

CLARIFYING THE NOMENCLATURE AND TAXONOMY OF *GAGEA KUNAWURENSIS* (ROYLE) GREUTER (LILIACEAE) AND ALLIED TAXA

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Study of relevant types has led to the conclusion that *Gagea kunawurensis* (Royle) Greuter (Liliaceae) is the correct name for what has recently been known as *G. stipitata* Merckl. ex Bunge; that *G. gageoides* (Zucc.) Vved. is the correct name for *G. persica* Boiss., and that *G. kashmirensis* Turritt should be reduced to synonymy of *G. tenera* Pascher. Anatomical and morphological data are presented for these and the related species *Gagea dschungarica* Regel and *G. afghanica* A.Terracc., and a key given to allow their discrimination.

Keywords. Anatomy, *Gagea*, taxonomy.

INTRODUCTION

An examination of the literature, with its extensive synonymy, shows that distinctions between *Gagea* Salisb. and *Lloydia* Salisb. ex Rchb. and specific delimitation within genera based solely on morphological characters have been fraught with difficulty. Recent molecular work (Peterson *et al.*, 2004, 2008; Peruzzi *et al.*, 2008a, 2008b; Zarrei *et al.*, 2009) has, perhaps unsurprisingly, shown that the distinctions between *Gagea* and *Lloydia* are artificial and that a single genus should be recognised. *Gagea* (Salisbury, 1806) being the earlier name, the species of *Lloydia* should all be transferred to it.

Gagea in this wide sense occurs in Eurasia and North Africa, the only exception being the widely distributed *G. serotina* (L.) Ker Gawl., which also occurs in North America (Jones & Gliddon, 1999; Zarrei *et al.*, 2009, 2010a, 2010b). The most recent treatment of *Gagea* (excluding *Lloydia*) is by Uphof (1958–60), but that was based largely on the early 20th-century work of A. Pascher (1881–1945) and A. Terracciano (1861–1917), reviewed in Zarrei *et al.* (2007, 2009). The number of

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species recognised in the two genera has varied greatly in recent accounts: Mabberley (2008) has c.90 species of *Gagea* and c.20 of *Lloydia*; Peruzzi *et al.* (2008a) quoted 275 species, but this figure appears to be based on the 240–250 species of *Gagea* (*sensu stricto*) estimated by Levichev (1999), the remaining 25 presumably being those until recently included in *Lloydia*. More than 550 specific and interspecific combinations have been published (Govaerts *et al.*, 2006) and every year further new species are described (Zarrei *et al.*, 2010a, 2010b).

It is clear that a general lack of understanding of this large genus is one among several reasons for the different estimates. Recent studies by the first author (M.Z.), combining fieldwork and anatomical and molecular work, have proved successful in helping to clarify the situation, and led to the realisation that many species are not worth retaining (certainly at specific rank): for example, *Gagea tehranica* Gand. and *G. perpusilla* Pascher have recently been found to be synonymous with *G. reticulata* (Pall.) Schult. & Schult.f. and *G. setifolia* Baker, respectively (Zarrei *et al.*, 2007). Another source of confusion arises from problems in typification. *Gagea* specimens, including types, are scattered in a large number of herbaria, particularly in Central Asia and in St Petersburg (which probably houses the highest number). Access to types and other important historical specimens is therefore problematic and, as a result, authors continue to take the easy option of describing new species without possessing sufficient knowledge of existing species, including their typification and nomenclature. Further problems are the inevitable result. In recent years, L. Peruzzi, J.-M. Tison, M. Zarrei and others have typified several, mostly Mediterranean, species of *Gagea* (Tison, 2001; Levichev & Tison, 2004a, 2004b; Peruzzi & Tison, 2004, 2005, 2006, 2007; Tison & Perret, 2004; Peruzzi, 2007; Peruzzi & Zarrei, 2007; Peruzzi & Jarvis, 2009), but for many other species types have yet to be identified and designated.

This paper is the result of re-examination of several already known types, and, in the case of *Lloydia kunawurensis* Royle, the study of a previously overlooked one. Morphological data have allowed a better understanding of a group of five species previously treated for Iran (Zarrei *et al.*, 2007).

MATERIALS AND METHODS

This study used comparative morphological methods and employed specimens of *Gagea* deposited in BM, GB, K, M, MSB, P, W and WU. Transverse sections of the basal leaf, pedicel and tepal were obtained using material from herbarium specimens collected on recent field trips in Iran. The species were also studied live in the field. Vouchers for anatomical studies (Table 1) are deposited in K, TUH and Shahed University Herbarium. Sections were stained using methyl blue and acetocarmine according to the method described by Gerlach (1977). Several slides were studied and photographed using a light microscope (Olympus Vanox AHBS3). Line drawings of such preparations are presented for three of the taxa.

TABLE 1. Voucher specimens used for anatomical study of *Gagea kunawurensis* and its related species. All material was collected in Iran

Species	Organ	Voucher
<i>G. afghanica</i>	Basal leaf	Khorassan: Hills before Bajgiran, beside the road, 37°35'31"N, 58°26'26"E, 1550 m, 29 iii 2002, Zarrei & Ajani 29200
	Pedicel	Gorgan: Kalaleh towards Ashkhaneh, 5 km after Robate Gharabil deviation, 37°41'N, 56°16'E, 620 m, 25 iii 2005, Zarrei & Golzarian 35207
	Tepal	Gorgan: Kalaleh towards Ashkhaneh, 5 km after Robate Gharabil deviation, 37°41'N, 56°16'E, 620 m, 25 iii 2005, Zarrei & Golzarian 35207
<i>G. dschungarica</i>	Basal leaf	Karaj: 5 km after Gachsar towards Chalus, 2400 m, 9 v 2003, Zarrei & Kamrani 30078
	Pedicel	Karaj: 5 km after Gachsar towards Chalus, 2400 m, 9 v 2003, Zarrei & Kamrani 30078
	Tepal	Karaj: 5 km after Gachsar towards Chalus, 2400 m, 9 v 2003, Zarrei & Kamrani 30078
<i>G. gageoides</i>	Basal leaf	Kohgilouyeh va Boyer Ahmad: Saverz Mts, 2500–3500 m, 4 vi 2003, Zarrei & Kamrani 30071
	Pedicel	Kohgilouyeh va Boyer Ahmad: Saverz Mts, 2500–3500 m, 4 vi 2003, Zarrei & Kamrani 30071
	Tepal	Kohgilouyeh va Boyer Ahmad: Saverz Mts, 2500–3500 m, 4 vi 2003, Zarrei & Kamrani 30071
<i>G. kunawurensis</i>	Basal leaf	Azərbaycan: Jolfa: St Steppanous Church, 15 km towards west from Jolfa, 1100 m, 24 iv 2002, Zarrei 29271
	Pedicel	Fars: Arsanjan towards Marvdasht, mts around Koreiy, Khafrake Olia, 29°51'N, 53°05'E, 1675 m, 18 iii 2007, Zarrei & Golzarian 1276
	Tepal	Azərbaycan: Jolfa: St Steppanous Church, 15 km towards west from Jolfa, 1100 m, 24 iv 2002, Zarrei 29271

TABLE 1. (*Cont'd*)

<i>G. tenera</i>	Basal leaf	Semnan: Bastam to Azad-Shahr, 8 km to the Khosh–Yeylagh pass, Dang deviation, 7 km to Dang from main road, 36°48'26"N, 55°15'01"E, 2090–2100 m, 28 iii 2002, Zarrei & Ajani 29185
	Pedicel	Semnan: Shahroud towards Shahpassand, 10 km after Olang deviation towards west, 36°47'N, 55°15'E, 2020 m, 8 iv 2007, Zarrei 1154
	Tepal	Semnan: Shahroud towards Shahpassand, 10 km after Olang deviation towards west, 36°47'N, 55°15'E, 2020 m, 8 iv 2007, Zarrei 1154

RESULTS AND DISCUSSION

A: *Gagea kunawurensis* and *G. stipitata*

The fortuitous appearance for sale on the internet of a letter from David Don to John Forbes Royle concerning his work on *Lloydia* for the latter's *Illustrations of the Botany of the Himalayan Mountains* (Royle, 1839–40) led to a renewed interest in the subject by the third author (H.N.). H.N. had previously worked on the genus for the *Flora of Bhutan* (Noltie, 1993, 1994), when it was discovered that the types of the two species concerned, *Lloydia kunawurensis* and *L. himalensis*, were missing from Royle's own herbarium at LIV. These were cited as types (i.e. lectotypified) by Dasgupta & Deb in their revisions of *Gagea* (1986a) and *Lloydia* (1986b) respectively, and the '!' following the citations shows that they were obtained on loan by, and seen by, the authors. However, as these have still not been returned to Liverpool (Wendy Atkinson, pers. comm.) they must be presumed permanently lost. Fortunately, previously overlooked duplicates of both are in Hooker's herbarium at K and as these form part of the original material they can be taken as replacement lectotypes.

The analytical (and therefore validating) illustration (t. 93 f. 3) of *Lloydia kunawurensis* was published by Royle in 1839, the associated text (p. 388) not until 1840. It should be noted that although Royle attributed the description to Don, the name was his own, so cannot be attributed to 'D. Don in Royle' (as done by Dasgupta & Deb, 1986a). No type was cited by Royle, merely the collecting locality 'Hab. Chango, in Kunawur'; the original material consisted of specimens in his own herbarium, duplicates given to Hooker, and the published plate. Greuter (1970) made the new combination *Gagea kunawurensis* (Royle) Greuter. He cited no type,

and had seen no original specimens, the combination being made more or less incidentally in a paper chiefly concerned with the Mediterranean species *Gagea graeca* (L.) A. Terracc. and *G. trinervia* (Viv.) Greuter. Greuter stated that '*L. kunawurensis* Royle, has generally been referred to *Gagea persica* Boiss. (*G. gageoides* (Zucc.) Vved.), whose correct name consequently is *G. kunawurensis*'. The 'generally been referred to' was presumably a reference to E. Boissier's treatment in *Flora Orientalis* (5: 210, 1882) and J. D. Hooker's in *Flora of British India* (6: 355, 1892), practically the only treatments of this taxon until recent times.

Dasgupta & Deb (1986a) followed Greuter's treatment of *Gagea kunawurensis*, but their account was based only on gross morphological characters of herbarium specimens, leading to the misunderstanding, and misapplication of names, of several species of *Gagea* from northern India and Pakistan. The aim of the present study is to clarify the typification of *Gagea kunawurensis* and related species.

The recently discovered sheet at Kew (Fig. 1) is annotated '*Lloydia kunawurensis* Royle, Ill. t. 93 [Fig. 1]. Kunawur. Herb Royle' and bears five individual plants. The left-hand specimen is mature and complete (with four flowers, a basal leaf, and bulb). One of the individuals is immature and incomplete (lacking flowers). Two individuals lack bulbs, and on these the flowers have been destroyed by insects. Zarrei *et al.* (2007) did not see this sheet, but on the basis of the published illustration (Royle, 1839–40) concluded that *Lloydia kunawurensis* was, indeed, a species of *Lloydia* (and excluded it from *Gagea*). The published illustration, a hand-coloured lithograph, is similar to the individual on the left-hand side of the K sheet, but shows pale creamy flowers typical of *Lloydia*. Although the colour on the herbarium specimen has faded, the tepals appear to have been pale yellow with darker tips. However, it is now recognised that flower colour is not a diagnostic character between *Gagea sensu stricto* and *Lloydia* (as discussed in Zarrei *et al.*, in press). For example, *Gagea ova* (a synonym of *G. stipitata*, as suggested by Zarrei *et al.*, 2007) possesses creamy to pale yellow flowers similar to those of some species of *Lloydia*.

As noted above Greuter (1970) stated that *Gagea kunawurensis* was the correct name for *G. gageoides*, but critical study shows this not to be the case: *G. gageoides* is a distinct species with several morphologically distinct character states (see below and Table 2). On the other hand *Gagea stipitata* and *G. kunawurensis* do form a single taxonomic entity. Both taxa possess a cymose inflorescence with more than three flowers (Fig. 2A–B). Their tepals are adaxially yellow, with longitudinal green abaxial stripes, and are purple at the tip (rarely in *Gagea stipitata*, but visible on the type of *G. kunawurensis*). Both possess only a single basal leaf. The bulb tunic is brown-leathery in both species and envelops small (1–2.5 × 1–2 mm) bulbils. The bulbils are ovoid to pyriform, dark in colour, with foveolate surfaces (one bulbil is present on the type of *Gagea kunawurensis*). They also share the following characters: tunic neck short (to 0.5 cm); roots all normal, none thickened; tepals narrowly elliptic, obtuse to acute at the tip, glabrous. We therefore conclude that *Gagea stipitata* is synonymous with *G. kunawurensis*.



FIG. 1. Lectotype of *Gagea kunawurensis* (Royle s.n., K).

B: Clarification of the typification of *Gagea persica* and *G. gageoides*

Gagea gageoides was described, as *Bulbillaria gageoides*, by Zuccarini from Mount Lebanon in 1843. The holotype of *Gagea gageoides* is Roth & Erdl 245, M!, comprising three specimens, only one of which has a bulb. The basal leaf is absent

TABLE 2. Summary of diagnostic characters of *Gagea kunawurensis* and its related species

Character	<i>G. afghanica</i>	<i>G. dschungarica</i>	<i>G. gageoides</i>	<i>G. kunawurensis</i>	<i>G. tenera</i>
Type of basal leaf	Linear	Flattened	Filiform	Linear	Filiform
Basal leaf width (mm)	1–1.5	5–8	c.0.5	0.5–1.5	0.4–0.6
Bulb tunic	Loosely fibrous, grey	Leathery, dark	Leathery, dark	Leathery, dark	Leathery, dark
Bulbils on the bulb	Absent	Present	Absent	Present	Rarely present
Bulbils on the inflorescence	Absent	Absent	Present	Absent	Absent, present only in immature individuals
Tepal length (mm)	8–12	5–8	4–7	5–10	6–7
Thickened roots	Present	Rarely present	Absent	Absent	Absent

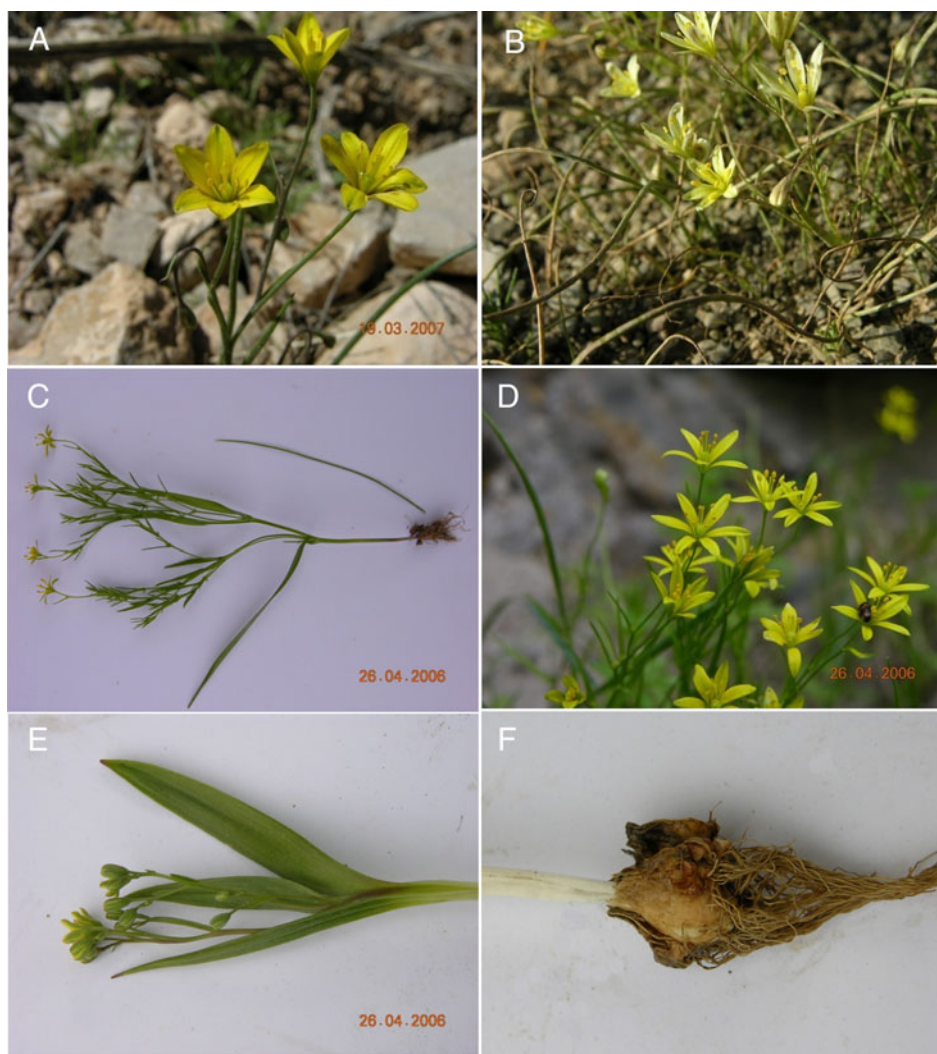


FIG. 2. A–B, *Gagea kunawurensis*; C–D, *G. gageoides*; E–F, *G. dschungarica*.

from all three specimens. The main diagnostic characters of this species are the clusters of bulbils in the axils of the cauline leaves and bracts, and the cymose inflorescence (Fig. 2C–D). The basal leaves are filiform (0.5 mm in diameter) and delicate, and for this reason are lacking from most herbarium specimens as they easily become detached during collection or drying.

Gagea persica was described by Boissier (1846: 108) based on two collections (syntypes) from Iran (Persia): ‘*prope Ispahan Aucher 5404*’ and ‘*ad ruinas Persepolis [between Astragalus shrubs, 15 iv 1842] Kotschy No. 237*’. Boissier later (1882: 210) realised that *Kotschy 237* was a mixed collection, splitting it into ‘Ky 237 A’, which

he assigned (with *Aucher* 5404) to the bulbiferous *Gagea persica* [var. *persica*], and ‘Ky 237’, one of the collections (syntypes) cited under his *Gagea persica* var. *ebulbillosa* Boiss., which lacked inflorescence bulbils (Boissier typified neither name). It is possible, however, that the distinguishing supplementary letter has not been placed after the number in duplicates in all herbaria.

Two sheets of *Kotschy* ‘237’ have been found at K, one at M and, according to Levichev (2006), there is a duplicate at LE.

Individuals on the sheet at M do not possess inflorescence bulbils and are therefore *Kotschy* 237. Individuals on one of the K sheets do possess inflorescence bulbils and are therefore *Kotschy* 237A (formerly filed under *Gagea amblyopetala* Boiss. & Heldr. var. *bulbifera* Boiss.), whereas the second one (and a duplicate at BM!) does not show this character and is therefore *Kotschy* 237 (s.s.). Levichev (2006) selected the sheet of *Kotschy* 237A at LE as lectotype of *G. persica*.

Dasgupta & Deb (1986a) cited the type of *Gagea persica* as ‘*Kotschy* 237 – BM! CAL! G! K – photo!’. It is not clear if they realised that 237 was a mixed collection (they did not treat Boissier’s *Gagea persica* var. *ebulbillosa*), but as they took *G. persica* to be bulbiferous, this specimen 237 (s.s., rather than 237A) is in conflict with the protologue and their lectotypification should be rejected (Art. 9.12, 17, McNeill *et al.*, 2006). Dasgupta & Deb excluded the other syntype of *Gagea persica*, *Aucher* 5404, referring it to *G. kunawurensis* (see below). They also reduced *Gagea stipitata* and *G. afghanica* to synonymy with *G. persica*. That *Gagea stipitata* differs from *G. persica* has been discussed above; the status of *G. afghanica* is treated below.

Gagea persica is morphologically indistinguishable from *G. gageoides*, the latter name having priority. On the other hand, the variety *Gagea persica* var. *ebulbillosa* has the morphological characters of *G. kunawurensis*, to which it is here referred as a synonym.

C: Status of *Gagea dschungarica* Regel, *G. afghanica* A.Terracc. and *G. persica* var. *kashmirensis* (Turrill) S.Dasgupta & Deb

Gagea gageoides and *G. dschungarica* were both treated as synonyms of *G. kunawurensis* by Dasgupta & Deb (1986a). For the former they were following the treatment of Greuter (1970), now known to be incorrect; the latter synonymy was new, and also incorrect. In order to clarify the situation, the typification of *Gagea gageoides* and *G. dschungarica* is discussed below.

Gagea dschungarica was typified by Wendelbo & Rechinger (1990: 20) with an unnumbered specimen collected by Regel at Jugantash (Turkmenistan), WU!. This lectotypification was confirmed by Zarrei *et al.* (2007), the collection consisting of four well-preserved and complete individuals (there are isotypes at K! and BM!). Dasgupta & Deb (1986a) cited China-Dzungarian, 3–6000 ft, *Regel* (LE) as type without further clarification. This specimen was not mentioned in the original description of the species and is rejected here as lectotype. The main characters that distinguish *Gagea dschungarica* from *G. gageoides* are the shape of the basal leaf and absence of

inflorescence bulbils. The former species possesses a flattened basal leaf (5–8 mm wide, Fig. 2E), whereas that of the latter is filiform (c.0.5 mm wide, Fig. 2C). The presence of inflorescence bulbils in *Gagea gageoides* (Fig. 2C) and their absence in *G. dschungarica* (Fig. 2E) is another diagnostic feature. Therefore, the statement of Dasgupta & Deb (1986a) that these two species are morphologically similar is misleading. Moreover, their interpretation of *Gagea kunawurensis* as the correct name for *G. gageoides* is not accepted here. Their observation that no bulbils are present on the bulb of *Gagea gageoides*, but numerous ones under the tunic of *G. dschungarica*, is correct.

Two types of bulbils may be present in the studied *Gagea* species. They are situated either under the tunic, in the space between the storage mass of the bulb and the tunic (*Gagea kunawurensis* and *G. dschungarica*), or on the inflorescence (*G. gageoides* and *G. tenera* Pascher).

It should be noted that the plants shown under the name *Gagea kunawurensis* as fig. 2a–e in Dasgupta & Deb (1986a: 86) represent several taxa. Figure 2a, with a flattened basal leaf and inflorescence with six flowers and no inflorescence bulbils, represents *Gagea dschungarica*. Figure 2b erroneously combines features of *Gagea gageoides* and *G. dschungarica*. The inflorescence (with one flower and several clusters of bulbils) belongs to the former, whereas the flattened basal leaf is that of *G. dschungarica*; no *Gagea* species possesses this combination of characters. The reason for the confusion of these authors was probably the fact that the narrow basal leaf of *Gagea gageoides* is absent from most herbarium specimens and they ‘reconstructed’ it in the wrong form. The tepals of both these species are in the same length range (Table 2).

Dasgupta & Deb (1986a) reduced *Gagea persica* to a synonym of *G. kunawurensis* based on *Aucher* 5404 (BM!), a syntype of *G. persica*. Based on the evidence in this paper, we disagree with this. On the basis of *Kotschy* 237 they accepted *Gagea persica* as a distinct species. However, *Kotschy* 237, as noted above, does not possess inflorescence bulbils.

Dasgupta & Deb (1986a) also reduced both *Gagea stipitata* and *G. afghanica* to synonyms of *G. persica*. The status of *Gagea persica* and *G. stipitata* has been discussed above. There are some morphological resemblances between *Gagea kunawurensis* and *G. afghanica*, particularly in inflorescence form, which is cymose in both. The tepals of *Gagea afghanica* are usually purple at the tip and because the type of *G. kunawurensis* possesses this feature, Dasgupta & Deb (1986a) synonymised them. However, these species belong to two different sections of the genus: the former to section *Didymobulbos* K.Koch, the latter to section *Plecostigma* Pascher. There are enough morphological differences between them to support their status as distinct taxa. The tunic is leathery and dark in *Gagea kunawurensis*, but loosely fibrous in *G. afghanica*. Thickened roots are the main diagnostic character of *Gagea afghanica*. All the roots are unthickened in *Gagea kunawurensis*. Bulbils are present on the bulb of *Gagea kunawurensis* and absent in *G. afghanica*. Thus we accept *Gagea afghanica* and *G. kunawurensis* as distinct species.

Dasgupta & Deb (1986a) considered *Gagea kashmirensis* Turrill as *G. persica* var. *kashmirensis* (Turrill) S.Dasgupta & Deb. The holotype, *Stokoe* 2, K!, has been

re-examined. The sheet has seven individual specimens of which only one is complete with two basal leaves; the others lack basal leaves or bulbs. The filiform basal leaves, sub-umbellate to cymose inflorescence, and broadly lanceolate lower cauline leaf show this species to be closely related to *Gagea tenera*. However, an immature individual with a cluster of bulbils (each bulbil with an apical green leaflet) is present on the type of *Gagea kashmirensis*. These bulbils resemble those found in immature individuals of *Gagea tenera* in northeastern Iran. The only difference between *Gagea kashmirensis* and *G. tenera* is that the former species has longer tepals (7–11 mm) than the latter (tepals 6–7 mm long). We conclude that *Gagea kashmirensis* is not a synonym of *G. kunawurensis*, but that it is a synonym of *G. tenera*.

D: Diagnostic key to the species

- 1a. Basal leaf flattened in transverse section, ≥ 5 mm wide ____ **1. *G. dschungarica***
 1b. Basal leaf terete, semicircular or circular in transverse section, ≤ 2 mm wide 2
- 2a. Bulbils present in clusters in axils of cauline leaves and bract _____
 _____ **2. *G. gageoides***
 2b. Bulbils absent in clusters in axils of cauline leaves and bract _____ 3
- 3a. Lower cauline leaves broadly lanceolate, flattened, differing from basal leaves in shape and width _____ **3. *G. tenera***
 3b. Lower cauline leaves filiform or narrowly lanceolate, resembling the basal ones 4
- 4a. Tunic leathery, non-fibrous, dark; thickened roots absent _ **4. *G. kunawurensis***
 4b. Tunics not leathery, readily separating into fibres, pale; thickened roots present
 _____ **5. *G. afghanica***

E: Enumeration of species

- 1. *Gagea dschungarica*** Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 6: 513 (1879).
 – Type: Turkmenistan, in Jugo Dschungarico Jugantasch inter Kersken-terek et Borochudsir, 6000–7000 ft, 25 v 1878, *Regel* s.n. (lecto WU!, designated by Wendelbo & Rechinger, 1990; isolecto BM!, K!, LE). **Fig. 2E–F.**

Distribution. Iran, Turkmenistan, Afghanistan, Pakistan, C Asia, ?India (Kashmir).

- 2. *Gagea gageoides*** (Zucc.) Vved., Fl. Turkmen. 1, 2: 261 (1932). – *Bulbillaria gageoides* Zucc., Abh. Math.-Phys. Akad. Wiss. Munchen, ser. 3, 1: 230, t. 2 f. 1 (?1843) [Pl. Nov. Fasc. 4]. – Type: Lebanon, crescit in subalpinis umbrosis montis Libani, *Roth & Erdl* 245 (holo M!, sole original specimen). **Fig. 2C–D.**

Gagea persica Boiss., Diagn. Pl. Orient. 1(7): 108 (1846). – *Hornungia persica* (Boiss.) Rouy in G.Rouy & J.Foucaud, Fl. France 12: 381 (1910). – Type: in rupestribus pr. Ruinas u. Persepolis, 15 iv 1842, *Kotschy* 237A (lecto LE, designated by Levichev, 2006; isolecto K!; syn *Aucher* 5404 BM!).

Distribution. Turkey and other eastern Mediterranean countries through the Caucasus, Iran and Turkmenistan to Kashmir.

3. *Gagea tenera* Pascher, Lotos 24: 128 (1904). – Type: Uzbekistan, Waterfall near the reservoir of Siyab, in the vicinity of Samarkand, 4 iii 1869, *Fedchenko* (holo LE, photo seen, sole original specimen).

Gagea kashmirensis Turrill, Bull. Misc. Inform. Kew 1928: 77 (1928). – *Gagea persica* var. *kashmirensis* (Turrill) S.Dasgupta & Deb, J. Bombay Nat. Hist. Soc. 83: 87 (1986). – Type: India, Kashmir, 5100 ft, iii 1926, *Canon Stokoe* 2 (holo K!).

Distribution. Turkey, NE Iran, Afghanistan, C Asia, India (Kashmir).

4. *Gagea kunawurensis* (Royle) Greuter, Israel J. Bot. 19: 155 (1970). – *Lloydia kunawurensis* Royle, Ill. Bot. Himal. Mts. 388 (1840), t. 93 f. 3 (1839). – Type: Chango in Kunawur, *Royle* s.n. (lecto LIV, designated by Dasgupta & Deb, 1986a, presumed lost; replacement lecto K!, designated here).

Figs 1, 2A–B.

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, *Lehman* (syn LE); bei Bakali, 27 iv 1842 (deflorata et fructificans), *Collector unknown* (syn LE).

Gagea ova Stapf, Denkschr. Kaiserl. Akad. Wiss., Wien. Math.-Naturwiss. Kl. 50: 16 (1885). – Type: Iran, Lorestan, in monte Karaghan (media), ad Schurab, 1882, *Pichler* s.n. (lecto K!, designated by Zarrei *et al.*, 2007; iso WU!).

Gagea ebulbillosa (Boiss.) Levichev, Bot. Zhurn. (Moscow & Leningrad) 91: 947 (2006). – *Gagea persica* var. *ebulbillosa* Boiss., Fl. Orient. 5: 210 (1882). – Type: in rupestribus pr. Ruinas u. Persepolis, 15 iv 1842, *Kotschy* 237 (lecto K!, designated here; iso BM!, M!).

Distribution. Iran, Turkmenistan, Afghanistan, Pakistan, C Asia, India (Himachal Pradesh, ?Kashmir).

5. *Gagea afghanica* A.Terracc., Boll. Soc. Orto Palermo II, 3: 3 (1904). – Type: Afghanistan, Hari-Rud Valley, 15 iv 1885, *Aitchison* 1130 (lecto FI, designated by Wendelbo & Rechinger, 1990; iso BM!, K!).

Distribution. Iran, Afghanistan, C Asia.

Note. In view of the differing species concepts, Indian records from Dasgupta & Deb (1986a) have not been included in the above distributions. In fact there are very few recent collections from the western Himalaya (Kashmir or Himachal Pradesh), and fieldwork in this area is to be encouraged.

TABLE 3. Summary of diagnostic characters for *Gagea kunawurensis* and its related species

Character	<i>G. afghanica</i>	<i>G. dschungarica</i>	<i>G. gageoides</i>	<i>G. kunawurensis</i>	<i>G. tenera</i>
Outline transverse section ^a	Circular-sinuate (Fig. 3B)	V-shaped, 5–8 mm wide (Fig. 3A)	Circular-irregular	Circular-sinuate	V-shaped, 0.4–0.6 mm wide (Fig. 3C)
Palisade parenchyma ^a	Present	Absent	Absent	Present	Present
Hypodermis ^a	Absent	Absent	Absent	Absent	Present
Sclerenchyma ^b	Present	Present	Absent	Present	Present

^aBasal leaf.

^bPedicele.

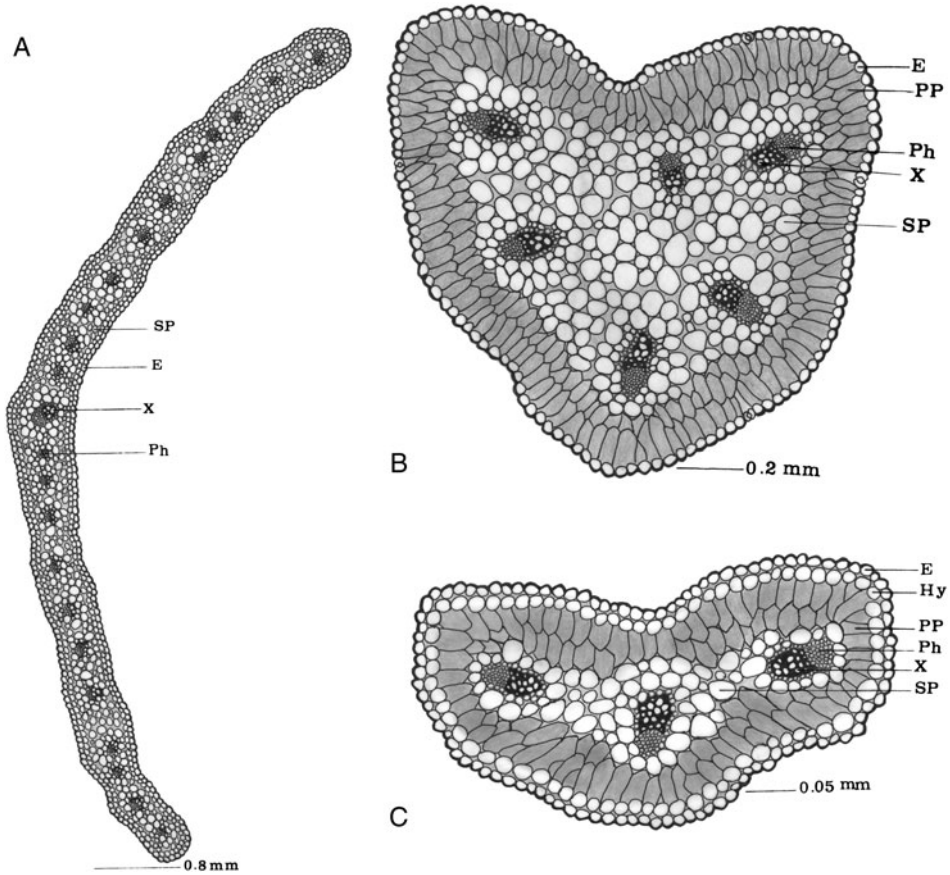


FIG. 3. Transverse section of basal leaf: A, *Gagea dschungarica*; B, *G. afghanica*; C, *G. tenera*. SP – spongy parenchyma, E – epidermis, X – xylem, Ph – phloem, PP – palisade parenchyma, Hy – hypodermis.

F: Anatomy

Anatomical characteristics of the basal leaf, pedicel and tepal of all five taxa (*Gagea afghanica*, *G. dschungarica*, *G. gageoides*, *G. kunawurensis* and *G. tenera*) have been investigated (Fig. 3, Table 3). No collenchymatous tissue was found in any of the organs studied (except hypodermis in *Gagea tenera*). The basal leaf does not possess sclerenchyma whereas the pedicel does. The anatomy of the tepals is similar in all five species. There are no obvious differences between species based on tepal anatomy. However, the basal leaf demonstrates enough anatomical variation to distinguish four taxa, but is not enough to distinguish between *Gagea afghanica* and *G. kunawurensis*. These characters are summarised in Table 3. The outline of the transverse section of the basal leaf, the mesophyll cell shapes of the basal leaf, and the presence/absence of hypodermis are of taxonomic importance. The outline of the

transverse section of the basal leaf is V-shaped (5–8 mm wide) in *Gagea dschungarica* (Fig. 3A) but circular in *G. afghanica* (Fig. 3B), *G. kunawurensis* and *G. gageoides*. *Gagea tenera* possesses a V-shaped basal leaf outline in transverse section (0.4–0.6 mm wide, Fig. 3C), and is the only species with a layer of collenchymatous hypodermis (Fig. 3C). The mesophyll is composed of both palisade and spongy parenchyma in *Gagea tenera* (Fig. 3C), *G. afghanica* (Fig. 3B) and *G. kunawurensis*, whereas spongy parenchyma alone is present in *G. gageoides* and *G. dschungarica* (Fig. 3A).

Pedicle anatomy does not demonstrate the same level of variation as basal leaf anatomy. The outline of the transverse section is similar within all five species (circular). There is a circle of sclerenchyma covering only the phloem in most species except *Gagea gageoides* (Table 3).

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