....9
- 8'. Radical leaves terete, semicircular or circular in cross-section.....14
9. Tunics fibrous to papery-fibrous; grey in colour; tepals acuminate.....10
- 9'. Tunics coriaceous; brown to dark-brown; tepals acute or obtuse.....11
10. Peduncles 1–1.5 cm, on soil level, longest pedicels always longer than the peduncle.....5. *G. vegeta*
- 10'. Peduncles long 4–8 cm, branching from stem above soil level, pedicels all shorter than the peduncle.....
- .....6. *G. commutata*
11. Tepals 5–8 mm long; inflorescence branches flexous-geniculate.....2. *G. dschungarica*
- 11'. Tepals 8–15 (–18) mm long; inflorescence branches not flexous geniculate.....12
12. Radical leaves 2–4 mm broad; pedicels hairy.....4. *G. chanae*
- 12'. Radical leaves more than 4 mm broad, rarely narrower; pedicels glabrous.....13
13. Radical leaves hooded at the apex, abruptly narrowing into a narrow tip; plant of open woods and scrub-lands; usually growing in shade; radical leaf and bracts glaucous.....3. *G. lutea*
- 13'. Radical leaves not hooded, gradually tapering towards apex; plant of open alpine, habitats, usually growing near melting snow; radical and cauline leaves dark green in colour.....1. *G. confusa*
14. Tepals long-acuminate at the apex.....15
- 14'. Tepals acute or obtuse at the apex.....19
15. Bulb tunic with distinct and elongate neck; usually covering the above-ground part of peduncle, reticulate; bulbs usually clustered.....10. *G. reticulata*
- 15'. Bulb tunic with short and indistinct neck; bulbs usually solitary, rarely in clusters.....16
16. Plant shorter than 5 cm; pedicels densely lanate throughout, hairs > 1.0 mm long.....7. *G. graminifolia*
- 16'. Plant taller than 5 cm; pedicels sparsely hairy, hairs < 1.0 mm long.....17
17. Bulbs enveloped by normal or thickened roots.....8. *G. caroli-kochii*
- 17'. Bulbs not enveloped by normal or thick roots.....18
18. Pedicels shorter than tepals; plant of dry areas; base of peduncle yellow.....11. *G. setifolia*
- 18'. Pedicels longer than tepals; plant of wet areas; base of peduncle not yellow.....9. *G. alexeenkoana*

19. Inflorescence 1(–3)-flowered; bulb tunic fibrous-reticulate; tepals becoming purple at the apex; plants of high altitudes (above 2500 m).....	18. <i>G. uliginosa</i>
19'. Inflorescence many-flowered; bulb tunic leathery or papery; tepals lacking purple apices; plants of lower altitudes (below 2000 m).....	20
20. Inflorescence umbel-like; pedicels often covered with long villous hairs (hairs longer than 1.0 mm).....	15. <i>G. villosa</i>
20'. Inflorescence cymose; pedicels glabrous or covered with hairs < 1.0 mm long.....	21
21. Lower cauline leaves broadly lanceolate, flattened, differentiated from radical leaves in shape and width.....	26. <i>G. tenera</i>
21'. Lower cauline leaves filiform or narrowly lanceolate, not differentiated from the radical leaves.....	22
22. Ovary pyriform, with a narrow stipe at the base.....	23
22'. Ovary ovoid, without a distinct stipe.....	26
23. Radical leaf ± linear; flowers more than 3.....	21. <i>G. stipitata</i>
23'. Radical leaves narrowly filiform; flowers 1–3.....	24
24. Tepals 5–7 mm.....	22. <i>G. exilis</i>
24'. Tepals 10–15 mm.....	25
25. Plant 3–8 cm tall; bulb tunic coriaceous.....	25. <i>G. wendelboi</i>
25'. Plant 10–20 cm tall; bulb tunic delicately reticulate.....	19. <i>G. iranica</i>
26. Tunics not separating into fibres.....	20. <i>G. chlorantha</i>
26'. Tunics readily separating into fibres.....	27
27. Inflorescence more than 3-flowered, repeatedly branched; tepals 9–12 mm long.....	24. <i>G. afghanica</i>
27'. Inflorescence 1–3 (or rarely more)-flowered, not branched; tepals 6–9 mm long.....	23. <i>G. olgae</i>

## ENUMERATION OF SPECIES

### 1. *GAGEA CONFUSA* A. TERRACC.

*Bull. Soc. Orto Palermo II*, 3: 5 (1904). TYPE (designated by Davlianidze, 1976): IRAN, In jugo Charson prope Kascoin (Kaswin [Qazvin], orthographic error caused by unclear handwriting), 1882, *Pichler s.n.* (LECTOTYPE: G; ISOTYPE: K!, NAP). *Gagea minimoides* Pascher, *Lotos* 52: 125. 1904. TYPE: IRAN, in jugo Kherson, ad Kaswin, 1882, *Pichler s.n.* (ISOTYPE: K!). *Gagea platyphyllos* Pascher, *Repert., Spec. Nov. Regni Veg.* 2: 67. 1906. TYPE: IRAN, Liwan [no information regarding the collector(s) or herbarium number given]

PLANTS (6–)8–20 cm tall, solitary or sometimes in groups of a few plants. BULBS ovoid, 1.0–2.0 cm in diameter × 1.0–1.5 cm long; tunics coriaceous, dark brown; bulbils present, numerous, black, triangular, finely reticulated, 3.0 mm long × 2.5 mm in diameter, rarely with a filiform appendix up to 2.5 mm long, enclosed by a common tunic; neck absent. ROOTS all thin, thickened roots absent. STEM erect, subterranean part yellow to white; aerial part green, 3.0–5.0 cm, glabrous. RADICAL LEAF solitary, broadly linear-lanceolate, flattened, overtopping the inflorescence (70.0–)100.0–150.0(–170.5) × (2.0–)4.0–8.0(–10.0) mm, glabrous. CAULINE LEAF solitary, shorter to longer than inflorescence, lanceolate to linear-lanceolate, attenuate-acuminate at the apex, surrounding the base of inflorescence, 45.0–60.0 × 8.0–11.0 mm; lower bracts linear-lanceolate,

acuminate-attenuate at the tip, shorter than the lower cauline leaf and the inflorescence, slightly clasping at the base, 30.0–45.0 × 3.0–4.0 mm; other bracts smaller, linear to ± filiform, 20 × 2 mm, sparsely villous-ciliate at the margins. Bracteoles sometimes present, one or two. INFLORESCENCE umbel-like, sometimes with a peduncle up to 8 mm (1–)3–6(–13)-flowered, pedicels slender, erect in fruit, 2–3 times longer than the flower, 30.0–45.0 × 0.5 mm, glabrous or sometimes sparsely papillose. TEPALS 8–14 mm long; outer tepals narrower than the inner ones; outer ones 3.0–3.5 mm wide, with five prominent green nerves on the abaxial surface, hyaline at the margins, oblanceolate, obtuse at the apex, glabrous; inner tepals 4.0–4.5 mm width, with 6–7 prominent green nerves, with a broad hyaline stripe at margin, elliptic to oblanceolate, acute to obtuse, glabrous. STAMENS 2/3–3/4 as long as perianth, filament dilated at the base, filiform; anther small, spherical to oblong-ellipsoid, 0.6–0.7 mm; yellow. OVARY obovate, attenuate at the base, truncate to retuse at the apex, 3.5–4.5 × 2.0–3.0 mm; style longer than ovary, 5 mm long, stigma capitate to slightly bilobed; capsule obovate, 4–9 × 3–5 mm.

*Phenology*: Fruiting and flowering between April and early July, peak flowering in May.

*Distribution and ecology*: Eastern Turkey (infrequent), northern and eastern Iraq, Georgia and Iran (Fig. 2A). Upper slopes of mountains, mostly

between cushion-forming plants such as *Astragalus*, *Acantholimon* and *Onobrychis*. It usually grows between melting snow patches and prefers soils with high percentage of clay; elevation (1200–)2200–2800(–3750) m.

*Conservation status*: LC (IUCN, 2001).

*Affinities, variation and typification*: Four papers have been published in which the type of *G. confusa* was indicated. The first of these was by Davlianidze (1976), who selected from the three syntypes of Terracciano (1904) a specimen from Kascoin (Kaswin = Qazvin) on the Cherson Pass in Iran (*Pichler s.n.*, G). Rix (1984) also stated that the type was the specimen from Kaswin. In Wendelbo & Rechinger (1990), a different Pichler specimen from Kashan (Kaschan) was selected as the lectotype (*Pichler s.n.*, WU). Davlianidze's work was not cited, and no evidence supporting a need to change the lectotype was provided. Finally, Peruzzi & Tison (2004) designated the Pichler specimen from Kaswin as the lectotype, but cited a duplicate specimen from Terracciano's herbarium in Naples (*Pichler s.n.*, NAP). They argued that this should be the case because it was the plant seen by Terracciano himself. However, they did not cite Davlianidze's lectotypification or state that they wished to change it; they also did not demonstrate that Terracciano could not have seen the Geneva (G) duplicate. Under article 9.17 of the St. Louis Code (Greuter *et al.*, 2000), it is clear that lectotypification was effected by Davlianidze (1976) and that the lectotype is the specimen he cited from Geneva. The *Pichler s.n.* specimen from Kaswin in Naples (NAP), which was superfluously designated as the lectotype by Peruzzi & Tison (2004), must therefore be an isolectotype.

The holotype of *G. minimoides* Pascher is also an isolectotype of *G. confusa* A.Terracc. Pascher had recognized this specimen as a new species (*G. minimoides*) and written it down on the sheet; Terracciano saw the specimens with Pascher's determination and published it as new species with another name, *G. confusa* A.Terracc., before Pascher's name was published. *Gagea platyphyllos*, which was published as new species from Iran, is also synonymous with *G. confusa*. Although we have not seen the type specimen, the original description in the protologue agrees with *G. confusa*. It has been mentioned by Pascher that *G. platyphyllos* differs from *G. confusa* in having broader tepals that are more rounded at the apex and a lower cauline leaf that is incurved towards its apex. All the above characters fall within the variation of *G. confusa*.

*Gagea confusa* (Fig. 1A, B) is closely related to *G. minima*, especially in habit and shape of basal leaf.

*Gagea minima* has narrower and longer tepals and a longer basal leaf than *G. confusa*.

*Gagea confusa* is similar to *G. dschungarica*, but not closely related to it (our unpubl. molecular data). Both species have a broad, flattened, lanceolate basal leaf and branched inflorescence. However, they are separated by the mostly shorter tepals of *G. dschungarica* (5–8 mm) (Fig. 4A) in contrast to larger tepals (8–14 mm) of *G. confusa*. Moreover, *G. confusa* is generally taller and more slender than *G. dschungarica*. Another difference between these two species is that the basal leaf apex is hooded in *G. dschungarica* but not so in *G. confusa*.

*Gagea elegans* Wall. ex D. Don and *G. lowariensis* Pascher from Pakistan, India and Nepal are related to *G. confusa*. Both of them, like *G. confusa*, have coriaceous, brown to dark-brown tunics that cover several small, black bulbils. All three species have one broad, flattened basal leaf that tapers gradually towards the apex. Although the tepals of *G. confusa* are slightly shorter than those of the two other species, the difference is not significant. Therefore, these two species need further study. *Gagea elegans* is the earliest name for a species in this group.

No specimens were found of *G. intercedens* Pascher. The type was collected from 'Persia, Sultanabad, prope Kengower, Legit Strauss'. According to the protologue, *G. intercedens* is a transitional form between *G. filiformis* and *G. luteoides* from sect. *Monophyllos* Pascher. Based on the description in the protologue, it is probably a small form of *G. confusa*.

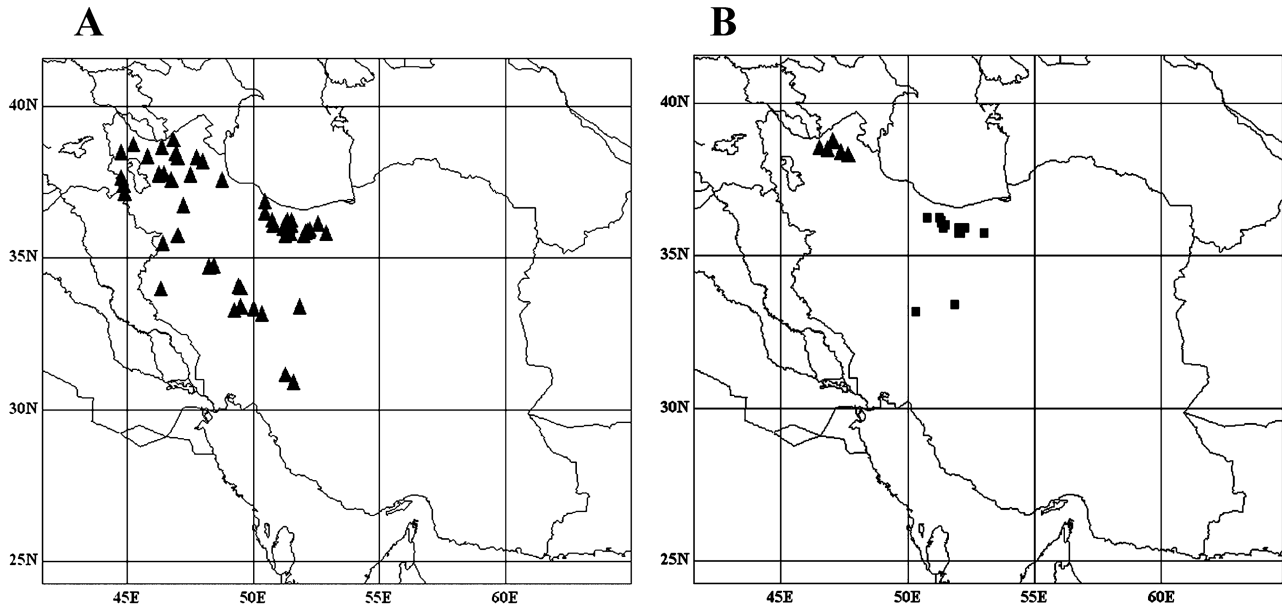
*Selected specimens examined*: Damavand Mts, south slope, *Furse & Synge* 461 (29947 in IRAN); north slope of Kandavan Mts, after Kandavan tunnel, *Wendelbo & Shirdelpour* 11656 (E, TARI); north slope of Kandavan Mts, after Kandavan tunnel, *Zarrei* 35288 (K, TUH); Chalus road, Mts around Kandavan tunnel, north slope, behind melting snow, *Zarrei & Kamrani* 30074 (TUH); Asalem towards Khalkhal, 7 km after Matach village, 22 km to Khalkhal, on the pass, *Zarrei* 860 (K, LE, M, TUH); 8 km after Meshginshahr towards Moeel, Sabalan foothills, *Zarrei* 868 (TUH); Myaneh, Ishligh, Boz-Ghoush, *Termeh & Daneshpajouh* 29934 (IRAN); Arasbaran protected region, east of Vaighan, *Assadi & Maassoumi* 20314 (TARI); Ghotour-Sou, Sabalan Mts, *Termeh & Mousavi* 29935 (IRAN); 36 km after Ghara-Zia-Oddin, *Wendelbo & Assadi* 19253 (TARI); rocky ground between Shahpur [Salmas] and Rezayieh [Orumyeh], 37°39'N, 44°46'E, *Jardine* 662 (E); south-east slope of kuh-e Sahand, *Furse & Synge* 2254 (E, 29958 in IRAN); Sahand, north side above Liqvan, *Furse* 2335 (E, K); Marivan, 35°30'N, 46°24'E, *Jacobs* 6531 (K, E); between Ganjnameh and Assadabad, *Wendelbo & Assadi* 16809 (TARI); north Azna, *Bowles Schol. Bot.*



**Figure 1.** *Gagea confusa*. A, plant habit. Scale bar = 2 cm. B, tepal segments, stamens and gynoecium. Scale bar = 2 mm. After Zarrei 35288.

*Exp.* 674 (K); Yasuj, Sisakht, Bijan pass, *Mozaffarian & Maassoumi* 77988 (TARI); Alborz Mts, *pro pagum Passgala, Kotschy* 109 (K); Alborz Mts, Tochal alpine part, *Bornmüller* 8295 (BM, K); Alborz Mts, Shahr-

estanak, Dasderre Valley, *Bornmüller* 8296 (BM); Tochal Mts, south-west slope, *Zarre & Zarrei* 766 (K, TUH); *ibid.*, *Zarrei & Zarrei* 35266 (K, TUH); between Shemshak and Dizin, 36°01'N, 51°27'E,



**Figure 2.** Distribution in Iran of A, *G. confusa* (▲); B, *G. chanae* (▲) and *G. dschungarica* (■).

*Logham 127* (K); *in jugo Kharsan, ad Kaswin, Pichler s.n.* (lectotype of *G. minimoides* and paralectotype of *G. confusa*) (K, ex. herb. Vindobonensis); Arak towards Malayer, 20 km Arak, Chepeghli (Ab-Robot), *Termeh et al.* 29939 (IRAN).

## 2. *GAGEA DSCHUNGARICA* REGEL

*Trudy Imp. S.-Peterburgsk. Bot. Sada* 6: 513. 1879. TYPE (designated by Wendelbo & Rechinger, 1990): TURKMENISTAN, *in Jugo Dschungarico Jugantash inter Kersken-terek et Borochudsir*, 6–7000 ft elev., 25.v.1878, *Regel s.n.* (LECTOTYPE: WU; ISOTYPE: BM!, K!, LE).

PLANTS 4–10 (–13) cm tall, solitary. BULBS ovoid, 1.0–1.5 cm in diameter  $\times$  0.7–1.0 cm long; outer tunics coriaceous, dark brown; inner ones coriaceous, greyish-brown; neck absent; bulbils present, numerous, older ones (last year's) dark-brown to yellow, those of the current year light-brown, triangular, surface finely reticulate, 1.0  $\times$  1.5 mm. ROOTS mostly thin, one thick root present. STEM erect, subterranean part 10.0–30.0  $\times$  0.5–1.0 mm, white to yellow, sometimes  $\pm$  angled, glabrous; aerial part 15.0–30.0  $\times$  1.0–2.0 mm, green, sparsely pubescent or glabrous. RADICAL LEAF solitary, linear-lanceolate, flattened, petiole-like at the base, yellow in colour, from middle towards apex hooded or slightly cucullate, equal to or longer than the inflorescence, 60.0–120.0  $\times$  5.0–8.0 mm, acute at the apex, with prominent nerves, glabrous or hairy. CAULINE LEAF solitary, sometimes absent, shorter

than or equal to inflorescence, lanceolate to linear-lanceolate, 20.0–25.0  $\times$  4.0–5.0 mm, clasping the stem at the base, glabrous. Cauline leaves verticillate, small, glabrous. INFLORESCENCE cymose (2–)4–10(–16)-flowered, dichotomously branched, branches flexuose-geniculate, pedicels unequal, slender, erect or curved, 10.0–20.0  $\times$  0.5–1.0 mm, glabrous. TEPALS 5.0–8.0  $\times$  1.5–2.0 mm, narrowly elliptic, obtuse; inner surface yellow, outer surface green, glabrous. STAMENS half as long as the perianth; filament 3.0–5.0 mm long, anther spherical, 0.5 mm in diameter, yellow. OVARY pyriform, 2.5–3.5  $\times$  1.5 mm, style 3.0 mm, stigma capitate; mature capsule not seen.

*Phenology:* Flowering between late April and May, peak flowering in early May.

*Distribution and ecology:* Iran (Fig. 2B), Turkmenistan, Afghanistan, north-west Pakistan, Central Asia. Higher slopes of mountains, mostly between cushion-forming plants such as *Astragalus*, *Acantholimon* and *Onobrychis*, but compared with *G. confusa*, this species prefers drier areas. The two species are mostly geographically distinct. *Gagea confusa* is restricted to eastern Turkey, north-eastern Iraq, and southern Georgia as well as western Iran (Fig. 2A). The eastern limit is the centre of the Alborz Range, whereas *G. dschungarica* is restricted to the centre of the Alborz Range (Fig. 2B), where both species overlap, and to Central Asia.

There are two specimens of *G. dschungarica* collected several hundred kilometres from the central

Alborz, in the Karkas and Golestan-Kuh mountains in central Iran. The intervening area is desert with no high mountains. Similarly, there are no known localities for this species between the central Alborz and Central Asia, more than 1000 km away; elevation (1900–) 2200–2800 (–3150) m.

*Conservation status:* LC (IUCN, 2001). The populations from the Karkas and the Golestan-Kuh mountains should be studied in detail to look for divergence that may have resulted from their isolation.

*Affinities and variation:* This species is similar to *G. confusa*, but can be easily distinguished from it (see also the notes under *G. confusa*) by its stronger and more branched inflorescence as well as shorter tepals (Fig. 4A).

*Selected specimens examined:* Lar Valley, Lar dam, Mts in front of dam, south slope of Damavand, Zarre 1006 (K, M, TUH); Tehran to Polur, c. 500 m after Emamzad-e Hashem pass, Zarrei 35815 (TUH); Damavand Mts, south slope, Furse & Synge 461-a (K); Karkas Mts, near television mast, north slope of the pass, Wendelbo & Foroughi 11442 (TARI); 2 km to Karaj from Gachsar, Nesae area, Zarrei & Zarre 921 (K, TUH); Karaj towards Chalus, Nesae area, Mts near the village, 36°04'51.6"N, 51°18'88.0"E, Zarrei 35290 (K, TUH); 5 km after Gachsar towards Chalus, Zarrei & Kamrani 30078 (TUH); above Shemshak, Wendelbo 17216 (TARI); Fashand, between Karaj and Ghazvin, Gauba 29954 (IRAN, mixed with *G. confusa*).

### 3. *GAGEA LUTEA* (L.) KER GAWL.

*Bot. Mag.* 30: t. 1200. 1809. *Ornithogalum luteum* L., *Sp. Pl.* 306. 1753. *Ornithoxanthum luteum* (L.) Link, *Handbuch* 1: 161. 1829. *Solenarium luteum* (L.) Dulac, *Fl. Hautes-Pyrénées*: 112. 1867. *Stellaster luteus* (L.) Kuntze, *Revis. General. Pl.* 2: 716. 1891. TYPE (designated by Stearn, 1983): EUROPE, *cultis masculis* [no more information given] (LECTOTYPE: LINN 428.3!).

PLANTS (6–)10–20(–25) cm tall, solitary. BULBS ovoid, 10.0–20.0 × 10.0–10.5 mm; tunics coriaceous, grey to black-brown; neck absent; bulbils absent. ROOTS all thin and enveloping the bulb. STEM erect; subterranean part 5.0–7.5 cm; aerial part 60.0–80.0 × 1–1.5 mm, glabrous. RADICAL LEAF solitary, flattened, linear oblanceolate, longer than the inflorescence (90.0–)150.0–200.0 × (2.0–)6.0–10.0(–15.0) mm, glabrous. CAULINE LEAVES verticillate, 20.0–75.0 × 5.0–8.0(–12.0) mm; outer ones linear-lanceolate, flattened, gradually narrowing towards apex, 30.0–50.0 × 3.0–

5.0 mm, shorter than the inflorescence, villous-ciliate at margins; inner ones shorter, villose-ciliate. BRACTEOLES absent. INFLORESCENCE umbel-like (1–)3–6(–10)-flowered; pedicels unequal, recurved to straight, 20.0–40.0 × 0.5–1.0 mm, 2–3 times longer than flowers, glabrous. FLOWERS relatively large, tepals 13–15(–18) mm long; outer tepals 2.5–3.0 mm wide, obtuse, white at the margins, wider than inner tepals; inner tepals 1.5–2.5 mm wide; glabrous. STAMENS half as long as the perianth, filaments 6.0–10.0 mm, anther spherical, 1.0–1.5 mm in diameter, yellow. OVARY pyriform, 8–9 mm long × 5.0–6.0 mm in diameter; style 7 mm, stigma capitate; capsule pyriform, 10–12 mm long × 5–7 mm in diameter.

*Phenology:* Flowering and fruiting between late March and May, peak flowering in April.

*Distribution and ecology:* Western Europe to eastern Asia, Georgia, northern Iran and Afghanistan. *Gagea lutea* is the most widespread species of the genus, occurring in moister parts of Eurasia from Great Britain (the only common species in this country) to Japan. It also can be found to 69°N in Scandinavia and southern Siberia (Zarrei, 2003). In Iran, this species is usually seen growing above the tree line of the Hyrcanian forest or in hollows under a canopy of shrubs. It can be also found near cultivated fields and orchards. *Gagea lutea* needs less sun than other *Gagea* species and has usually completed its life cycle before the canopy is closed; elevation (700–) 1900–2500 m.

*Conservation status:* LC (IUCN, 2001); it is rare in Iran because it is a Eurasian (primarily Eurosiberian) floristic element, which has a more northerly distribution.

*Affinities and variation:* *Gagea lutea* is morphologically similar to *G. confusa*, but differs in having the basal leaf abruptly tapering at the apex, in having three cauline leaves (instead of one in *G. confusa*) that are glaucous (in contrast to the green to dark green of *G. confusa*).

*Selected specimens examined:* Loveh forest, 132 km east of Gorgan, Hower 3659 (E, K); Chalus road, Siah-Bisheh, hills above village, in front of Sahara restaurant, Zarre & Zarrei 770 (K, TUH); *ibid.*, Zarrei & Zarre 914 (TUH); *ibid.*, 36°12'68.4"N, 51°18'96.7"E, Zarrei 35285 (K, TUH); Chalus road, Pol-e Zangouleh, Zarrei & Kamrani 1073 (TUH); Karaj towards Chalus, north slope of Kandavan Mts, 2 km after tunnel, Zarrei 35287 (K, TUH); Javaher-Deh, Mts above village, Zarrei 30081 (TUH); Asalem towards Khalkhal, 2 km after Matach village, 27 km to



Khalkhal, *Zarrei 858* (BM, IRAN, M, TUH); between Shahpassand [Azadshahr] and Shahroud, Kuh-e Abar, north of Shahroud, *Wendelbo et al. 11170* (TARI).

#### 4. *GAGEA CHANAE* GROSSH.

Grossh. & Schischkin, *Pl. Or. Exsicc. fasc. 1*, 8: 16. 1924. TYPE: GEORGIA, Tbilisi, in *fruticetis*, 12.3. 1923, *Grossheim s.n.* (HOLOTYPE: LE, photo. K!; ISOTYPE: BM!, K!).

PLANTS (4–)8–15 cm tall, solitary. BULBS round, 1.0–1.5 cm in diameter; tunics coriaceous, brown to black; neck absent; bulbils absent. ROOTS all thin, enveloping the bulb. Stem erect; subterranean part 1.5–5.0 cm; aerial part 4.0–7.0(–10.0) cm, glabrous. RADICAL LEAF solitary, flattened, linear, equal to or longer than the inflorescence (50.0–)80.0–150.0(–200.0) × 2.0–4.0 mm, glabrous. CAULINE LEAVES 3, verticillate, outer ones linear-lanceolate, flattened, gradually narrowing towards apex, shorter than the inflorescence; inner ones shorter, all villosiciliate at the margin. BRACTEOLAS absent. INFLORESCENCE umbel-like, 2–4-flowered; pedicels unequal, obliquely erect to erect, 1.5–3.0 cm, slightly villous. TEPALS 14.0–17.0 × 2.5–3.5 mm long, oblong, obtuse to acute at the tip, glabrous, yellow inside, green outside. STAMENS 2/3 as long as the perianth, filaments 7 mm, anther oblong-ellipsoid, 2 × 1 mm, yellow. OVARY ovate, 3–4(–6) × 2–3 mm, style 7 mm, much longer than ovary, stigma capitate; capsule round, 10 mm in diameter; seeds globose.

*Phenology*: Flowering and fruiting mainly in late April.

*Distribution and ecology*: North-eastern Turkey, north-western Iran (Fig. 2B) and Georgia. It grows mainly in disturbed areas beside roads or edge of cultivated fields; elevation 1350–2000 m.

*Conservation status*: VU C2a(i) (IUCN, 2001). This species is infrequently encountered in small numbers of individuals in north-western Iran. Increasing agricultural development is likely to threaten its preferred habitat, which is moist soil with high percentage of clay.

*Affinities and variation*: It can be distinguished from its close relative, *G. lutea*, by its narrower basal leaf and more or less hairy pedicels; in fruiting specimens the hairs have been shed. *Gagea chanae* is recorded here for the first time from Iran. Five specimens were collected by the first author during an excursion to

north-western Iran. Records from Turkey are based on the maps of Grossheim (1935).

*Specimens examined*: 50 km from Meshginshahr towards Ahar, hills near the road, *Zarrei 870* (TUH, LE: fruiting specimens); 32 km from Ahar towards Varzaghan, 10 km to Varzaghan, *Zarrei 878* (IRAN, K, LE, TUH); 8 km from Meshginshahr towards Moeel, foothills of Sabalan, *Zarrei 867* (K, LE, TUH); 10 km from Ahar towards Kaleybar, hills on the left, *Zarrei 874* (TUH); Varzaghan towards Jolfa, 5 km after Mashkanbar deviation, foothills of Kasabeh Mts, *Zarrei 882* (TUH).

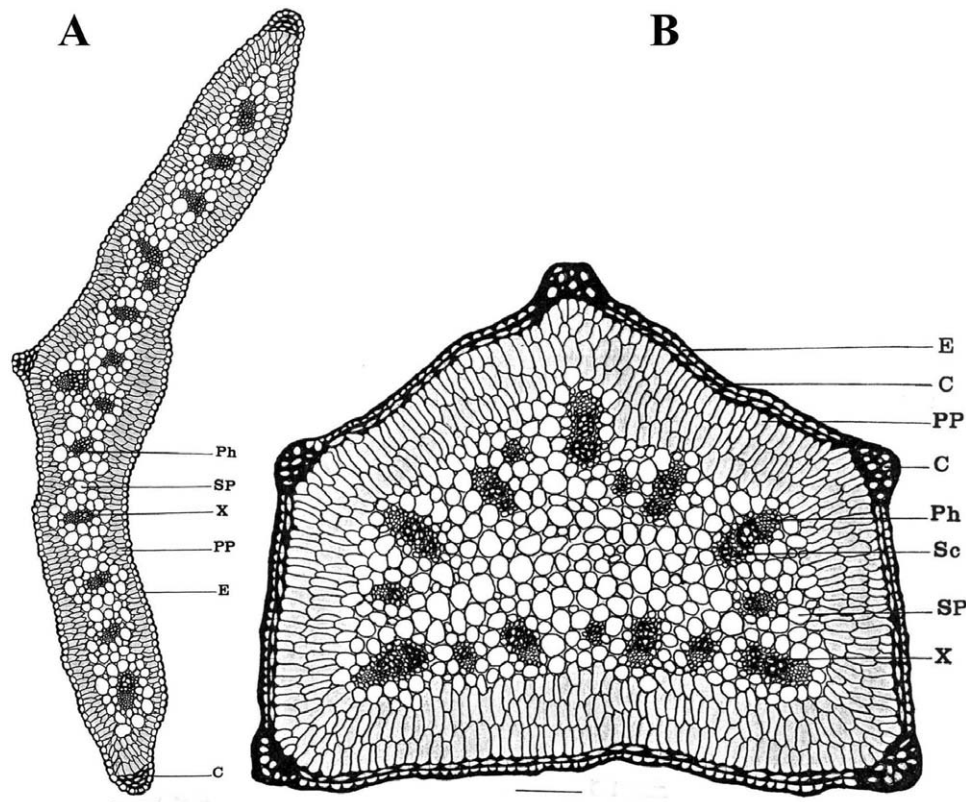
#### 5. *GAGEA VEGETA* VVED.

*Bot. Mater. Gerb. Bot. Institute. Komarova Akad. Nauk S.S.S.R.* 9: 238. 1946. TYPE: TADJIKISTAN, in *jugo Hissarico in valle fl. Varzob infra pag. Zigdy, ad declivia argillosa inter fruticetes*, fl. & fr. 20.v.1937, *Vvedensky 62* (HOLOTYPE: TASH).

PLANTS (4–)7–12(–15) cm tall, solitary or in clumps. BULBS ovoid, 0.5–1.0 in diameter × 0.5–1.5 cm long; tunics reticulate-papery; neck 1.0–1.5 cm, splitting at the top; bulbils absent. ROOTS normal, thickened ones present, enveloping the bulb. STEM erect; subterranean part 1.0–1.5 cm; aerial part absent (inflorescence branching at the soil surface). RADICAL LEAF solitary, grass-like, longer than the inflorescence (60.0–)100.0–220.0 × 1.5–4.5(–7.0) mm, glabrous. CAULINE LEAVES 3–5, verticillate; outer ones linear-lanceolate, flattened, gradually narrowing towards apex, 30.0–70.0(–120.0) × 1.0–3.0(–5.0) mm, equal to or longer than the inflorescence, glabrous; inner ones shorter, strigose-ciliate. BRACTEOLAS absent. INFLORESCENCE umbel-like (1–)2–4(–8)-flowered; pedicels unequal, erect, 15.0–50.0(–90.0) × 0.5–1.0 mm, 2–4 times longer than flower, sparsely spreading-strigose, hairs 0.2–0.3 mm long. OUTER TEPALS 15.0–19.0(–25.0) × 1.5–3.0(–4.0) mm, acuminate, villose at the tip, white at margins; inner tepals 12.0–17.0(–20.0) × 1.0–1.5(–2.5) mm, white at margins, acute to acuminate, glabrous to ciliate. STAMENS half as long as the perianth; filaments 6–8 (–10) mm, anther, oblong in longitudinal cross-section, 1.2–1.6 × 0.7–0.9 mm, yellow. OVARY obovate, 4.0–10.0 × 1.2–3.5 mm, style 5–7 mm, stigma capitate; mature capsule half as long as tepals, tepals persistent.

*Phenology*: Flowering and fruiting between late March and early April, peak flowering early in April.

*Distribution and ecology*: Iran, Afghanistan and Central Asia. In *Artemisia* steppe on clay soil in north-eastern Iran, sometimes under *Berberis* spp.; elevation (90–)200–1350 m.



**Figure 3.** Diagrammatic transverse section of radical leaf in A, *G. vegeta* – scale bar = 0.2 mm; and B, *G. bergii* – scale bar = 0.1 mm. C: collenchyma, E: epidermis, Ph: phloem, PP: palisade parenchyma, Sc: sclerenchyma, SP: spongy parenchyma, X: xylem.

*Conservation status:* LC (IUCN, 2001). Restricted in Iran to north-east, but common there.

*Affinities and variation:* *Gagea vegeta* is closely related to *G. hissarica* Lipsky, but it is more robust and has more flowers in the inflorescence, with longer and more acuminate tepals. *Gagea hissarica* has few small erect hairs on the pedicels whereas *G. vegeta* mostly has glabrous pedicels. However, we have seen some hairs on the pedicels in few populations of *G. vegeta*. *Gagea vegeta* is usually recorded as growing at a lower elevation, usually among shrubs such as *Berberis* sp. and *Quercus macranthera* Fisch. et Mey., in contrast to *G. hissarica*, which usually grows in the alpine meadows between cushion-forming plants (Wendelbo & Rechinger, 1990).

Wendelbo & Rechinger (1990) mentioned another species, *G. bergii* Litv., as closely related to *G. vegeta*. Both species have long acuminate tepals, long pedicels that usually branch at the soil surface, and short peduncles that are hidden under the soil, but *G. vegeta* has a grassy flattened but triquetrous radical leaf with bundles of collenchyma at the three

edges of the leaf (Fig. 3A), whereas *G. bergii* has a pentamerous radical leaf with a layer of lamellar collenchyma under the epidermis that is thickened at each of five edges (Fig. 2B). Moreover, *G. bergii* has several bulbils at the axils of the cauline leaves whereas *G. vegeta* has no bulbils.

*Selected specimens examined:* North Gonbad, alongside tracks in the bottom of shallow valleys near Gharah-Gol, c. 10 km east of Hottan, in Turkeman Sahra, *Hewer 3559* (E); 18 km from Marveh-Tappeh towards Ashkhaneh, *Assadi & Maassoumi 55599* (TARI); Kalaleh, Ajan-Sangarly village, *Ajani 908* (LE, TUH); Kalaleh, Khaled-Nabi Sanan area, *Zarrei 1018* (LE, TUH); Golestan National Park, *Riedl & Ershad 30046* (IRAN); 62 km east Loveh, 37°24'N, 55°45'E, vs. Dasht, 37°17'N, 56°00'E, *Rechinger 33147* (E); Golestan National Park towards Bojnourd, 15 km after Chamanbid, 80 km before Bojnourd, hills near the road, 37°25'46"N, 56°37'55"E, *Zarrei & Ajani 812* (IRAN, K, LE, M, TUH); north of Bojnourd, around Raz village, *Zarrei 1023* (LE, TUH).

6. *GAGEA COMMUTATA* K. KOCH

*Linnaea* 22: 227. 1849. TYPE (designated by Levichev & Tison, 2004a): ARMENIA, Elisabethp[ol], Koch 2720 (LECTOTYPE: G)

PLANTS 8–15 cm tall, solitary. BULBS large, ovoid, 1.0–1.5 cm in diameter  $\times$  0.5–1.0 cm long; tunics reticulate to fibrous, grey to light brown; neck usually present, not firm, split at the top, up to 4.5 cm long; bulbils absent, stolons sometimes present. ROOTS thin, thickened roots present, not enveloping the bulb. STEM erect; subterranean part 3.5–4.0 cm long aerial 1.0–4.0 cm, glabrous or sparsely puberulent. RADICAL LEAVES 2 (originating from the same bulb under the tunic), flattened, equal to or shorter than the inflorescence, 10–20 cm long,  $\pm$  2 mm wide, glabrous or sometimes sparsely ciliate. CAULINE LEAVES 3–5, verticillate; outer ones linear-lanceolate, flattened, gradually narrowing towards apex, enveloping the stem at the base, 60.0–75.0  $\times$  2.0 mm, equal to or slightly longer than the inflorescence, villose-ciliate at margins; inner ones shorter. BRACTEOLES absent. INFLORESCENCE solitary to umbel-like, 1–3-flowered; pedicels unequal, erect, up to 65.0  $\times$  1.0 mm, c. 4 times longer than the flowers, glabrous or shortly villose. TEPALS 16.0–25.0  $\times$  2.5–3.5 mm long, long-acuminate at the tip, yellow on the inner surface, green outside, white at the margin. STAMENS 1/3–1/2 as long as the perianth, filaments 10–15 mm, anther oblong-ellipsoid, yellow, 2.5  $\times$  1.5 mm. OVARY cylindrical, 12  $\times$  7 mm, style 10 mm, stigma capitate.

*Phenology*: Flowering late in April.

*Distribution and ecology*: (Russia) Daghestan, Georgia, Armenia, Azerbaijan and north-western Iran. Open ground between *Quercus* sp. in deep soil; elevation 1200–1300 m.

*Conservation status*: LC (IUCN, 2001), based on the specimens cited by Davlianidze (1976) from the Caucasus, although clearly rare in Iran.

*Affinities and variation*: This species is recorded here from Iran for the first time, although Wendelbo (1985) mentioned it from north-western Iran without citing any specimens. *Gagea commutata* is easily identified by its narrowly long-acuminate tepals (Fig. 6A), long pedicels (c. 4 times longer than tepals), grassy, flattened radical leaves and a long, divided neck.

*Specimens examined*: Ardabil, Mts around Kalibar, *Zarrei* 876 (K, LE, TUH).

7. *GAGEA GRAMINIFOLIA* VVED.

B.A. Fedtschenko *et al.* *Fl. Turkmen.* 2, 2: 268. 1932. TYPE: UZBEKISTAN, Tashkent, no collector or other data given (TASH).

PLANTS 2–3(–5) cm tall, solitary. BULBS ovoid, 1.0–1.5 cm in diameter  $\times$  0.5–1.0 cm long; tunics fibrous, grey to brown; neck up to 1 cm long or absent. ROOTS all thin and enveloping the bulb; bulbils absent. STEM erect or curved; subterranean parts 0.5–1.5 cm; aerial parts 1–2 cm, densely strigose. RADICAL LEAF solitary, linear, longer than the inflorescence, 50.0–100.0  $\times$  2.0 mm, grass-like, densely pubescent, ciliate at margins. CAULINE LEAVES 2–3, verticillate; lower one similar to radical leaf, flattened, equal to or longer than the inflorescence, 20.0–30.0  $\times$  1.0–2.0 mm, lamina glabrous, margin villous-ciliate; upper ones linear or filiform, shorter than the inflorescence, lamina villous, margin villous-ciliate. INFLORESCENCE solitary to umbel-like, 1–2-flowered; pedicels unequal, slender, erect, shorter than the flowers, 5.0–12.0  $\times$  0.5–0.8 mm, densely villous. TEPALS (9.0–)10.0–13.0  $\times$  2.0–2.5 mm; inner tepals 1–2 mm shorter and 0.5–1.0 mm narrower than the outer tepals, acuminate, inner surface yellow, outer surface green, becoming brown towards tip and at the base, pubescent abaxially, villous-ciliate at the margins and tip. STAMENS 2/3 as long as perianth, filaments 6–7 mm long, anther spherical, 0.5 mm in diameter. OVARY cylindrical, 4  $\times$  1 mm, style 5 mm, stigma capitate; capsule obovoid, half as long as tepals.

*Phenology*: Flowering and fruiting in May.

*Distribution and ecology*: North-eastern Iran, Afghanistan and Central Asia. Open ground with *Onobrychis cornuta* (L.) Desv.; elevation c. 2500 m.

*Conservation status*: DD (IUCN, 2001). Populations in Afghanistan and Central Asia are poorly known. It is an extremely rare plant in Iran (based on a single herbarium specimen).

*Affinities and variation*: The specimen cited below (Wendelbo *et al.* 11174, TARI!) is the only specimen of *G. graminifolia* that has been recorded by Wendelbo & Rechinger (1990) from Iran. They have determined this specimen according to Vvedensky's determination in LE. In contrast to its close relative, *G. hissarica* Lipsky, it has short hairs that are dense even on the pedicels, basal leaf and on the outside of the tepals.

*Specimen examined:* Ghatri Mts (Abr Mts), north Shahroud, *Wendelbo et al. 11174* (TARI).

#### 8. *GAGEA CAROLI-KOCHII* GROSSH.

*Fl. USSR.* 4: 736. 1935. TYPE: GEORGIA (?), *Prope Migry*, 15.v.1934, *Karjagin s.n.* (HOLOTYPE: BAK).

PLANTS 5–9 cm tall, solitary. BULBS ovoid, small, 0.5–1.0 cm in diameter  $\times$  1.0–1.5 cm long, tunics fibrous-papery, grey to light-brown; neck up to 0.5 cm or absent. ROOTS all thin, enveloping the bulb. STEM erect; subterranean part 1–2 cm; aerial part 10.0–40.0  $\times$  1.0–1.5 mm, glabrous. RADICAL LEAF solitary, narrowly linear, longer than the inflorescence, 60.0–110.0  $\times$  0.5–1.1 mm, glabrous. CAULINE LEAVES 2–3(–4), verticillate, the lower one linear-lanceolate, longer than the inflorescence, 25.0–35.0  $\times$  2.0–3.0 mm, glabrous; the upper ones linear to filiform, shorter than the inflorescence, glabrous. INFLORESCENCE umbel-like, 1–2(–3)-flowered, pedicels unequal, slender, shorter than the flowers, up to 1 cm, glabrous or pubescent. TEPALS 9–13  $\times$  2–3 mm, inner surface yellow, abaxially green to pale green, margins hyaline, lanceolate to linear-elliptic, acuminate, villous-ciliate at the tip. STAMENS 1/2–2/3 as long as perianth, filaments 5–6 mm, anther oblong-ellipsoid, 3.0–4.0  $\times$  0.5–1.0 mm, yellow. OVARY cylindrical, 3.0–4.0 long  $\times$  1.5–2.0 mm in diameter, style 5 mm, stigma capitate; capsule obovate, half as long as tepals.

*Phenology:* Flowering and fruiting between late May and June.

*Distribution and ecology:* Northern Iran, Armenia and Georgia. Subalpine region of high mountains; elevation 2600–4150 m.

*Conservation status:* VU C2a(i) (IUCN, 2001). Represented in Iran by five specimens from two isolated groups of high mountains.

*Affinities and variation:* *G. caroli-kochii* differs from *G. alexeenkoana* mainly in its thin and slender habit. The former has a slender radical leaf, peduncle and pedicel as well as smaller and narrower tepals (Fig. 6B).

*Specimens examined:* Larijan, Rineh, Damavand Mts, *Moussavi et al. 29914* (IRAN); Near border of Iraq, Dizaj, Mts above village, 37°09'026"N 44°52'85.1"E, *TUH-E Bot. Exp. (Zarrei et al.) 35715* (TUH); Sarein, Sabalan Mts, above skiing site, 38°12'83.1"N 47°52'20.3"E, *TUH-E Bot. Exp. (Zarrei et al.) 35306* (TUH); above Shemshak, *Wendelbo*

*17214* (TARI); between Karaj and Chalus, *Kandavan Pass, Assadi & Mozaffarian 32885* (TARI).

#### 9. *GAGEA ALEXEENKOANA* MISCZ.

*Turdy Bot. Sada Imp. Jur'evsk. Uni.* 9: 76. 1908. TYPE: Dorf Chaltan, Quellgebeit d. Sinsdul-Tschai, 10.iv.1902, *Alexeenko s.n.* (BAK).

PLANTS 6–13 cm tall, solitary or clump-forming. BULBS large, ovoid, 1.0–1.5 cm in diameter  $\times$  1.5–2.0 cm long; tunics fibrous-papery, grey to light brown; neck present, up to 2.5 cm, splitting at the top; bulbils absent. ROOTS all thin, enveloping the bulb. Stem erect; subterranean part 1.5–3.0 cm; aerial part 20.0–60.0  $\times$  1.5–2.0 mm, sparsely spreading-strigose or glabrous. RADICAL LEAF linear, longer than the inflorescence, 70.0–195.0  $\times$  1.0–3.0 mm, glabrous. CAULINE LEAVES 4–7, verticillate; the lower linear-lanceolate, flattened, gradually narrowing towards apex, enveloping the stem at the base, 45.0–70.0  $\times$  3.0–4.5 mm, equal to or longer than the inflorescence, lamina glabrous, strigose-ciliate or glabrous on the margins; the upper ones bract-like. BRACTEOLES absent. INFLORESCENCE umbel-like (1–)2–4(–6)-flowered; pedicels unequal, erect, 25.0–50.0  $\times$  0.5–1.0 mm, as long as or up to twice as long as the flower, sparsely spreading-strigose; hairs 0.15–0.25(–0.30) mm long. TEPALS 22–28 mm long; outer attenuate-acuminate or acute, 2.0–3.5 mm wide, hairy at tip, with 0.5–1.0 mm white margin, narrower than those of the inner tepals; inner tepals 1.5–2.5 mm wide, margins white, glabrous. STAMENS 1/3–1/2 as long as the perianth, filaments 8–10 mm, anther oblong-ellipsoid, 2.5  $\times$  0.7–0.8 mm, yellow. OVARY cylindrical, 5.0  $\times$  1.7 mm, style 10 mm, stigma capitate; capsule obovate to globose, longer than tepals.

*Phenology:* Flowering and fruiting between late April and early July, peak flowering in May.

*Distribution and ecology:* Iran, Azerbaijan, Georgia, Dagestan and Ossetia (Russia). Upper slopes of mountains; elevation 1700–3300 m.

*Conservation status:* NT (IUCN, 2001). Restricted to high montane areas. Potentially threatened by overgrazing and global warming.

*Affinities and variation:* This species is an altogether stouter plant than *G. caroli-kochii* (see note under *G. caroli-kochii*) (Fig. 6B, C).

*Selected specimens examined:* Lar Valley, Lar dam, Mts in front of dam, south slope of Damavand, *Zarrei 1009* (K, TUH); Alamout area, above the village Evan,

south slope of Khash-e Chal Mts, *Assadi & Maassoumi 51122* (TARI); Sarein, Sabalan Mts, above skiing site, 38°12'83.1"N 47°52'20.3"E, *TUH-E Bot. Exp. (Zarrei et al.) 35305* (TUH); Alwand Mts, near Ganjnameh, *Wendelbo & Assadi 16832* (TARI); Hamadan towards Toysarkan from Ganjnameh, just near the pass, 34°43'52.5"N 48°44'23.6"E, *TUH-E Bot. Exp. (Zarrei et al.) 35716* (TUH); Aligudarz towards Esfahan, c. 30 km from main road towards Shoul-Abad, 33°11'10.6"N 49°30'70.4"E, *TUH-E Bot. Exp. (Zarrei et al.) 35721* (TUH); Ghatri (Abr) Mts, north of Shahroud, *Wendelbo et al. 11173* (TARI); north of Tehran, Tochal Mts, *Zarre & Zarrei 765* (K, LE, TUH).

10. *GAGEA RETICULATA* (PALL.) SCHULT. & SCHULT. F.

J.J. Roemer & A.J. Schultes, *Syst. Veg.* 7: 542. 1829. *Ornithogalum reticulatum* Pall., *Reise Russ. Reich.* 3: 727. 1776. *Stellaster reticulatus* (Pall.) Kuntze, *Revis. General. Pl.* 2: 716. 1891. TYPE (Designated by Heyn & Dafni, 1971): 'Astrachan' *Pallas s.n.* (HOLOTYPE: LINN 428.18!; ISOTYPE: BM!). *Ornithogalum circinnatum* L.f., *Suppl. Pl.* 199. 1782. *Gagea circinata* (L.f) Loudon, *Hort. Brit.* 134. 1830. *Hornungia circinnata* (L.f) Bernh., *Flora* 23: 390. 1840. TYPE (Designated by Heyn & Dafni, 1971): 'Astrachan' *Pallas s.n.* (HOLOTYPE: LINN 428.18!; ISOTYPE: BM!). *Gagea tenuifolia* (Boiss.) Fomin, Fomin & Woronow., *Operd. Rast. Kavk. Krimo* 1: 233. 1909. *Gagea reticulata* var. *tenuifolia* Boiss., *Fl. Orient.* 5: 208 (1882). LECTOTYPE (Designated by Wendelbo & Rechinger, 1990): IRAN, Persepolis [Takht-e Jamshid], *Haussknecht s.n.* (G-BOIS). *Gagea tehranica* Gand., *Bull. Soc. Bot. France* 66: 291. 1920. TYPE (designated here): IRAN, Teheran, *in planitie*, 1200–1300 m, 18.ii.1892, *Bornmüller 4787* (LECTOTYPE: K!).

PLANTS (3.5–) 7–20 (–35) cm tall, in a clump or sometimes solitary. BULBS ovoid, 1.0–2.0 cm in diameter × 1.5–3.5 cm long; tunics reticulate, grey to light brown; neck present, well-developed, always multilayered (1.0–)2.5–4.5 (–11.0) cm; bulbils absent. ROOTS thin, thickened roots occasionally present, enveloping the bulb. Stem erect; subterranean part 4–5(–10) cm; aerial part 40.0–75.0(–200.0) × 1.0–2.0(–3.5) mm, papillose or strigose. RADICAL LEAVES 1(–2), filiform to linear, longer than the inflorescence (6.5–) 11.5 (–38.0) cm, glabrous or ciliate. CAULINE LEAVES 4–7, verticillate; the lower one linear-lanceolate, flattened, gradually narrowing towards apex, enveloping stem at the base, 45.0–70.0 × 3.0–4.5 mm, equal to or slightly longer than the inflorescence, lamina glabrous, margins strigose-ciliate or glabrous; inner ones shorter. BRACTEOLE absent.

INFLORESCENCE usually umbel-like (1–)2–8(–16)-flowered; pedicels unequal, erect, 25.0–50.0 × 0.5–1.0 mm, as long as or up to twice as long as the flowers, sparsely spreading-strigose; hairs 0.15–0.25 (–0.3) mm long. TEPALS (15–)18–22(–28) mm long, outer tepals 2.0–3.5 mm wide, attenuate-acuminate or acute at the apex, hairy at tip; with 0.5–1.0 mm white margins, narrower than the inner tepals; inner tepals 1.5–2.5 mm wide, with 1.0–1.5 mm white margin, glabrous. STAMENS 1/3–1/2 as long as the perianth, filaments 8–10 mm, anther oblong-ellipsoid, 2.0–3.0 mm long × 0.7–1.5 mm wide, yellow. OVARY cylindrical, 4.0–6.0 mm long × 1.5–2.5 mm in diameter, style 10 mm, stigma capitate; capsule obovate, 8–12 × 5–8 mm.

*Phenology*: Flowering and fruiting between March and May, peak flowering in April.

*Distribution and ecology*: Found from Palestine to India, but distribution centred on Iran; also in North Africa. Lower slopes of mountains and deserts with sandy soils; elevation (90–)1000– 1800(–3300) m.

*Conservation status*: LC (IUCN, 2001).

*Typification, affinities and variation*: Heyn & Dafni (1971) gave the type of *Ornithogalum reticulatum* Pallas as LINN 428.18 on which the collecting locality is given as Astrakan. However, Wendelbo & Rechinger (1990) stated that the holotype is a Pallas specimen from Astrakan (Astrachan) in LE, with an isotype at M. They did not cite Heyn & Dafni (1971) or discuss why they rejected their typification with LINN 428.18. Levichev & Tison (2004b) designated a lectotype, *Pallas s.n.* from Caspi, also held at LE. Intriguingly, they did not cite Wendelbo & Rechinger (1990) or discuss the Pallas specimen from Astrakan at LE. Levichev & Tison (2004b) rejected LINN 428.18 as the type because they believed that the writing on both the label and at the bottom of the herbarium sheet on LINN 428.18 was not that of Pallas and that the label information did not give Pallas' place of publication of *O. reticulatum* accurately. Thus, although it is a Pallas collection, it was not one on which he had worked. It was, however, collected at the locality cited in the protologue (Astrachan = Astrakan) and thus must be original material. Under article 9.2 of the St. Louis Code (Greuter *et al.*, 2000), this can include duplicate specimens not seen by the publishing author. Furthermore, under article 9.17, lectotypifications can only be superseded if they are in serious conflict with the protologue, if a selected specimen is a mixed collection, or if a holotype believed to be lost has been rediscovered. Neither Wendelbo & Richinger (1990)

nor Levichev & Tison (2004b) demonstrated that LINN 428.18 is in serious conflict with the protologue of *Ornithogalum reticulatum* and our own study suggests that there is no such conflict. It is also not a mixed collection. Thus, Heyn & Dafni's lectotypification by LINN 428.18 must stand. Levichev & Tison's (2004b) designation of a different lectotype is superfluous. Further research may demonstrate that the specimens cited by Wendelbo & Rechinger (1990) are isolectotypes.

*Gagea tenuifolia* (Boiss.) Fomin was lectotypified by Davlianidze (1976) with *Hohenaker s.n.* (LE). In this case, Levichev & Tison (2004b) demonstrated that there was conflict between all the Hohenaker specimens from the two localities given in the protologue of the basionym (*G. reticulata* Schult. & Schult. f. var. *tenuifolia* Boiss.) at LE and G-BOIS. Thus, the lectotype must be the Haussknecht specimen they chose. However, the same specimen was selected by Wendelbo & Rechinger (1990), so that must be the place for designation of the lectotype.

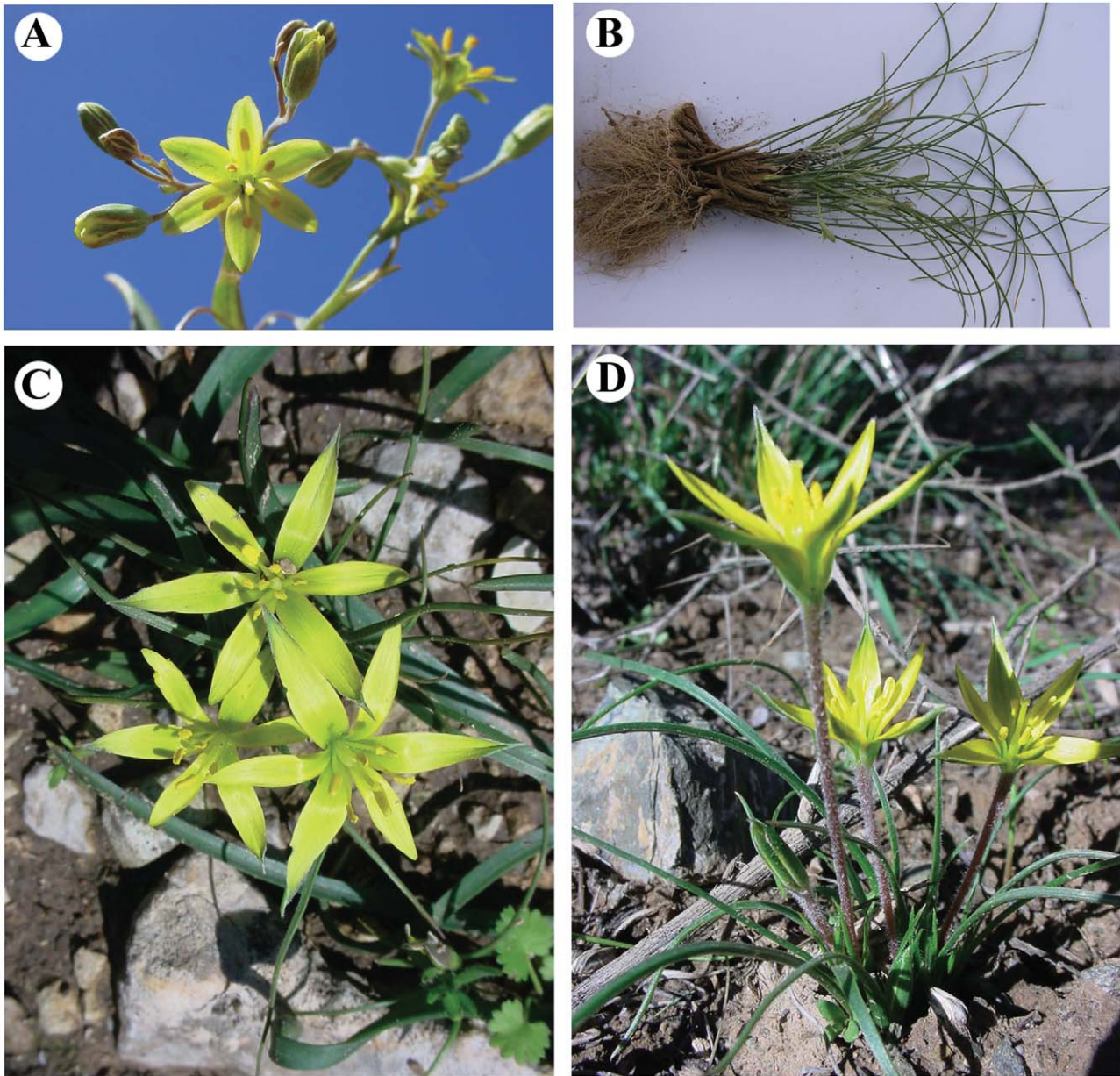
*Gagea reticulata s.l.* is the most variable species of *Gagea* in Iran. Its narrow and circinate basal-leaf forms were known as *G. tenuifolia*, solitary plants with a more or less straight leaf as *G. reticulata s.s.* and forms with broader basal leaves as *G. tehranica*. In our examination of many specimens, we found that there is neither a sharp delimitation between these forms nor a clear pattern for their distribution. All forms can be found in the same population (personal field observation, M.Z.).

*Gagea reticulata* usually grows in sandy soils with a low percentage of clay. The long, multilayered neck (Fig. 4B) around the peduncle that often reaches the soil surface, lamellar collenchyma layer under the epidermis of the narrow, five-edged radical leaf, hairy indumentum and narrowly long-acuminate tepals (Fig. 4C) are all adaptations to hot deserts and dry plateaus. This species prefers dry areas and is the most xerically adapted species of *Gagea*. Moreover, *G. reticulata* is the most widespread species in the dry and hot parts of the world, extending from North Africa (Algeria, Egypt) eastwards to Central Asia (eastern Afghanistan and India). Iran is probably the centre of distribution of this species. In Iran, along with *G. gageoides*, *G. reticulata* is the most widespread species; it is concentrated in the west and south-west of the country and eastwards is gradually replaced by *G. setifolia*.

Wendelbo & Rechinger (1990) mentioned *G. circumplexa* Vved. from Iran, identifying the species on the basis of having thickened roots around the bulb. There are two types of thickened root in *Gagea* species. Some are regular and even, and emerge from base and/or side of bulb; this type is found in *G. circumplexa*. A second type can be found in *G. reticulata*

or *G. setifolia* in which the roots are irregular. All cited materials in *Flora Iranica* under *G. circumplexa* belong to to last species.

*Selected specimens examined:* 45 miles east north-east Gonbad-e Kabus [Kavus] (Golestan Forest), *Furse 5142* (K); Golestan National Park, along road to Almeh, *Wendelbo et al. 10972* (TARI); *ibid.*, hills above Almeh Plain, *Zarrei & Zarre 1032* (K, TUH); Golestan National Park, Sharlegh Plain, *Zarrei 895* (K, M, TUH); Golestan National Park, Mirzabaylou Plain, *Zarrei 898* (TUH); Manjil, Mts around Manjil Dam, *Zarrei 857* (K, LE, TUH); 40 km after Khalkhal to Ardabil, 5 km after Kiwi village, hills beside the road, *Zarrei 864* (TUH); 10 km from Ahar toward Kaleybar, hills on left, *Zarrei 875* (TUH); 45 km after Varzaghan towards Jolfa, *Zarrei 889* (TUH); Jolfa, Mts above St. Steppanous Church, 15 km west from Jolfa, *Zarrei 891* (TUH); 36 km from Takestan towards Avaj, 35°48'27"N, 49°23'37"E, *Zarrei & Zarre 778* (K, TUH); Mahidasht to Eslamabad-e Gharb, on the Mersad pass, 34°13'18"N, 46°40'43"E, *Zarrei & Zarre 844* (K, M, TUH); Ilam, Mts above Ilam University, *Zarrei & Zarre 848* (BM, M, TUH); Dehloran towards Murmuri, 5 km after deviation Dehloran and Dasht-e Abbas, 32°41'22"N, 47°25'57"E, *Zarrei & Zarre 786* (K, TUH); on the pass just after deviation Darreh-Shahr, on the road Poldokhtar-Andimeshk, 33°06'19"N, 47°43'29"E, *Zarrei & Zarre 793* (K, LE, M, TUH); 25 miles south of Arak, 15 miles south-east of Azna, *Furse 1502* (K); 60 km to Yasuj from Babameydan, 30°22'22"N, 51°28'43"E, *Zarrei & Zarre 805* (BM, M, TUH); 15 miles from Shahr-e Kord, *Furse 1401* (E, K); south of Deh-Bid, north- and west-facing volcanic outcrops of soft basalt, *Archibald 1212* (E, K); *Prope ruines U. Perspolis, Kotschy 235* (BM, K); Andika to Izeh, 5 km past Abbaspour Dam, 32°01'19"N, 49°38'19"E, *Zarrei & Zarre 797* (K, M, TUH); between Kangan and Khurmouj, *Iranshahr & Termeh 30037* (IRAN); Minab towards Roudan, 13 km Roudan, 250 m, *Moussavi & Tehrani 30026* (IRAN); Bandar-e Abbas, high region of Kuh-e Geno, *Wendelbo & Foroughi 15390* (TARI); Iranshahr, 87 km Bazman Road, *Foroughi 16642* (TARI); 80 km after Torbat-e Heydarieh towards Gonabad, 35°03'N, 58°53'E *Zarrei & Goltarian 35229* (K, TUH); 5 km after Fariman toward Aghar, 33°45'50"N, 59°55'15"E, *Zarrei & Ajani 831* (LE, TUH); 10.2 miles north of Torbat-e Heydaryeh, road to Mashhad, *Grey-Wilson & Hewer 420* (K); Mashhad towards Torbat-e Heydaryeh, 5 km after Garmab (after Robat-e Sefid), 2 km before Sarhang, 47 km towards Torbat-e Heydaryeh, *Zarrei 594* (Shahed University Hb.); north of Bojnourd, around Raz village, *Zarrei 1022* (LE, TUH); Bastam to



**Figure 4.** A, *G. dschungarica* – (Zarrei 35290); B, *G. reticulata* – (Zarrei 594); C, *G. reticulata* – (Zarrei & Zarre 805); D, *G. bergii* – (Zarrei 1011).

Azadshahr, 8 km to Khoshyeilagh pass, Dang deviation, 7 km to Dang from the main road, 36°48'26"N, 55°15'01"E, Zarrei & Ajani 810 (K, TUH); Semnan, top of pass, on the road between Shahpassand [Azadshahr] and Shahroud, Wendelbo *et al.* 11140 (TARI); Ghaemshahr towards Firouzkuh, 5 km to Veresk, 170 km to Tehran, 35°57'N, 53°00'E, Zarrei & Golzarian 35252 (K, TUH); Shahdasht, south of Karaj, Rechinger 54494-b (E); Qazvin

towards Loushan, 5 km after Kuhin Mts, above Asb-e Sefid restaurant, Zarrei 856 (TUH).

#### 11. *GAGEA SETIFOLIA* BAKER

*Bot. J. Linn. Soc.* 18: 101. 1880. TYPE (designated by Wendelbo, 1958): AFGANISTAN, Kurram Valley, *inter Kurran et Habibkala*, 1879, Aitchison 104 (LECTO-TYPE: K!). *Gagea anonyma* Rech.f., *Pl. Syst. Evol.*

153: 288. 1986. TYPE: IRAN, Prov. Kerman: 100 km S Yazd, *in collibus saxosis*, 25.3. 1965, *Lamond 68* (HOLOTYPE: E!; ISOTYPE: BG, W). *Gagea perpusilla* Pascher, *Lotos* 52: 125. 1904. TYPE: IRAN, Lurestan, Kuh-e Savers, *ad nives*, ?vii.1868, *Haussknecht s.n.* (HOLOTYPE: G-BOIS; ISOTYPE: K!, BM!).

PLANTS (4–)6–13(–20) cm, solitary, or sometimes in a clump. BULBS ovoid, 0.8–2.0 cm long  $\times$  0.5–1.0 cm in diameter; tunics papery or reticulate, pluritunicate; neck usually absent, but if present very short, dark brown; bulbils absent. ROOTS thin, thickened ones occasionally present, entwined around the bulb, sometimes with 1–2(–4) mm stolons ending with small (2–3 mm diameter) bulbils. STEM erect; subterranean parts 1–5(–7) cm, white when fresh, yellow to orange when dried, becoming narrower towards the bulb; aerial parts 20.0–60.0(–80.0)  $\times$  2.0–3.0 mm, glabrous. RADICAL LEAF linear, longer than the inflorescence, 80.0–200.0  $\times$  1.0–2.0 mm, glabrous to villous-ciliate. CAULINE LEAVES 2–3, verticillate, villous-ciliate, the lower one narrowly lanceolate, longer to shorter than the inflorescence, 20.0–80.0  $\times$  2.0–4.0 mm; upper ones shorter. BRACTEOLES absent. INFLORESCENCE umbel-like (1–)3–5(–8)-flowered; pedicels shorter, equal to or longer than the perianth, 4–10 cm, sparsely villous to glabrous. TEPALS (10.0–)12.0–20.0(–25.0)  $\times$  2.0–3.5 mm, ovate-oblong, inner ones acute to acuminate, yellow inside, green to black green outside, hyaline on the margins, villous-ciliate at the tip and margins. STAMENS 1/2–2/3 as long as the perianth, filament 5–8 mm long, anther yellow, oblong-ellipsoid, 1.5–2.5  $\times$  0.8–1.5 mm. OVARY cylindrical, 4–6  $\times$  1–2 mm, style 3.5–7.0 mm, stigma capitate; capsule glob shape, 6–8 mm in diameter, two times shorter than the perianth segments.

*Phenology*: Flowering and fruiting between March and May, peak flowering in late March.

*Distribution and ecology*: Iran, Afghanistan and north-western Pakistan. This species is adapted to drier regions than where *G. reticulata* grows and can be found in flat meadows in submontane steppe; elevation (750–) 1800–2800 m.

*Conservation status*: LC (IUCN, 2001).

*Selected specimens examined*: Hamadan, Alwand Mts, *Bowles Schol. Bot. Exp. 1661* (K); 100 km south of Yazd, *in collibus saxosis*, *Lamond 68* (E, type of *G. anonyma*); 90 km south of Yazd, Kermanshah Pass, *Zarrei 1017* (K, LE, TUH); Lorestan, Kuh-e Savers, *ad nives*, *Haussknecht s.n.* (BM, K, ISOTYPES of *G. perpusilla*); 55 km ssw Baft towards Khabr Mts,

28°53'01"N, 56°23'48"E, *Zarrei & Ajani 842* (K, LE, TUH); from Ravar towards Kerman, 35 km to Kerman, 30°56'39"N, 56°56'41"E, *Zarrei & Ajani 838* (IRAN, K, LE, TUH); 10 km Rayen towards Romanabad, Hezar Mts, 29°35'19"N, 57°19'37"E, *Zarrei & Ajani 839* (K, LE, TUH); between Doroudy and Naroun, foothills of Taftan, *Zarrei 1015* (K, LE, TUH); Zahedan, 27.8 miles south Zahedan, road west to Khash, *Grey-Wilson & Hewer 158* (E); 5 km after Khanic, between Ghaen and Birjand, *Zarrei 1012* (TUH); Qaen towards Khaf, 5 km after Ebrahim-Abad, 33°57'N, 59°38'E, *Zarrei & Golzarian 35254* (K, TUH); 10.2 miles north of Torbat-e Heydariyeh, road to Mashhad, *Grey-Wilson & Hewer 420* (E); 20 km south-west of Sabzevar, *Rajamand & Bazargan 31642* (TARI); Bojnourd towards Gorgan, 5 km to Robot-e Gharabil, Mts above Sparkho village, 37°32'N, 56°22'E, *Zarrei & Golzarian 35246* (TUH); *Oasis de Chapanam entre Tehran et Tabas, all sud da Dasht-e Kavir*, 33°30'N, 54°04'E, *Leonard 5405* (K); 35 miles east of Tehran, foothills of Alborz, *Furse 1695* (K); north of Tehran, Tochal Mts, *Zarrei & Zarrei 35268* (K, TUH).

## 12. GAGEA BERGII LITV.

B.A. Fedtschenko *et al.* *Fl. Turkm.* 1: 267. 1932. TYPE: KAZAKHSTAN, Alma Ata, 6.iv.1900, *Berg s.n.* (LE).

PLANTS 5–10 (–15) cm, clumped or solitary. BULBS 1 cm in diameter; tunic finely fibrous to membranous, grey; neck up to 1.5 cm, splitting at the top; bulbils absent. ROOTS thin, thickened roots occasionally present, not enveloping the bulb. STEM erect; subterranean parts up to 1.5 cm; aerial parts absent (no peduncle), inflorescence at the level of soil. RADICAL LEAF linear, canaliculate above, keeled below, longer than the inflorescence, 60.0–100.0  $\times$  0.5–1.0 mm; glabrous or with fine hairs. CAULINE LEAVES 3–5, verticillate, linear to filiform, unequal, up to 6 cm long, 0.5–1.5 mm wide; the lower one longer than the inflorescence; upper ones shorter than the outer, sparsely ciliate, 1–4 bulbils present in the axils of bracts. INFLORESCENCE solitary to umbel-like, 1–3-flowered, pedicels unequal, becoming much longer after anthesis, 30.0–50.0 cm  $\times$  0.7–1.0 mm, up to twice as long as the perianth, densely villous. TEPALS 10–15(–18)  $\times$  2–4 mm, linear-lanceolate; inner ones 1–2 mm shorter and 0.5–1.0 mm narrower, shortly acuminate, yellow inside, green outside (with 3–5 nerves); outer ones long-acuminate and villous-ciliate at the tip. STAMENS half as long as the perianth, filaments 5–7 mm long, anther oblong-ellipsoid, 2  $\times$  1 mm, yellow. OVARY cylindrical, 3–4  $\times$  2 mm, style 5 mm, stigma capitate; capsule 1/2–2/3 as long as perianth, obovoid.



*Phenology*: Flowering in March.

*Distribution and ecology*: Eastern Iran, Afghanistan and Central Asia. Growing in soil with a high percentage of clay; elevation 1600 m.

*Conservation status*: EN C2a(i) (IUCN, 2001). Known from not more than three localities in eastern Iran and only two sites in Afghanistan. There is little information available on the Central Asian populations.

*Affinities and variation*: *Gagea bergii* is well characterized by the absence of a peduncle (Fig. 4D) and by having a bulbil in the axil of each cauline leaf and, sometimes, an indumentum of densely long hairs on the pedicels and abaxial surface of the tepals. It clear that its persistent layer of lamellar collenchyma under the epidermis (Fig. 3B) is essential with being a species of arid areas and may be an adaptation to prevent grazing by animals.

Wendelbo & Rechinger (1990) recorded this species from three localities. One from north of Iran (near Manjil, *Jacobs 6185 E!*), which is *G. reticulata*, and two other localities from eastern Iran for which we could not find specimens. Jacobs' specimen has no bulbils in the axils of the cauline leaves, and the bulb is entwined by thick roots.

*Specimens examined*: 65 km from Gonabad towards Ghaen, 10 km before Khezry, on the pass, *Zarrei 1011* (K, TUH); *ibid.*, 34°05'N, 58°50'E, *Zarrei & Goltzarian 35222* (K, TUH).

### 13. *GAGEA FISTULOSA* (RAMOND EX DC.)

KER GAWL.

*J. Sci. Arts (London)* 1: 180. 1816. *Ornithogalum fistulosum* Ramond ex DC., *Fl. Fr. ed.* 3: 215. 1805. TYPE: FRANCE (?), *montes Pyrenaei, de Carbonnieres Ramond* (P).

PLANTS 6–20 (–25) cm tall, solitary, rarely in clumps of a few plants. BULBS in pairs, ovoid, composed of a large and a smaller one, enclosed by common tunics, new bulb arising just above base of old one, 1.0–2.0 cm long × 1.0–1.5 cm in diameter; tunics coriaceous, grey to pale brown; neck absent; bulbils absent. ROOTS all thin, not enveloping bulbs. STEM erect; subterranean part 2–5 cm; aerial part 4–9 cm, glabrous. RADICAL LEAF linear-fistulose, canaliculate above, longer than the inflorescence. CAULINE LEAVES 2–6, verticillate or with a lower one remote from the others; the lower one lanceolate to linear-lanceolate, gradually narrowing towards apex, enveloping the

stem at the base, 3–6(–8) cm, equal to or shorter than the inflorescence, glabrous or sometimes villous-ciliate at the margin; upper ones similar to the outer or shorter. Bracteoles sometimes present. INFLORESCENCE usually umbel-like (1–)2–6(–9)-flowered; pedicels unequal, erect at flowering and fruiting time, 2–5 cm, 2.0–2.5 times longer than flowers, elongating after flowering, glabrous to densely villous. TEPALS (9–)12–17 mm, 1.5–2.5 mm wide, oblanceolate or narrowly elliptic, obtuse to acute at the tip, inner surface yellow, outer surface green, with 4–5 distinct green nerves, glabrous. STAMENS 1/2–2/3 as long as the perianth, filaments 5–6 mm long, anther globe shape, 0.5–1.5 in diameter; yellow. OVARY obovoid, 4–6 mm long × 1–3 mm in diameter; capsule obovoid, as long as the persisting perianth segments or slightly shorter than it, 11–17 × 6–8 mm.

*Phenology*: Flowering and fruiting between March and June, peak flowering in May.

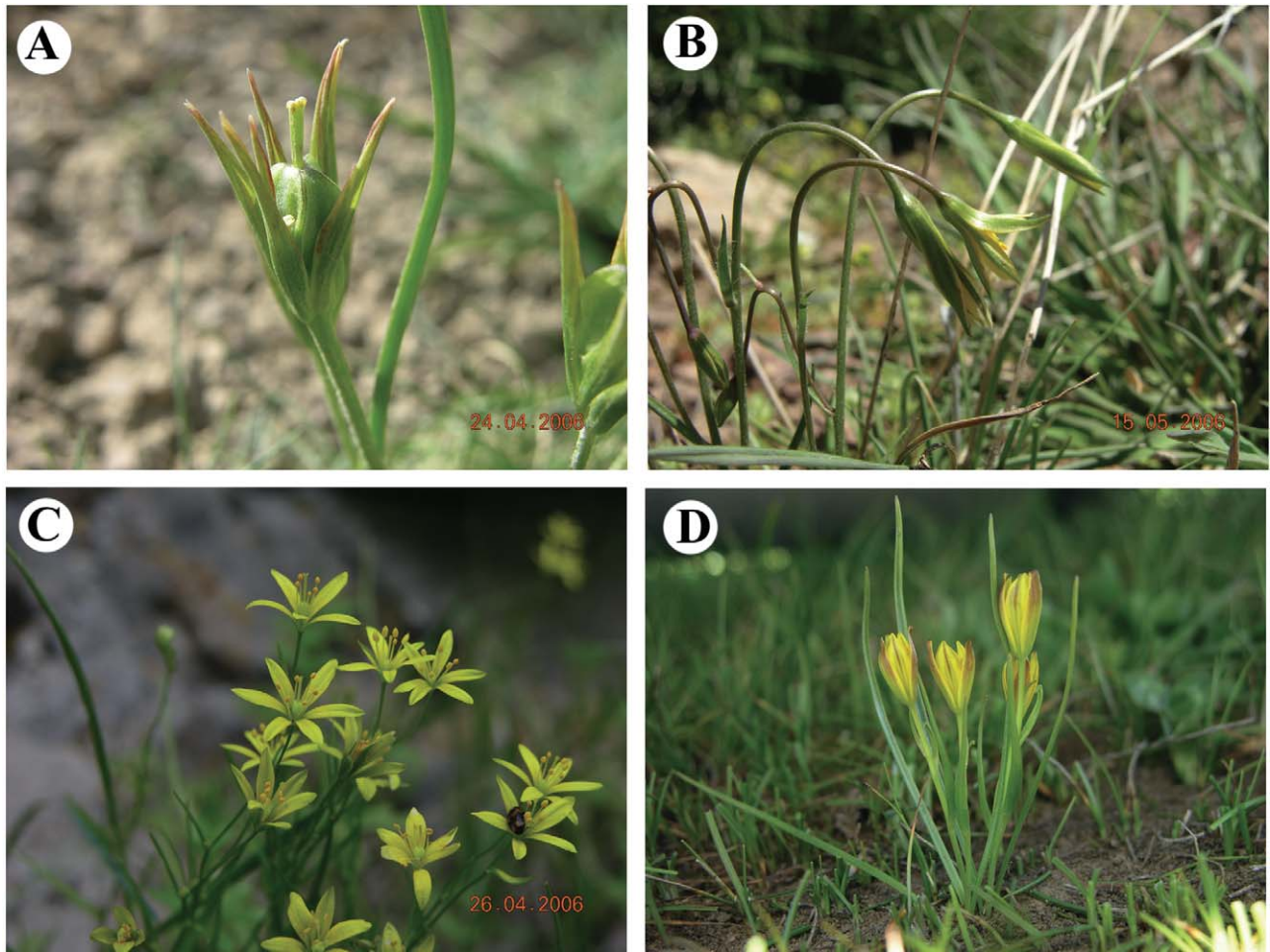
*Distribution and ecology*: Europe, Turkey, northern and eastern Syria, northern and eastern Iraq, Iran and Georgia. Moist areas in high mountains, usually among patches of melting snow or by streams; elevation (1700–) 2300–3000 (–3500) m.

*Conservation status*: LC (IUCN, 2001).

*Affinities and variation*: It is distinguished by its hollow, fleshy radical leaves, opposed stem leaves and usually hairy pedicels (Phillips & Rix, 1989). Its tepals twist inward as they senesce (Fig. 5A).

*Gagea luteoides* Stapf is recorded from the Arasbaran protected area, north-western Iran, according to *Massoumi & Assadi 20315* (TARI; Assadi, 1988). The record of this species is as a small form of *G. fistulosa*, although the presence of this species in north-western Iran is likely.

*Gagea glacialis* K.Koch has been recorded from Golestan National Park, north-eastern Iran (Akhani, 1999). Examination of *Akhani & Shasavari 6102* (Hb. Akh.), on which the record is based, revealed that it is a small form of *G. fistulosa*. Morphological differences between those two species are so slight that we must rely on perianth length (longer or shorter than 12 mm) and/or number of flowers (1–3 in *G. glacialis* and 2–6 in *G. fistulosa*; Rix, 1984). It is likely that the number of flowers and/or tepal length is related to the age of bulb and habitat condition in the previous year. Larger and healthier bulbs produce inflorescences with more flowers and longer tepals. Molecular data do not show differences between these species (unpublished data). It seems *G. glacialis* might be best placed in synonymy



**Figure 5.** A, *G. fistulosa* – (Zarrei 548); B, *G. bulbifera* – (Zarrei 502); C, *G. gageoides* (Zarrei 627); D, *G. uliginosa* (Zarrei 503).

with *G. fistulosa* but more supporting data are needed to confirm this hypothesis.

*Selected specimens examined:* Damavand Mts, south slope, Zarrei & Kamrani 1071 (K, TUH); 5 km after Chalus towards Kandavan tunnel, Zarrei & Zarrei 769 (BM, LE, TUH); Javaherdeh, Mts above village, Zarrei 30082 (TUH); Mahneshan, Alam Kandy, Gharghalan Mts, Moussavi *et al.* 29972 (IRAN); Ardabil, Talysh, Bowles *Schol. Bot. Exp.* 563 (K); Maku towards Khoy, Mts south-western Kelisa-Kandi, Assadi & Mozaffarian 30327 (TARI); west of Rezayeh [Oroumyeh], hills west of Silvana village, Runemark & Foroughi 19619 (TARI); 23 km west of Hamadan, Cowan & Darlington 338 (K); Islamabad towards Ilam, Ghalajeh pass, 33°57'39"N, 46°21'51"E, Zarrei & Zarrei 785 (K, LE, M, TUH); North of Azna, marshy bank of small stream, Bowles *Schol. Bot. Exp.* 677 (K); Savers Mts, Zarrei & Kamrani 1075 (K, TUH); 10 km

after Yasuj towards Babameydan, wet pasture by stream, Davis & Bokhari D-56422 (E, K); Shahroud towards Azadshahr, 10 km after Olang deviation towards Olang, Olang pass, Zarrei 548 (Shahed University, Hb.); Tochal Mts, south-west slope, Zarrei & Zarrei 35265 (K, TUH).

14. *GAGEA CHOMUTOVAE* (PASCHER) PASCHER  
*Bull. Soc. Imp. Nat. Mosc.* 19: 372. 1907. *Gagea olgae* Regel var. *chomutovae* Pascher, *Feddes Repert.* 2: 67. 1906. TYPE: UZBEKISTAN, Tashkent, *Chomutova s.n.* (HOLOTYPE: LE).

PLANTS (10–)15–26(–35) cm tall, solitary. BULBS in pairs, 1.0–2.0 cm long × 1.0–1.5 cm in diameter, the larger, subtended by the radical leaf, the other small, subtended by the stem, enclosed in common tunics,

tunics coriaceous, grey to dark-brown; neck present, short, with tunics cleft; bulbils present, numerous, current year's light-brown to brown,  $2.0 \times 1.0$ – $1.5$  mm, last year's dark-brown, pyriform, located at the base of bulbils,  $2.5$ – $1.5$  mm, finely reticulate. ROOTS thin, thickened roots occasionally present. STEM arch-like; subterranean part 2–3 cm, purple; aerial part 2.0–2.5 cm, green. RADICAL LEAF linear, distinctly cylindrical-fistulose,  $130.0$ – $300.0 \times 2.0$ – $2.5$  mm, longer than the inflorescence, glabrous. CAULINE LEAVES up to 10 in number, the lowest one linear-lanceolate, long-acuminate, sheathing at the base,  $45.0$ – $85.0 \times 4.0$ – $6.0$  mm, indistinctly veined, sparsely ciliate at the margin, shorter than the inflorescence, an auxiliary inflorescence usually present in the axil of the lower cauline leaf; upper ones linear to linear-lanceolate, weakly sheathing, acute, gradually tapering ( $2.5$ –) $4.0$ – $4.5 \times 1.5$ – $2.5$  mm, villous-ciliate at margin, equal to or shorter than the inflorescence; bracts shorter than cauline leaves, gradually diminishing,  $15.0$ – $25.0 \times 1.0$ – $1.5$  mm, densely villous ciliate especially below. INFLORESCENCE (2–)4–9-flowered, cymose, usually dichotomously branched; Pedicels nodding in bud, erect at flowering,  $10.0$ – $35.0 \times 0.5$  mm, 2–3 times longer than flowers, glabrous; TEPALS large, conspicuous, outer tepals smaller and thinner than inner,  $10.0$ – $13.0 \times 3.0$ – $3.5$  mm, elliptic-obovate, acute to obtuse; inner tepals  $12.0$ – $14.0 \times 4.0$ – $5.5$  mm, oblong-obovate, obtuse to somewhat rounded; outer surface green, inner yellow, becoming purple towards apex and margin, inner tepals purple only at the tip, glabrous. STAMENS  $2/3$  as long as perianth, filament usually triangular, tapering towards anther, 6 mm long; anther yellow, oblong-ellipsoid,  $2.0$ – $2.5 \times 0.7$ – $1.0$  mm. OVARY ovate to cylindrical, obtuse,  $4.5$ – $5.0 \times 1.0$ – $2.0$  mm, style as long as ovary or slightly shorter, 3.0–4.5 mm long, stigma  $\pm$  globose; capsule oblong-obovoid, half the length of perianth.

*Phenology:* Flowering and fruiting between late March and early May, peak flowering in April.

*Distribution and ecology:* Iran (Fig. 7A), Turkmenistan, Afghanistan and Central Asia. It prefers humid areas, usually in soils with a high percentage of clay, under *Poa bulbosa* L., *Rosa persica* Michx. ex Juss., *Scariola orientalis* (Boiss.) Sojak and *Stipa* sp.; elevation (850–) 1000–2100 (–2800) m.

*Conservation status:* LC (IUCN, 2001).

*Affinities and variation:* *Gagea chomutovae* is easily distinguished by its hollow basal leaf, nodding buds and tepals that are purple at the tip.

*Selected specimens examined:* 15 km north of Golestan, dry slope among rocks, *Hedge & Ekberg W-7322* (E); Golestan National Park, hills above Almeh Plain, *Zarrei & Zarre 1031* (K, TUH); Damavand Mts, north-west of Telkamar city, *Mozaffarian 45376* (TARI); Alborz, 35 km of Tehran, *Furse 1648* (K); 65 km from Gonabad towards Ghaen, 10 km before Khezry, just on the pass,  $34^{\circ}05'N$ ,  $58^{\circ}50'E$ , *Zarrei & Golzarian 35224* (K, TUH); Gonabad district, Kakhk town, Kalat-e Vally, *Zarrei 752* (LE, TUH); *ibid.*, *Zarrei 903* (IRAN, K, M, TUH); Khajeh Morad, on the road from Mashhad towards Neyshabour, above holy place,  $36^{\circ}09'N$ ,  $59^{\circ}41'E$ , *Zarrei & Golzarian 35218* (K, TUH); between Quchan and Darreh-Gaz, Tandooreh National Park, Shekarab, *Assadi & Maassoumi 50611* (TARI); Allah-A kbar Pass, *Ghahreman et al. 22291-A* (TUH); Shirvan, after Hename village, near Gadeganlou village, Ghalee-Ches Mts,  $37^{\circ}31'56'N$ ,  $58^{\circ}05'03'E$ , *Zarrei & Ajani 820* (IRAN, TUH); 20 miles south-east of Bojnourd, *Furse 5189* (K); Shahpassand [Azadshahr] to Shahroud, past summit of pass, *Furse 7204* (K); 2 km from Gachsar towards Karaj, Nesae area, *Zarrei & Zarre 918* (TUH).

#### 15. *GAGEA VILLOSA* (M. BIEB.) SWEET

*Hort. Brit.* 418. 1826. *Ornithogalum villosum* M. Bieb., *Fl. Taur.-Cauc.* 1: 247. 1808. *Ornithoxanthum villosum* (M. Bieb.) Link, *Handbuch* 1: 161. 1829. = *Gagea arvensis* (Pers.) Dumort., *Fl. Belg.* 1: 140. 1827. *Ornithogalum arvense* Pers., *Usteri, Ann. Bot.* 11: 8, tab. 1, fig. 2, *nom. illeg.* 1794. TYPE (designated by Heyn & Dafni, 1977): GEORGIA, in *Tauriae agris et campis, in promontorio Caucasico, von Bieberstein s.n.* (LECTOTYPE: LE).

PLANTS (4–)10–15(–22) cm tall, solitary or sometimes clumped. BULBS in pairs, ovoid, 1.0–2.0 cm long  $\times$  1.0–1.5 cm in diameter, larger one subtended by the radical leaf, yellow, smaller subtended by stem, black, or sometimes yellow, foveolate; tunics coriaceous, grey to brown; bulbils sometimes present, black, 3 mm in diameter, reticulate-foveolate. ROOTS all thin, not enveloping bulb. STEM erect; subterranean part 3–6 (–12) cm; aerial part 2–10 cm, villous, sometimes glabrous. RADICAL LEAVES 2, linear, fistulose, canaliculate above, slightly keeled below, longer than the inflorescence ( $45.0$ –)100.0–200.0(–300.0)  $\times$  (1.0–)1.5–3.0 mm, glabrous or with very hairs. CAULINE LEAVES 3–8, verticillate; the lowest one linear-lanceolate, equal to or longer than the inflorescence,  $25.0$ – $50.0$ (–100.0)  $\times$  3.0–6.0(–8.0) mm, lamina glabrous or villous, villous-ciliate at the margins, sometimes with a group of bulbils in its axils; upper ones bract-like, similar to outer cauline leaves or

narrower and filiform, shorter than the inflorescence, villous ciliate. INFLORESCENCE usually umbel-like (1–)3–6(–12)-flowered; pedicels unequal, becoming much longer in fruit, as long as perianth or up to 3 times longer, 10.0–30.0(–60.0) × 1.0 mm, abaxially densely villous, with hairs up to 0.5 mm long. TEPALS (9.0–)12.0–15.0(–18.0) × 1.5–3.0 mm, much longer in fruit, linear-elliptic, obtuse, recurved at the tip, acuminate, abaxially densely villous, yellow inside, green outside. STAMENS 1/2–2/3 as long as the perianth, filaments 6–8 mm long, anther yellow, spherical, 1 mm in diameter. OVARY ellipsoid to obovoid, 3–5 mm long × 1–2 mm in diameter, style 6–7 mm, capsule ellipsoid to obovoid, 6–15 × 3–6 mm, as long as perianth segments or slightly shorter.

*Phenology:* Flowering and fruiting between late March and early May, peak flowering in April.

*Distribution and ecology:* Europe, North Africa, Turkey, Palestine, Iran, Syria, north-eastern Iraq, Georgia and Armenia. It usually grows in disturbed areas near roads and fields; elevation 1000–2200(–2800) m.

*Conservation status:* LC (IUCN, 2001).

*Affinities and variation:* Wendelbo & Rechinger (1990) determined all specimens of this species at IRAN and TARI as *G. dubia* except *Davis & Bokhari D-56426*. Examination of specimens in UK herbaria revealed that *G. dubia* is a Mediterranean species and does not grow in Iran. Its indumentum consists of long villose hairs, especially on the pedicels even on the tepals. Some plants have a group of bulbils in the axils of the cauline leaves.

*Selected specimens examined:* Shahpassand [Azadshahr] to Shahroud, north-east of Khoshyeilagh, *Wendelbo et al. 11131* (TARI); Alborz Mts, north of Allamul, NW-facing slope among scrub, *Archibald 1115* (E, K); Karaj towards Chalus, north slope of Kandavan Mts, Siahbisheh, Mts above village, 36°12'68.4"N, 51°18'96.7"E, *Zarrei 35286* (K, TUH); Chalus road, Pol-e Zanguleh, *Zarrei & Kamrani 30073* (TUH); Asalem towards Khalkhal, 2 km after Matach village, 27 km before Khalkhal, *Zarrei 859* (K, LE, M, TUH); Asalem towards Khalkhal, 5 km before Khalkhal, above village, *Zarrei 862* (K, LE, TUH); 8 km after Meshginshahr towards Moel, Sabalan foothills, *Zarrei 869* (K, M, TUH); 32 km after Ahar, 10 km before Varzaghan, *Zarrei 880* (TUH); 12 km from Hamadan towards Assadabad, 34°50'03"N, 48°11'24"E, *Zarrei & Zarre 779* (IRAN, TUH); Mahidasht to Eslamabad-e Gharb, on the Mersad pass, 43°13'18"N, 46°40'43"E, *Zarrei & Zarre*

*781* (K, LE, M, TUH); Islamabad towards Ilam, Ghajlajeh pass, 33°57'39"N, 46°21'51"E, *Zarrei & Zarre 783* (K, LE, M, TUH); Abdanan to Darreh-Shahr, 5 km before Darreh-Shahr, after Kabirkuh Pass, 33°05'29"N, 47°19'42"E, *Zarrei & Zarre 791* (LE, TUH); 5 km after Zagheh towards Borujerd, Zagheh pass, 33°32'56"N, 48°50'05"E, *Zarrei & Zarre 854* (LE, TUH); Azna, marshy bank of small stream, *Bowles Schol. Bot. Exp. 676* (K); Golestan Kuh, near Khomein, *Wendelbo & Assadi 16400* (TARI); 52 km after Babameydan towards Yasuj, 30°23'50"N, 51°29'54"E, *Zarrei & Zarre 804* (TUH); Dasht-e Arjan, *Jefferies s.n.* (K); 25–30 km from Babameydan to Yasuj, *Davis & Bokhari D-56426* (E, K); Gardan-e Khaneh Sorkh, 122 km from Kerman, 2450 m, *Wendelbo & Foroughi 15870* (TARI); Ghatri Mts (Abr Mts), north Shahroud, 2200 m, *Wendelbo et al. 11157* (TARI); Firuzkuh towards Tehran, 105 km before Tehran, Mts near 3rd tunnel, Chehel-Cheshmeh Valley, *Zarre & Zarrei 758* (K, LE, TUH); Lashkarak, north-east of Tehran, in foothills of Alborz, *Parris 7523* (E, K); Karaj towards Chalus, Nesae area, Mts near the village, 36°04'51.6"N, 51°18'88.0"E, *Zarrei 35282* (K, TUH); Sultanabad, *in cultis*, *Bornmüller 4375* (E).

#### 16. *GAGEA BULBIFERA* (PALL.) SALISB.

*Ann. Bot.* 2: 557. 1806. *Ornithogalum bulbiferum* Pall., *Reise Russ. Reich.* 2: 736. 1773. *Stellaster bulbifer* (Pall.) Kuntze, *Revis. General. Pl.* 2: 715. 1891. *Hornungia bulbifera* (Pall.) Rouy, G. Rouy & J. Foucad, *Fl. France* 12: 381. 1910. TYPE: Kazakystan/Russia (Astrakhan), *in aridis limosis ad Wolgam et Jaicum*, *Pallas s.n.* (HOLOTYPE: LINN 428.17; ISOTYPE: BM!).

PLANTS 3–12 (–15) cm tall, in clumps. BULBS, ovoid, 4.0–10.0 mm long × 2.5–7.0 mm in diameter; tunics coriaceous, grey-brown; neck sometimes present, up to 10 mm, splitting at the top; bulbils absent. ROOTS thin, thickened roots occasionally present, enveloping the bulb. STEM erect, nodding in bud; subterranean part 1.0–2.5 cm, aerial part indistinguishable, cauline leaves emerge just above the bulb, densely villous. RADICAL LEAF (rarely 2) filiform-linear, equal to or shorter than inflorescence, 70.0–150.0 × 1.0–1.5 mm, canaliculate above, with adpressed sparse short hairs below. CAULINE LEAVES 3–9, alternate, similar to radical leaves, filiform-linear, shorter than inflorescence, V-shaped to canaliculate adaxially, adaxially more densely hairy, one bulbil present in each axil. INFLORESCENCE solitary to a raceme, few-flowered (mostly one, sometimes two or three); pedicels 4–5 cm long, 3–4 times longer than flower, deflexed in bud and at anthesis, becoming ± erect later, glabrous.

FLOWERS with outer tepals smaller and thinner than inner ones, outer tepals 12.0–13.0 × 2.5–3.0 mm, narrowly obovate-oblong, acute, with thin yellow or hyaline margin, somewhat purple towards apex, around mid-point green or with purple nerves; inner tepals 10–11 × 3 mm, obovate, acuminate to acute, margins hyaline; glabrous. STAMENS 1/2–2/3 as long as of the perianth, 6–7 mm, anthers oblong-ellipsoid, 2–3 × 1 mm, yellow. OVARY ovate, half as long as perianth, 3.0 mm long × 1.5 mm in diameter, style two times longer than ovary, slightly longer than stamens, 6 mm, stigma capitate or slightly bifid; capsule ovoid, half as long as perianth.

*Phenology*: Flowering and fruiting between late in April and early in June, peak flowering in May.

*Distribution and ecology*: Romania and southern European Russia to Central Asia and possibly Mongolia (Fig. 7A), between cushion form plants such as *Astragalus* and *Acantholimon*; elevation 900–2000 m.

*Conservation status*: LC (IUCN, 2001).

*Affinities and variation*: *Gagea bulbifera* is easily distinguished by its slender stem with one bulbil in the axil of each cauline leaf. It usually has a solitary inflorescence (Fig. 5B).

*Selected specimens examined*: Asalem towards Khalkhal, 5 km before Khalkhal, Mts above village, *Zarrei* 863 (IRAN, K, LE, M, TUH); 32 km after Ahar towards Varzaghan, 10 km before Varzaghan, *Zarrei* 879 (M, TUH, IRAN); Varzaghan to Jolfa, 5 km after Mashkanbar deviation, foothills of Kasabeh Mts, *Zarrei* 884 (K, M, TUH); 30 km after Varzaghan towards Kharvana, *Zarrei* 868 (TUH); hills south of Shahpour, Tabriz, *Bowles Schol. Bot. Exp.* 1344 (K); west of Rezayieh [Oroumeyeh], Targevar Valley, west of Solak, *Rounemark & Foroughi* 19751 (TARI); Sarein, Sabalan Mts, 38°11'34.2"N, 47°53'97.2"E, *TUH-E Bot. Exp. (Zarrei et al.)* 35308 (TUH); *ibid.* *Zarrei* 502 (Shahed University, Hb.); near border of Iraq, Dizaj, Mts above village, 37°09'02.6"N, 44°52'85.1"E, *TUH-E Bot. Exp. (Zarrei et al.)* 35713 (TUH).

#### 17. *GAGEA GAGEOIDES* (ZUCC.) VVED.

*Fl. Turkmen.* 1, 2: 261. 1932. *Bulbillaria gageoides* Zucc., *Abh. Bayer. Akad. Wiss.* 3: 229. 1843. TYPE: LEBANON, *crescit in subalpinis umbrosis montis Libani, ibidem florifera lacta a clar, Roth & Erdl* 4 (HOLOTYPE: M).

PLANTS (6–) 8–19 cm tall, in a clump or sometimes solitary. BULBS ovoid, 0.4–0.6 mm in diameter × 0.6–1.0 cm long; tunics coriaceous, brown to black; neck usually absent, but is present not well developed; bulbils absent. ROOTS all thin and not enveloping the bulb. STEM erect; subterranean part 1.0–2.5 cm; aerial part 2.0–4.5 cm × 0.5–1.0 mm, glabrous. RADICAL LEAF filiform (mostly absent on herbarium sheets), shorter than the inflorescence, 70.0–90.0 × 0.5 mm, glabrous. CAULINE LEAVES more than 5, alternate; the lowest one linear-lanceolate, flattened, gradually narrowing, clasping the stem, 40.0–70.0 × 3.0–5.5(–8.0) mm, equal to or slightly shorter than the inflorescence, glabrous, without bulbils in the axil; upper leaves linear to filiform, 0.7–2.5 cm, with 1–5 bulbils present in each axil. BRACTEOLE sometimes present, filiform. INFLORESCENCE composed of 1–10 alternate flowers, cymose; pedicels unequal, erect or nodding when flowering, 0.9–3.5 cm, as long as the flowers or up to 5 times longer, glabrous. TEPALS 4.0–7.0 × 1.3–1.8 mm, narrowly oblanceolate to oblong, obtuse to acute, glabrous, abaxially yellow with three green nerves, adaxially pale yellow with hyaline margins. STAMENS 2/3–3/4 as long as the perianth, filaments 4 mm, anthers spherical to ellipsoid, yellow, 0.4–1.2 mm long × 0.6–0.7 mm in diameter. OVARY pyriform, distinctly stipitate, 2.0–3.0 × 1.0–2.4 mm, style 2–3 mm, stigma capitate; capsule pyriform with a distinct stipe.

*Phenology*: Flowering and fruiting between late in April and end of July, peak flowering in May.

*Distribution and ecology*: Turkey, Lebanon, Palestine (?), Syria, Iraq, Iran, Georgia, Turkmenistan, Afghanistan and Pakistan. Under other plants and or rocks, preferring moist soils in shade; elevation (1000–) 2000–3000(–4200) m.

*Conservation status*: LC (IUCN, 2001).

*Affinities, variation and synonymy*: *G. gageoides* and *G. exilis* possess the smallest flowers (Fig. 5C) of the *Gagea* species found in Iran, and it and *G. reticulata* are the most widespread Iranian species.

*Gagea gageoides* is easily distinguished by a group of bulbils in the axils of the upper cauline leaves and small flowers (tepals 4–7 mm long); on most herbarium sheets there is no radical leaf due to loss during the collection period.

*Gagea kunawurensis* (Royle) Greuter (= *Lloydia kunawurensis* Royle) was stated by Greuter (1970) to be the correct (earliest) name for *G. gageoides*. However, according to the protologue *Lloydia kunwa-*

*rensis* is typified by tab. 93 f. 3 of Royle (1839). The plant illustrated is not *Gagea gageoides* and is probably a species of *Lloydia*.

*Selected specimens examined:* Golestan National Park, Almeh, *Termeh & Matin 29960* (IRAN); Rineh, Damavand Mts, *Zarrei & Zarre 923* (K, TUH); 45 miles of Tehran, near Polur, *Furse 7056-A* (K); south-east slope of Kuh-e Sahand, *Furse & Synge 226-A* (K); Silvana village, Mts south of Dizaj, *Runemark & Foroughi 19715* (TARI); near border of Iraq, Dizaj, Mts above village, 37°09'02.6"N, 44°52'85.1"E, *TUH-E Bot. Exp. (Zarrei et al.) 35714* (TUH); in monte Alwand (Media), on river supra Ganjnameh, *Pichler s.n.* (K); Alwand Mts, *Bowles Schol. Bot. Exp. 1701* (K); Kermanshah, Shahabad [Eslam Abad-e Gahr], 34°10'N, 46°30'E, *Jacobs 6223* (K); Kuh-e Nur, ad nives, *Haussknecht s.n.* (BM); Oshrankuh, north-west of Thiun ledges, on north facing cliffs, *Archibald 1588* (E, K); Esfahan, Dameneh, 60 km west of Esfahan, *Furse 1423* (K); Shirkuh, 20 km S-SW of Taft, 31°40'N, 54°10'E, *Aryavand et al. 1391* (E); Dena Mts, Bijan neck, *Assadi & Mozaffarian 31195* (TARI); between Yasuj and Sisakht, foot of Kuh-e Dinar, *Davis & Bokhari D-56440* (E, K); 25–30 km from Babameydan to Yasuj, *Davis & Bokhari D-56425* (E); hills Mts Sirjan, *Cowan & Darlington 2278* (K); Kuh-e Hezar, 5 km south of Zehrud Bala, just before waterfall, stream side, *Edmondson & Miller 1610* (E); south-east slope of Binalud Mts, around Kang village, *Zarrei 627* (Shahed University Hb.); 15.5 miles north-east of Neyshabour, Binaloud Mts, beyond Bujan village, *Grey-wilson & Hewer 469* (K); between Quchan and Darreh-Gaz, Tandooreh National Park, Shekarab, *Assadi & Maassoumi 50612* (TARI); Shahroud, Kuh-e Peyghambar, south of Samanabad, *Iranshahr 30000* (IRAN); Alborz, 35 km east of Tehran, *Furse 1698* (K); north of Tehran, Tochal Mts, *Zarre & Zarrei 767* (TUH); 3–4 km to Karaj from Ghachsar, Mts beside the road, *Zarre 709* (K, TUH); 2 km to Karaj from Gachsar, Nesae area, *Zarrei & Zarre 916* (BM, TUH); Arak area, Barfkhaneh Mts, *Wendelbo & Assadi 16486* (TARI); Arak towards Malayer, 20 km from Arak, Chepeghli (Ab-Robat), *Termeh et al. 29998* (IRAN).

#### 18. *GAGEA ULIGINOSA* SIEHE & PASCHER

*Lotos* 52(5): 127. 1904. TYPE: TURKEY. Cilicien, Ketsebile, 2600 m, ?.viii.1896, *Siehe 308* (HOLOTYPE: WU; ISOTYPE: BM!, K!). *Gagea uliginosa* Siehe & Pascher var. *soleimani* Bornm. ex Pascher, *Bull. Soc. Imp. Naturalistes Moscou* 19: 371. 1907. *Gagea soleimani* (Bornm. ex Pascher) Rech.f., *Fl. Iran.* 165: 43.

1990. TYPE (designated by Wendelbo & Rechinger, 1990): IRAN. *M. Elburs, in alpe Tachti-Soleiman, ad nives prope Häsartschal*, 4000–4100 m, 29.vi.1902, *Bornmüller 8299* (LECTOTYPE: B; ISOTYPE: K!).

PLANTS 5–9 cm tall, forming a clump. BULBS ovoid, 0.5–1.0 cm long × 0.4–0.7 cm in diameter, tunics fibrous-papery, grey to brown; neck well developed, 0.7–1.5 cm long, splitting at the top; bulbils absent. ROOTS all thin, enveloping the bulb. Stem erect; subterranean part 0.5–2 cm long; aerial part 20.0–30.0 cm, glabrous. RADICAL LEAF linear, 50.0–80.0 × 1.0–1.7 mm, equal to or shorter than the inflorescence, glabrous. CAULINE LEAF linear-lanceolate, 20.0–40.0 × 2.0 mm, glabrous. INFLORESCENCE 1–2-flowered, unbranched; pedicels 10.0–25.0 × 0.5–1.0 mm, as long as perianth to twice as long, glabrous. TEPALS 7–15 × 2–4 mm, abaxially brown to black-brown; adaxially yellow, with hyaline margins, apex acute to rounded, glabrous. STAMENS half as long as perianth, filaments 5 mm long, anthers ellipsoid to linear-ellipsoid, 1.2–3.0 mm long × 0.6 mm in diameter, yellow. OVARY cylindrical, 3.0–5.0 mm long × 1.0–1.5 mm in diameter, style 3–5 mm; capsule 8 mm or longer in diameter, ellipsoid, retuse, enclosed by persistent perianth.

*Phenology:* Flowering and fruiting in late May and June.

*Distribution and ecology:* Eastern Turkey, northern Iraq and Iran. Upper slopes of mountains, mainly among grasses and mosses; elevation 3200–4150 m.

*Conservation status:* EN B2ab(iii) (IUCN, 2001). Restricted to three small, isolated populations in high montane areas in Iran, two localities in Iraq and five in Turkey. Potentially threatened by over-grazing, global warming and development for tourism (e.g. in Sabalan). The locality in the Damavand Mountains has been revisited four times since 2001 (by M.Z.) without seeing any individuals of this species.

*Affinities and variation:* Rechinger stated (Wendelbo & Rechinger, 1990) that *G. soleimani* (endemic to northern Iran) has larger and more rounded tepals as well as a taller radical leaf than *G. uliginosa* from Turkey and Georgia. This is true only of the type specimen. The ranges of variation shown by non-type specimens from Turkey match that from Iran exactly; the differences between the types of *G. soleimani* and *G. uliginosa* are probably caused by environmental variation.

*Gagea uliginosa* is a small, undistinguished plant in the field, with a one or rarely two-flowered inflorescence with tepals abaxially brown that have purple

tips (Figs 5D, 6D). This species mainly grows in the high mountains of Turkey, Iran and Iraq, in the alpine belt above 3200 m, among grasses and mosses, in moist places on the edge of lakes formed by melting snow patches, on the edge of waterfalls and by streams. It has a notably disjunct distribution. It may be a recent species that has rapidly spread or an ancient one with a formerly broader distribution because it is now confined to isolated summits.

*Specimens examined:* Alborz, in alpe Tacht-Soleiman, ad nives prope Häsartschal, Bornmüller 8299 (BM, E, K, ISOTYPES of *G. soleimani*); Larijan, Rineh, Damavand Mts, Moussavi et al. 30018 (IRAN); Elika, Kuh-e Varasht, Termeh et al. 30019 (IRAN); Shahzad-i-Kuh (Sahand Mts), Bornmüller 289 (K); Saraein, Sabalan Mts, above skiing site, 38°12'83.1"N, 47°52'20.3"E, TUH-E Bot. Exp. (Zarrei et al.) 35304 (TUH); *ibid.*, Zarrei 503 (Shahed University Hb.).

#### 19. *GAGEA IRANICA* ZARREI & ZARRE

*Nord. J. Bot.* 23: 270. 2005. TYPE: IRAN, 15 km after Chamanbid towards Bojnourd, 80 km before Bojnourd, hills near the road, 37°25'46"N, 56°37'55"E, 1340–1350 m, 28.iii.2002, Zarrei & Ajani 29191 (HOLOTYPE: TUH!; ISOTYPE: IRAN!, K!, LE!, TARI!).

PLANTS 10–20 cm tall, single or sometimes two or three plants in a clump. BULBS ovoid, 0.5–1.0 cm in diameter × 1.0–1.5 cm long; tunics coriaceous, delicately reticulate, grey; neck usually absent, but if present up to 1.5 cm long; bulbils absent. ROOTS thin; thickened roots present, enveloping the bulb. STEM erect, subterranean part 0.5–1.5 cm long; aerial part 1.5–4.0 cm, sparsely villous. RADICAL LEAF linear, flattened, canaliculate, longer to shorter than the inflorescence, 100.0–220.0 × 1.0–1.5 mm. CAULINE LEAVES 3–4, lowest one as wide as the radical leaf, 60.0–100.0(–140.0) × 0.5–1.5(–2.0) mm, abaxially sparsely villous, adaxially glabrous, ciliate at margins; upper ones usually positioned at the base of pedicel(s), distinctly shorter than lower one and bract-like, 0.5–2.5 cm long, villous-ciliate on the margins. BRACTEOLES present on pedicels of some flowers, linear. INFLORESCENCE cymose, 2–4-flowered; pedicels becoming much longer at maturing, 3.0–7.5(–10.0) cm, glabrous, erect at flowering time, becoming somewhat curved at maturing. FLOWERS tubular; tepals deep green except for white narrow margins and purple tips, 10.0–12.0 (–14.0) × 1.5 mm, oblong-oblancheolate, acute, glabrous. STAMENS 2/3 the length of the perianth; filaments 6–7 mm long; anthers narrowly oblong-ellipsoid, yellow, 2.0 mm long × 0.7 mm

in diameter. OVARY obovoid-pyriform, attenuate towards base, 1/2 as long as the perianth, 6 mm long × 2.7 mm in diameter; style *c.* 2.5 mm, longer than stamens, stigma capitate; capsule obovoid, as long as the tepals or slightly shorter, 10–12 × 5–7 mm; seeds flattened.

*Phenology:* Flowering and fruiting between March and April.

*Distribution and ecology:* Endemic to northern and north-eastern Iran. Growing in shrublands and *Artemisia* steppes; elevation 850–1350 m.

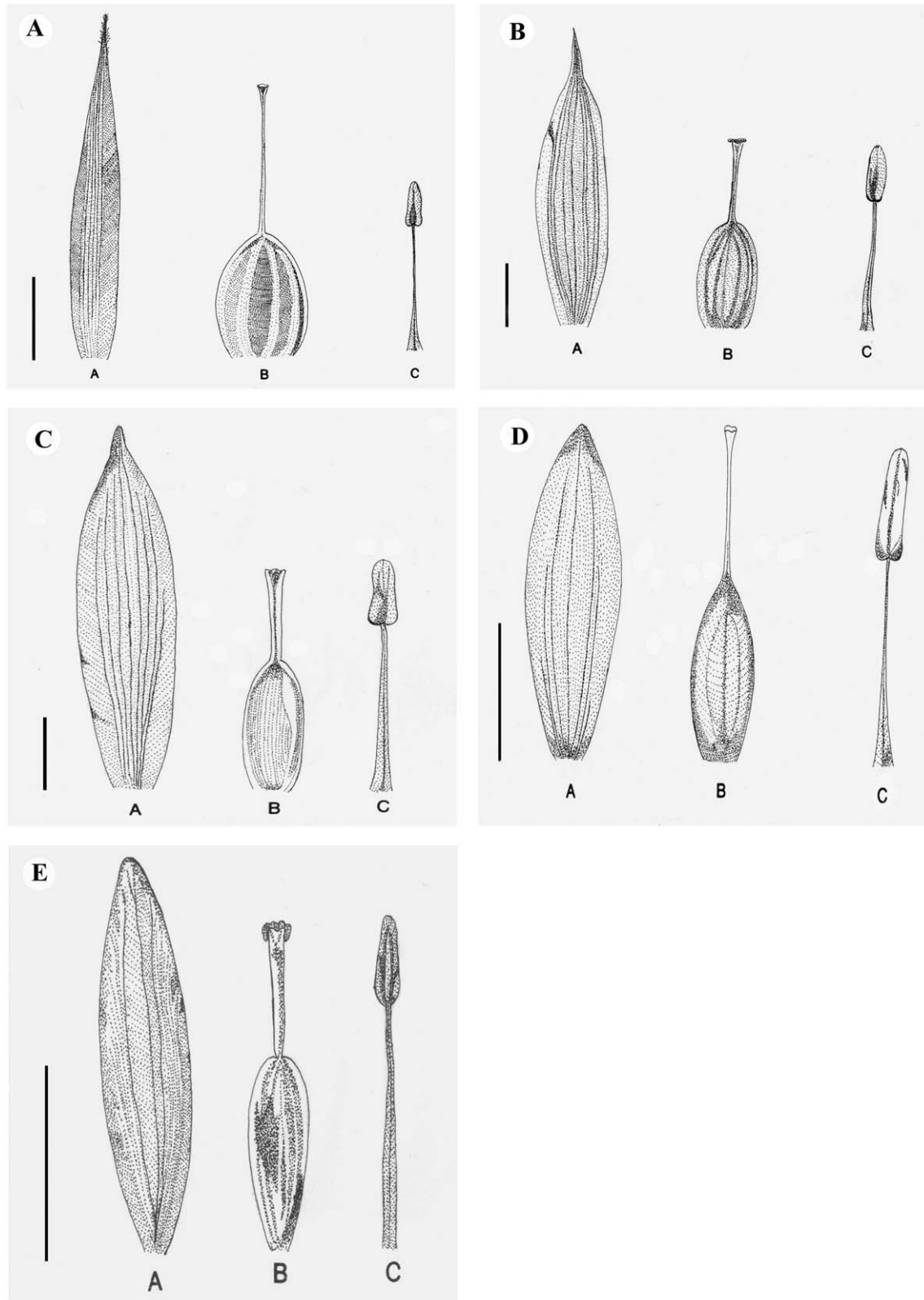
*Conservation status:* EN B2ab(iii) (IUCN, 2001). Known from four populations in Iran. When encountered, plants of this species are usually under thorny shrubs, suggesting that over-grazing is a significant problem. It needs relatively high humidity and a high percentage of clay in the soil.

*Specimens examined:* 18 km from Marveh-Tappeh towards Ashkhaneh, Assadi & Maassoumi 55591 (TARI); 35 km after Ashkhaneh towards Bojnourd, 37°34'N, 56°59'E, Zarrei & Golzarian 35205 (K, TUH); Kalaleh towards Ashkhaneh, 3 km before Eslam-Abad village, 37°39'N, 56°04'E, Zarrei & Golzarian 35210 (K, TUH); 80 km after Bojnourd towards Gorgan, 7 km to Chamanbid, 37°25'N, 56°37'E, Zarrei & Golzarian 35250 (K, TUH); Ghaemshahr towards Firouzkuh, 5 km to Veresk, 170 km to Tehran, 35°57'N, 53°00'E, Zarrei & Golzarian 35251 (K, TUH).

#### 20. *GAGEA CHLORANTHA* (M. BIEB.) SCHULT. & SCHULT. F.

J.J.Roemer & J.A.Schultes, *Syst. Veg.* 7: 551. 1829. *Ornithogalum chloranthum* M.Bieb., *Fl. Taur.-Caucas.* 2: 264. 1808. *Stellaster chloranthus* (M.Bieb.) Kuntze, *Revis. General. Pl.* 2: 715. 1891. *Hornungia chlorantha* (M.Bieb.) Rouy, G.Rouy & J.Foucad, *Fl. France* 12: 381. 1910. TYPE: GEORGIA, in promontorii Caucasici septentrionalis campestribus apricis in hortis *c. opp. Kisljar, von Bieberstein s.n.* (LE). *Gagea grey-wilsonii* Rech.f., *Pl. Syst. Evol.* 153: 290. 1986. TYPE: IRAN, Fars, Kuh-i Maimand 10.5 miles SE of Firuzabad, in declivibus aridis calc., 4400 ft., 2.iii.1971, Grey-Wilson & Hewer 58 (HOLOTYPE: W; ISOTYPE: E!, K!).

PLANTS 5–12(–17) cm tall, solitary or sometimes in clumps of a few plants. BULBS globose to ovoid, 5–15 mm long × 5–10 mm in diameter; tunics coriaceous-fibrous, grey; neck sometimes present, to 1.0 cm long, splitting at the top; bulbils absent.



**Figure 6.** A, *G. commutata* – after Zarrei 876; B, *G. caroli-kochii* – after Zarrei *et al.* 35715; C, *G. alexeenkoana* – after Zarrei *et al.* 35305; D, *G. uliginosa* – Zarrei *et al.* 35304; E, *G. afghanica* – after Zarrei & Golzarian 35257. Scale bar = 5 mm.



ROOTS thin; thickened roots occasionally present, enveloping the bulb. STEM erect; subterranean part up to 0.5 cm long (bulbs usually near the soil surface); aerial part 1–2 cm; hairs spreading, strigose or glabrous. RADICAL LEAF filiform, longer than the inflorescence, 60.0–120.0(–170.0) × 0.3–2.0 mm, glabrous. CAULINE LEAVES alternate, the lowest one narrowly linear, 2.0–4.5(–5.5) × 1.0 mm, margins sparsely villous-ciliate; equal to or longer than the inflorescence; upper ones shorter, villous-ciliate at the margin. BRACTEOLE absent. INFLORESCENCE cymose (1–)2–5(–7)-flowered; pedicels unequal, erect at flowering and in fruit, 40.0–45.0(–50.0) mm, as long as the flowers or up to 2 times longer, elongating in fruit to 3–7 cm, glabrous or villous. TEPALS (6–)8–11 (–14) × 2–3 mm, narrowly lanceolate, acute to obtuse, abaxially green, adaxially yellow, white to purple at margins, glabrous. STAMENS 2/3 as long as the perianth, filaments 5–6 mm long, anthers ellipsoid, yellow, 0.5–1.3 mm long × 0.4–0.7 mm in diameter. OVARY ovoid to ellipsoid, 3.5–4.5 mm long × 1.0–2.5 mm in diameter, style 3.5 mm, stigma capitate; capsule narrowly obovoid, 5–8(–11) mm, shorter than persistent perianth.

*Phenology:* Flowering and fruiting between late February and early May, peak flowering in March.

*Distribution and ecology:* Cyprus, Syria, Iraq, western and south-western Iran and Georgia. This species grows in calcareous soil and is an early flowering species in Iran; elevation 200–900(–1400) m.

*Conservation status:* LC (IUCN, 2001).

*Selected specimens examined:* Mts around Kaleybar, *Zarrei* 877 (TUH); between Ghasre-Shirin and Sare-Pol, *Evans M-1209* (E); Tang-e Tir, c. 40 km west of Khorramabad, *Wendelbo & Assadi 16545* (TARI); 1 km after Malavi towards Khorramabad, Mts around Malavi, 33°15'25"N, 47°45'15"E, *Zarrei & Zarre 853* (K, TUH); Dehloran to Murmuri, 5 km after deviation Dehloran and Dasht-e Abbas, 32°41'22"N, 47°25'57"E, *Zarrei & Zarre 787* (K, LE, M, TUH); 5 km after Pahleh towards Dehloran, *Zarrei & Zarre 788* (K, M, TUH); on the pass just after deviation Darrehshahr, on the Poldokhtar and Andimeshk road, *Zarrei & Zarre 901* (TUH); Gachsaran to Shiraz and Yasuj, c. 35 km after Gachsaran, c. 118 km to Yasuj, hills beside the road, 30°19'20"N, 51°07'09"E, *Zarrei & Zarre 800* (BM, M, TUH); Gachsaran to Shiraz-Yasuj road, 206 km to Shiraz, 30°19'15"N, 57°14'13"E, *Zarrei & Zarre 801* (K, M, TUH); Kuh-i Maimand, 16 km south-east Firuzabad, *in decl. aridis calc.*, *Grey-Wilson & Hewer 58* (E, K, ISOTYPES of *G. grey-wilsonii*); 5 km to Andika from

dam, 5 km after tunnel, Mts behind river, 32°02'35"N, 49°24'55"E, *Zarrei & Zarre 798* (K, M, TUH); 5 km after Shushtar Masjed-Soleyman deviation, on the Ahvaz Masjed-Soleyman pass, 31°59'09"N, 49°02'26"E, *Zarrei & Zarre 795* (K, LE, M, TUH); Ramhormoz, 2 km on the Haftgel road, *Foroughi 2997* (TARI); 17 km after Dezful towards Sardasht, 32°29'N, 48°38'E, 470 m, *Zarrei & Kamrani 35192* (K, TUH); Khurmuj, Beyrami Mts, *Iranshahr & Termeh 29920* (IRAN).

#### 21. *GAGEA STIPITATA* MERCKL. EX BUNGE

*Mém. Sav. Étr. Acad. St. Pétersbourg* 7: 512. 1851. TYPE: *Auf dem Dioritplateau zwischen Juss-Chuduk und Bakali* 25.iv.1842, Collector unknown (SYNTYPE: LE); *bei Bakali* 27.iv.1842 (*deflorata et fructificans*), Collector unknown (SYNTYPE: LE).

*Gagea ova* Stapf, *Denkschr. Kaiserl. Akad. Wiss., Wien. Math.-Naturwiss. Kl.* 50: 16. 1885. LECTO-TYPE (designated here, see below): IRAN, Lorestan, *in monte Karaghan (media), ad Schurab*, 1882, *Pichler s.n.* (K!).

PLANTS 5–15(–20) cm tall, solitary. BULBS ovoid to ovoid-globose, 1.0–1.5 cm long × 0.5–1.0 cm in diameter; tunics coriaceous, brown to black, occasionally grey; neck usually weakly developed, to 0.5 cm long; bulbils present, ovoid to globose, 1.0–2.5 × 1.0–2.0 mm, papilate or foveolate. ROOTS thin, not enveloping the bulb. Stem erect; subterranean part 1.0–3.5(–4.5) cm; aerial part 2.0–3.5 cm, glabrous. RADICAL LEAF linear, longer than the inflorescence (50.0–)70.0–140.0(–165.0) × 0.5–1.5 mm, glabrous. CAULINE LEAVES alternate; the lowest one narrowly linear-lanceolate, gradually narrowing, clasping the stem, 30.0–55.0(–95.0) × (1.0–) 2.0–3.0 mm, equal to or slightly longer than the inflorescence, glabrous or villose-ciliate, upper ones shorter, villous-ciliate. BRACTEOLE[S] sometimes present. INFLORESCENCE cymose, 3–10(–15)-flowered; pedicels unequal, erect, 0.5–3.0 cm, as long as the flowers or up to 3 times longer, nodding before anthesis; glabrous. TEPALS 5.0–10.0 × 1.0–2.5 mm, linear-elliptic to linear-oblongate, abaxially green, adaxially yellow to pale-yellow, obtuse to acute, glabrous. STAMENS 2/3–3/4 as long as the perianth; filaments 4–6 mm long; anthers yellow, spherical to ellipsoid, 0.5–1.2 mm long × 0.5–1.0 mm in diameter. OVARY pyriform, sometimes a distinct stipe at the base, 2.0–4.0 mm long × 1.5–2.0 mm in diameter, style 3–4 mm, stigma capitate; capsule ovoid with ±distinct stipe at the base.

*Phenology:* Flowering and fruiting between April and May, peak flowering in April.

*Distribution and ecology:* Iran, Turkmenistan, Afghanistan, western Pakistan and Central Asia. Moist clay soils; elevation (220–)1500–2700(–4000) m.

*Conservation status:* LC (IUCN, 2001).

*Typification:* Stapf cites specimens from Schurab and Kabuterchan in the Karaghan Mountains. The Pichler s.n. sheet from Schurab comprises 11 individuals at K; of these, that on the top right is the most complete and representative and is selected here as the lectotype.

*Selected specimens examined:* Golestan National Park, Sharlegh Plain, Zarrei 899 (LE, TUH); 16 km south of Hottam, near Ai Tamar village, Hewer 3565 (K); after Ashkhaneh, 35 km before Bojnourd, 37°34'N, 56°59'E, Zarrei & Golzarian 35204 (K, TUH); Damavand Mts, Zarrei & Kamrani 1072 (TUH); Jolfa, St. Stepanous church, 15 km to the west from Jolfa, Zarrei 892 (K, TUH); Alwand Mts, Bowles Schol. Bot. Exp. 1699 (K); in monte Karaghan (media), ad Schurab, Pichler s.n. (K); c. 30 km southwest of Ardestan, Wendelbo & Foroughi 11522 (TARI); Shirkuh, south-east of Esfahan, Bowles Schol. Bot. Exp. 921 (K); Shahr-e Kord, west ground between road and ploughed field, Furse 1389 (K); Saadat-Shahr towards Abadeh, 30°05'N, 53°12'E, Zarrei & Kamrani 35197 (K, TUH); Bandar-e Abbas, 256 km from Bandar-e Abbas, on the road from Kerman, Wendelbo & Foroughi 15306 (TARI); Darmazar, 20 km towards Ravour, near the road, 29°17'03"N, 57°04'47"E, Zarrei & Ajani 840 (K, M, TUH); hills west of Deh-Bakri, Parris 75222 (E); Qaen towards Khaf, main road towards Vorezgh, 35°41'N, 59°20'E, Zarrei & Golzarian 35259 (K, TUH); Mashahd, Khajeh Morad, hills above holy place, 33°59'01"N, 59°41'42"E, Zarrei & Ajani 826 (K, LE, M, TUH); 7 km west of Kalat-e Naderi (GG2), Assadi & Maassoumi 55814 (TARI); 30 miles east of Sultanabad and Mashad, Furse 5231 (K); 13 miles north-east of Neyshabur, Binalud Mts, road to Bujan, Grey-Wilson & Hewer 457 (K); Shirvan, Henameh village, near Gadeganlu village, Ghalee-Ches Mts, 37°31'56"N, 58°05'03"E, Zarrei & Ajani 919 (IRAN, TUH); Abyek towards Taleghan, 2 km after Zeyaran towards Samgh-Abad, Zarrei & Kamrani 35275 (K, TUH); near Arak, Agriculture land, Bowles Schol. Bot. Exp. 629 (K).

## 22. *GAGEA EXILIS* VVED.

*Bot. Mater. Gerb. Bot. Institute. Komarova Akad. Nauk S.S.S.R.* 9: 236. 1946. TYPE: Kyrgystan, n parte occidentali vallis Alaica ad ripas sinistras fluvii

Kyzyl-su prope Daraut-kurgan, solo subarenoso pallide castaneiformi, 30.v.1934, Velitschko 4 (HOLOTYPE: TASH).

PLANTS 5–8(–11) cm tall, solitary or in clumps. BULBS ovoid, 1.0–1.5 cm long × 1 cm in diameter, tunics coriaceous, fibrous; neck when present up to 0.5 cm long; bulbils present, ovoid, c. 2.5 mm long × 1.5 mm in diameter, purple or black, papillose or foveolate. ROOTS thin, enveloping the bulb. STEM erect; subterranean part 0.5–2.0 cm; aerial part 2–3 cm, glabrous. RADICAL LEAF filiform to narrowly linear, shorter to longer than the inflorescence, 40.0–75.0(–95.0) × 0.2–0.7 (–1.0) mm, glabrous. CAULINE LEAVES 3–4; the lowest one filiform, similar to radical leaf, 13.0–40.0 × 0.7–1.5 mm, equal to or shorter than the inflorescence, glabrous; upper ones shorter, bract like, glabrous. BRACTEOLES absent. INFLORESCENCE cymose, 2–8(–11)-flowered; pedicels unequal, erect, 1.0–2.5 cm, as long as or up to 2 times longer than the tepals; glabrous. TEPALS 5–7 × 1–2 mm, linear-lanceolate, glabrous, abaxially yellow, adaxially green to pale yellow. STAMENS 2/3–3/4 as long as the perianth, filaments 2.5–3.0 mm, anthers yellow, spherical to ovoid, 1.2–2.0 mm long × 0.5–1.0 mm in diameter. OVARY obovoid, 2–3 mm long × c. 1 mm in diameter, style c. 2 mm, stigma capitate; capsule obovoid, with short stipe at the base.

*Phenology:* Flowering in June.

*Distribution and ecology:* Iran (Fig. 7B), Afghanistan and Central Asia. Arid places in high mountains; elevation 2550–3400 m.

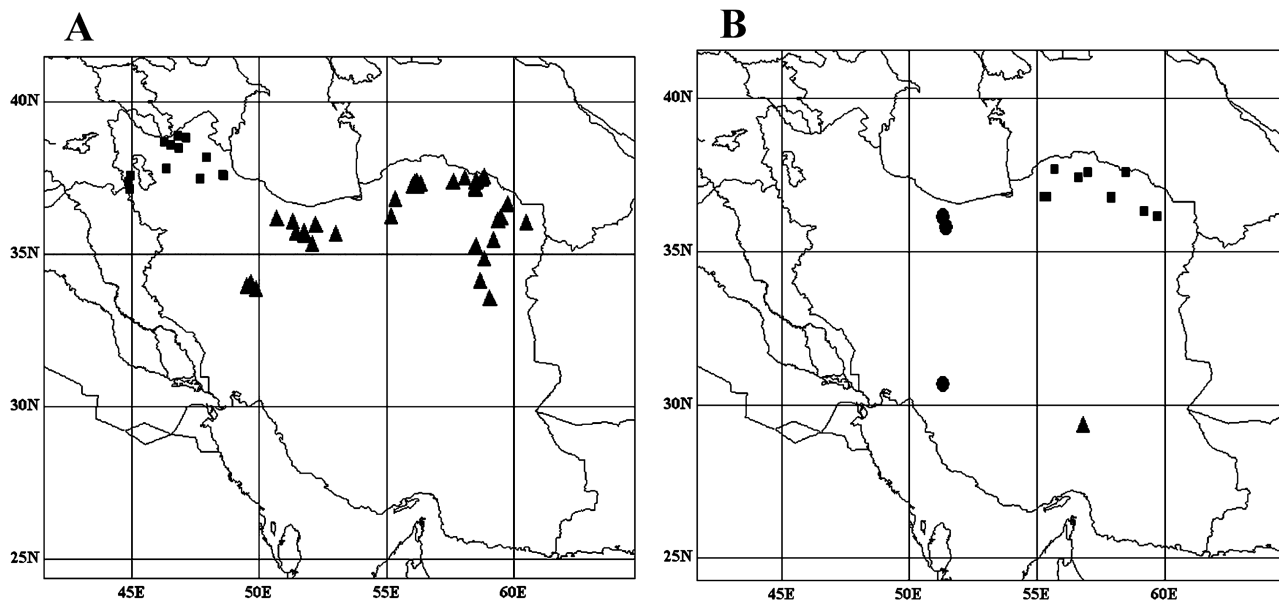
*Conservation status:* NT (IUCN, 2001). Known from just two isolated localities in Iran but apparently more common in Afghanistan and Central Asia.

*Specimens examined:* 8 km S of Maraveh-Tappeh, on the road to Gonbad-e Kavus, Hewer H3588 (K); Laleh-Zar Mts, Zarda Valley, Foroughi & Assadi 16338 (TARI); Laleh-Zar Mts, Moussavi & Tehrani 29970 (IRAN); *ibid.*, Moussavi & Tehrani 29971 (IRAN).

## 23. *GAGEA OLGAE* REGEL

*Turdy Imp. S.-Peterburgsk. Bot. Sada* 3(2): 292. 1875. TYPES: UZBEKISTAN, in *Turkestaniam prope Samarkand, Fedschenko s.n.* (SYNTYPE: LE); *prope puteum Ajak in desertis inter Turkestaniam et Khiwam, Korolkow et Krause s.n.* (SYNTYPE: herbarium unknown).

PLANTS 8–18 cm tall, solitary. BULBS ovoid to spherical, 0.5–1.5 cm in diameter; tunics with fine fibres,



**Figure 7.** Distribution in Iran of A, *G. bulbifera* (■) and *G. chomutovae* (▲); B, *G. exilis* (▲), *G. tenera* (■) and *G. wendelboi* (●).

grey, neck if present to 1 cm long; bulbils absent. ROOTS all thin. STEM erect or arch-like; subterranean part 1–4 cm; aerial part 3–7 cm, glabrous. RADICAL LEAF linear, longer than the inflorescence, 120.0–210.0 × 0.5–1.6 mm, glabrous. CAULINE LEAVES 3–6, alternate; the lowest one linear, 60.0–100.0 × 1.0–1.5 mm, glabrous; upper ones bract-like, glabrous or occasionally villous-ciliate. BRACTEOLES sometimes present. INFLORESCENCE cymose, 4–10-flowered, pedicel unequal, 1–3 cm, glabrous. TEPALS 6–10 × 2–3 mm, oblong to oblanceolate, obtuse, glabrous, adaxially yellow, abaxially pale yellow, purple at the tip. STAMENS 1/2–2/3 as long as tepals, filament c. 5 mm long, anther yellow, oblong-ellipsoid, 1.0–1.5 mm long × 0.3–0.5 mm in diameter. OVARY cylindrical to ovoid 3.0–5.0 mm long × 1.0–1.5 mm in diameter, style 3.0–5.5 mm; capsule 6–8 mm long, obovoid, 1/2–1/3 as long as tepals.

*Phenology:* Flowering and fruiting between March and April.

*Distribution and ecology:* Eastern Iran, Afghanistan, north-western Pakistan and Central Asia, in low mountainous areas; elevation 1050–2900 m.

*Conservation status:* LC (IUCN, 2001), but known from just three disjunct localities in eastern Iran.

*Specimens examined:* Gorgan-Bojnourd road, before Robot-e Gharabill village, in *Artemisia* steppe, *Assadi & Shahsavari* 69129 (TARI); Yazd, Taft to Nir,

Sakhvid Pass, *Mozaffarian* 77509 (TARI); Khash, *Sharif* 30007 (IRAN); 15–18 km north of Khash (Mts), *Iranshahr & Ershad* 30006 (IRAN); Khash, 14 km Ladiz road, *Foroughi* 10822 (TARI).

#### 24. *GAGEA AFGHANICA* A. TERRACC.

*Boll. Soc. Orto Palermo* II, 3: 3. 1904. TYPE (designated here): AFGHANISTAN, Hari-Rud Valley, 15.iv.1885, *Aitchison* 1130 (LECTOTYPE: BM!; ISOTYPE: K!)

PLANTS (3–)10–15 cm tall, solitary or sometimes in clumps. BULBS ovoid, 0.5–1.0 cm in diameter; tunic loosely fibrous, grey; neck absent; bulbils absent. ROOTS thin, thickened roots occasionally present. STEM erect to arching; subterranean parts 0.5–2.0 cm; aerial parts 0.5–4.0 cm, glabrous to sparsely pubescent. RADICAL LEAF narrowly linear (40.0–)80.0–120.0 × 1.0–1.5 mm, shorter to longer than the inflorescence, canaliculate, glabrous. CAULINE LEAVES 5–12, the lowest ones similar to radical leaf, shorter than inflorescence, villous-ciliate; upper ones shorter, bract-like, villous-ciliate. INFLORESCENCE cymose, 2–15-flowered; pedicel as long as or up to 3 times longer than the perianth, glabrous to pubescent. TEPALS (6.0–) 8.0–12.0(–15.0) × 1.5–2.5 mm, oblong-lanceolate, obtuse, adaxially yellow, abaxially green, purple at the tip, glabrous, sometimes ciliate at the tip margins. STAMENS 2/3 t-3/4 as long as the perianth; filament 4–7 mm; anther yellow, spherical to ovoid, 1.0–2.0 mm long × 0.5–1.0 mm in diameter.

OVARY ovoid, 2.0–3.0 mm long  $\times$  1.0–2.0 mm in diameter; style 2–5 mm; stigma capitate; capsule ovoid, 8–10 mm long  $\times$  5–7 mm in diameter; seeds globose, testa foveolate.

*Phenology*: Flowering and fruiting in March.

*Distribution and ecology*: Iran, Afghanistan and Central Asia. Mountainous areas, in soils with a high percentage of clay; elevation 200–620 m.

*Conservation status*: LC (IUCN, 2001).

*Affinities, variation and typification*: The cymose inflorescence and the obtuse tepals (Fig. 6E) as well as the thick roots entwining the bulbs are the main diagnostic characters for this species. These roots, like the thin roots, always emerge from the base of the bulb and surround it like a basket. This species is related to *G. stipitata* and *G. olgae*.

The lectotype for *G. afghanica* (cited above) was chosen from the six syntypes cited by Terracciano because it is the most complete and representative material. It was also cited as the type of the species by Wendelbo & Rechinger (1990) but not as lectotype.

*Specimens examined*: Hottam, north of Gonbad-e Kavous, *Hewer 3547* (TARI); near Hottam, *Hewer 3510* (TARI); Gharah-Gol, c. 10 km east of Hottam, *Hewer 3557* (TARI); Marraveh-Tappeh, *Hewer 3517* (TARI); Kalaleh, Khaled-Nabi Sanan area, *Zarrei 1019* (K, LE, TUH); Kalaleh towards Ashkhaneh, 5 km after Robate Gharabil deviation, 37°41'N, 56°16'E, *Zarrei & Golzarian 35207* (K, TUH); 27 km to Darreh-Gaz, on the road from Quchan, *Assadi & Maassoumi 55059* (TARI); 65 km after Gonabad towards Ghaen, 10 km before Khezry, at the pass, 34°05'N, 58°50'E, *Zarrei & Golzarian 35223* (K, TUH); Bajgiran towards Quchan, 4 km after Bajgiran, 37°35'N, 58°26'E, *Zarrei & Golzarian 35257* (K, TUH).

#### 25. *GAGEA WENDELBOI* RECH. F.

*Pl. Syst. Evol.* 153: 291. 1986. TYPE: IRAN, Prov. Mazandaran, *in valle Haraz, in rupium*, fissures west of Emarat, 36°15'N, 52°18'E, 2200 m, 24.iv.1959, *Wendelbo 349* (HOLOTYPE: BG).

PLANTS 3–8 cm tall, solitary or in clumps. BULBS ovoid-pyriform, 5–9 mm long  $\times$  5–7 mm in diameter; tunics coriaceous to fibrous, bright brown to grey; neck absent to small; bulbils absent. ROOTS thin. STEM erect; subterranean part up to 1 cm; aerial parts 0.5–1.0 cm, with fine hairs. RADICAL LEAVES 1(–2), filiform, 40.0–90.0  $\times$  0.3 mm, longer than the

inflorescence, glabrous. CAULINE LEAVES 2–3(–4), similar to radical leaves, shorter than the inflorescence, ciliate at the margin. INFLORESCENCE 1(–2) flowered; pedicels slender, 1–2 cm, puberulent. TEPALS (6–)10–15  $\times$  2–3 mm, adaxially pale yellow, with five green nerves, brown to purple apically, oblong-linear, obtuse, glabrous. STAMENS 1/2–2/3 as long as perianth, filaments 4–6 mm, anthers spherical to ovoid, 0.5–0.8 mm in diameter  $\times$  0.8–1.5 mm long. OVARY pyriform, with distinct stipe at the base, 2–4 mm long  $\times$  2 mm in diameter, style 4 mm, stigma capitate; capsule and seeds not seen.

*Phenology*: Flowering between March and June.

*Distribution and ecology*: Endemic to the Alborz Mountains of Iran (Fig. 7B). In seasonally flooded grassy areas of mountains; elevation 570–2400 m.

*Conservation status*: CR C1 (IUCN, 2001). Both the *locus classicus* near Emarat and the Alborz Mountains as a whole have been searched extensively for this species since 2001, but no individuals have been found. Over-grazing is likely to be the most significant threat to this species, especially near Emarat.

*Specimens examined*: East of Haraz River, east of Emarat, *Matin s.n.* (IRAN); central Alborz watershed, north slope of Gachsar, *Furse 2735* (K); east Alborz, south side of watershed, between Qazwin and Rasht, *Furse 1098* (K).

#### 26. *GAGEA TENERA* PASCHER

*Lotos* 24: 128. 1904. TYPE: UZBEKISTAN, Waterfall near the reservoir of Siyab, in the vicinity of Samarkand, 4.iii.1869, *Fedchenko* (LE).

PLANTS slender, 5–13 cm tall, in a clump or sometimes solitary. BULBS ovoid, 0.5–0.7 cm long  $\times$  0.5 cm in diameter; tunics coriaceous, dark-brown; bulbils sometimes absent; neck absent. ROOTS all thin. STEM erect, slender; subterranean parts up to 0.5 cm, aerial parts 7.5–8.0 cm; sparsely villous. RADICAL LEAVES 1(–2), filiform, 90.0–100.0  $\times$  0.4–0.6 mm, equal to or shorter than the inflorescence, glabrous. CAULINE LEAVES 3–6, alternate; the lowest one lanceolate to linear-lanceolate, with prominent nerves, long attenuate-acuminate, slightly clasping stem; 30.0–35.0 (–50.0)  $\times$  2.0–5.0 mm; glabrous, sparsely ciliate-villous; shorter than inflorescence, occasionally a group of bulbils present in its axil, upper cauline leaves becoming smaller and narrower, much smaller than lower cauline leaf; acute; 10.0–18.0  $\times$  0.5–1.5 mm, weakly clasping stem at the base, sparsely villous-ciliate; bracts smaller than the upper leaves,

becoming smaller and narrower further up, sparsely villous-ciliate, 1.0–1.5 time smaller than pedicels. BRACTEOLES sometimes present, filiform, sparsely villous-ciliate. INFLORESCENCE 1–3(–6)-flowered; pedicels slender, filiform, subflexuous, ± equal, erect and indurate in fruit, 1.5–2.0 times longer than flowers, sparsely villous, 10.0–15.0 mm. TEPALS  $6.0\text{--}7.0 \times 1.5\text{--}1.7$  mm, obovate to oblong, acute to slightly retuse, with three prominent green nerves abaxially, middle one greener than the others, reaching the apex; adaxially yellow, glabrous. STAMENS 2/3 as long as perianth; filament dilated, filiform, 4.5–5.0 mm; anther small, yellow, spherical, 0.6–0.8 mm. OVARY ovoid, truncate to retuse, 2–3 mm long  $\times$  1–2 mm in diameter, style shorter than ovary, 1.7 mm long; stigma weakly tri-lobed; capsule ovoid, half as long as perianth segments.

*Phenology*: Flowering and fruiting from late March through May.

*Distribution and ecology*: Turkey (according to Rix, 1984), north-eastern Iran (Fig. 7B), Afghanistan and Central Asia. Found in high montane areas between cushion-forming plants such as *Astragalus* and *Onobrychis*; elevation 2000–3000 m.

*Conservation status*: NT (IUCN, 2001). Three populations known in north-east Iran, one specimen from Turkey and one from Afghanistan. The Central Asian populations remain poorly known. Restricted to high montane areas. Potentially threatened by overgrazing and global warming.

*Affinities and variation*: This species has a broadly lanceolate lower cauline leaf and a filiform radical leaf. In some plants, there is a group of bulbils in the axil of the cauline leaves.

*Selected specimens examined*: 45 miles east north-east of Gonbad-e Kavus, *Furse 5111* (K); Mashhad, north slope of Binaloud, Mts above Zoshk village, Abdollah village, *Mozaffarian 48885* (TARI); Khajeh Morad, on the road towards Neyshabour from Mashhad, above holy place, 36°09'N, 59°41'E, *Zarrei & Golzarian 35219* (K, TUH); Bajgiran towards Quchan, 4 km after Bajgiran, 37°35'N, 58°26'E, *Zarrei & Golzarian 35256* (K, TUH); hills before Bajgiran, beside the road, 37°35'31"N, 58°26'26"E, *Zarrei & Ajani 824* (K, M, TUH); 80 km after Bojnourd towards Gorgan, 7 km to Chamanbid, 37°25'N, 56°37'E, *Zarrei & Golzarian 35248* (K, TUH); top of the pass, on the road between Shahpassand [Azadshahr] and Shahroud, *Wendelbo et al. 11139* (TARI).

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