

## Three records of *Gagea* for the flora of Iraq

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### Abstract

*Gagea* is a perennial bulbous genus widely distributed in mountainous and subalpine areas throughout Eurasia, SW Asia, and N Africa. The Flora of Iraq includes nine species of the genus *Gagea*, all of which occur in the Kurdistan region, often in mountain meadows, near the melting zone of snow, sometimes in oak forests, and steppe meadows ranging from 800–3000 m altitudes. In this study, which has been conducted on the taxonomy of the genus *Gagea* in the Kurdistan region of Iraq, three records of the genus *Gagea*, including *G. bulbifera* (sect. *Bulbiferae*), *G. vegeta* (sect. *Platyspermum*), and *G. chomutovae* (sect. *Stipitatae*), are reported for the first time for the flora of Iraq. *Gagea bulbifera* is identified by single bulbil in the axils of cauline leaves, and non fistulose radical leaves with semicircular in cross-section; *G. vegeta* is distinguished by linear-lanceolate, acuminate tepal with very acute apex, one radical leaf, ovate ovary, and *G. chomutovae* is recognized by elliptic-obovate tepal with acute to obtuse apex, radical leaf 20–23 cm, circular-fistulose in cross-section, with 4 cauline leaves. Detailed morphological descriptions of the new species, photographs of different parts, and their distribution map along with the identification key based on morphological features are also given.

**Keywords:** Identification, Iraqi Kurdistan, *Liliaceae*, morphology, taxonomy

### گزارش سه گونه جدید نجم طلایی برای فلور عراق\*

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### خلاصه

جنس نجم طلایی با نام علمی *Gagea* Salisb. (سوسنیان)، گیاهی چندساله و پیازی است که اعضای آن به طور گسترده در مناطق کوهستانی و زیرآلپی سراسر اوراسیا، جنوب‌غربی آسیا و شمال آفریقا پراکنش دارند. فلور عراق دارای نه گونه از این جنس است که همگی در استان کردستان عراق، بیشتر در مراتع کوهستانی، نزدیک مناطق ذوب برف، گاهی در جنگل‌های بلوط و مراتع استپی از ارتفاع ۵۰۰ تا ۳۰۰۰ متری یافت می‌شود. مطالعه حاضر که به بررسی آرایه‌شناسی جنس *Gagea* در کردستان عراق پرداخته است، سه گونه از این جنس شامل *G. bulbifera* (بخش *Bulbiferae*)، *G. vegeta* (بخش *Platyspermum*) و *G. chomutovae* (بخش *Stipitatae*) برای نخستین بار برای فلور عراق گزارش می‌شوند. *G. bulbifera* با دارا بودن پیاز منفرد روی محور برگ‌های ساقه‌ای و قاعده‌ای غیرتوخالی و دارای برش عرضی نیم‌دایره‌ای؛ *G. vegeta* به واسطه گلپوش خطی-سرنیزه‌ای نوک‌دار کشیده، داشتن یک برگ قاعده‌ای و تخمدان تخم‌مرغی و *G. chomutovae* به خاطر برگ‌های قاعده‌ای بیضوی-واژتخم‌مرغی نوک تیز یا نوک کند، برگ‌های قاعده‌ای به طول ۲۰–۲۳ سانتی‌متر، با برش عرضی توخالی و ۴ برگ ساقه‌ای شناسایی شدند. شرح ریخت‌شناسی دقیق گونه‌ها، تصاویر قسمت‌های مختلف و نقشه پراکنش آن‌ها به همراه کلید شناسایی براساس ویژگی‌های مربوطه نیز ارائه شده است.

**واژه‌های کلیدی:** تاکسونومی، ریخت‌شناسی، سوسنیان، شناسایی، کردستان عراق

\* مستخرج از رساله دکتری نگارنده نخست به راهنمایی دکتر مرضیه بیگم فقیری ارائه شده به دانشکده علوم دانشگاه گیلان، رشت

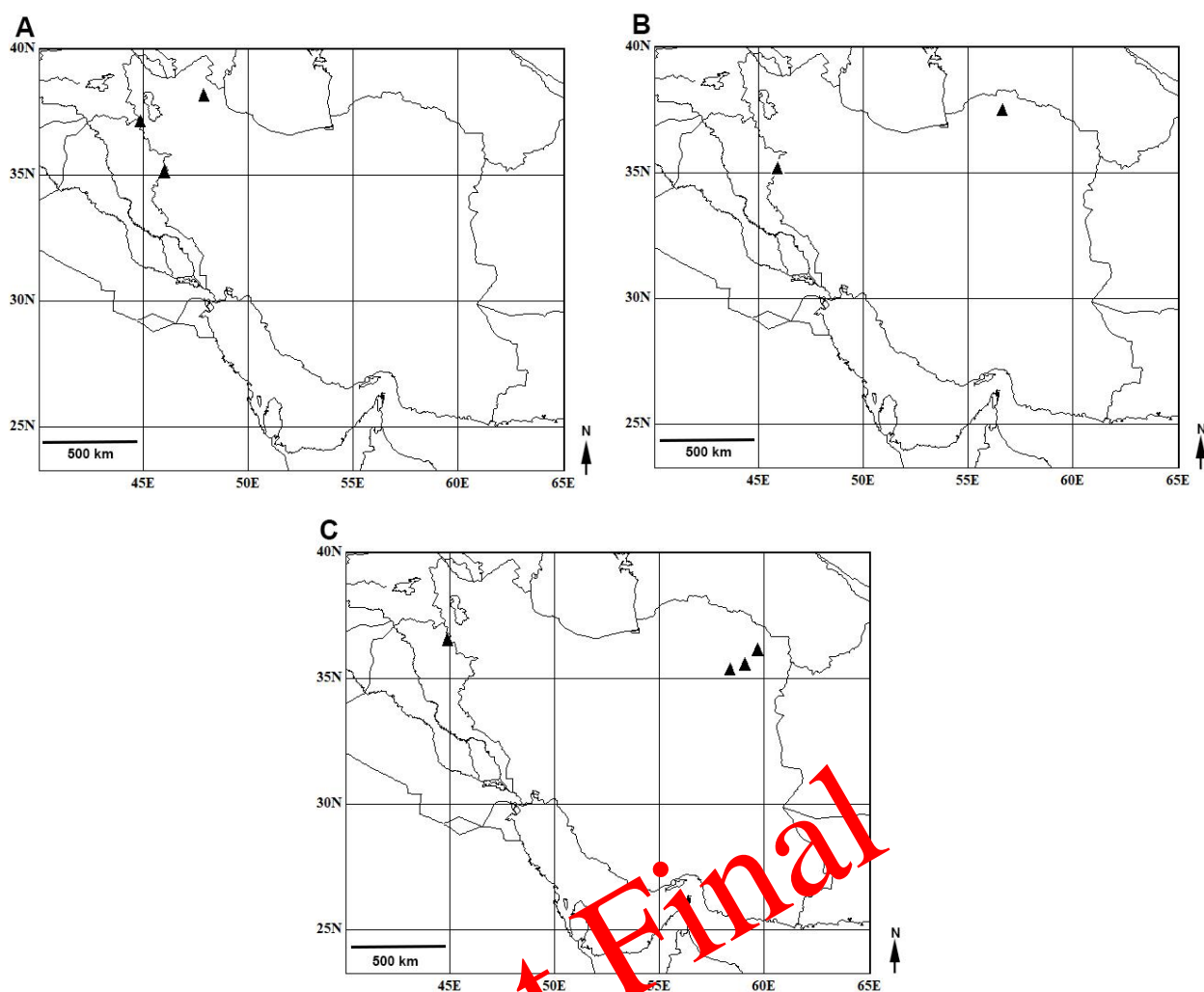
## Introduction

The genus *Gagea* Salisb., a member of *Liliaceae* (tribe: *Tulipeae*), shows the highest number of species (ca. 300) within the family (Peruzzi 2016). It comprises perennial bulbous species widely distributed in mountainous and subalpine areas throughout Eurasia, especially SW Asia, and N Africa (Peterson *et al.* 2008, 2009, 2019). This genus is diagnosed by some characters such as flowers in a lax, branched inflorescence with leafy bracts, sometimes contracted and subumbellate, several-nerved tepals with yellow and a broad greenish stripe outside (Wendelbo 1985). Nine species of this genus reported in the Flora of Iraq (Wendelbo 1985) are classified in two subgenera and seven sections (Wendelbo & Rechinger 1990, Tekşen & Erkul 2015). Subgenus *Gagea* includes two sections i.e., sect. *Didymbulbos* (K.Koch) Boiss. with three species i.e., *G. luteoides* Stapf., *G. dubia* A. Terracc., and *G. fragifera* (Vill.) E.Bayer & G.López; and sect. *Minimae* (Pascher) Davlianidze with single species i.e., *G. confusa* A. Terracc. Subgenus *Platyspermum* Boiss. includes three sections, namely, sect. *Platyspermum* Boiss. with two species: *G. commutata* K.Koch and *G. reticulata* (Pall.) Schult. & Schult.f., sect. *Plecostigma* (Turcz.) Pascher with two species: *G. chlorantha* (M.Bieb.) Schult. & Schult.f. and *G. uliginosa* Siehe & Pascher; and sect. *Persicae* (Levichev) Peruzzi with single species. i.e., *G. gageoides* (Zucc.) Vved. Among these species, *G. uliginosa* and *G. commutata* are described as rare species (Wendelbo 1985). All of the above-mentioned species occur only in Kurdistan region of Iraq (Wendelbo 1985), often in mountain meadows, near the melting zone of snow, sometimes in oak forests, and steppe meadows ranging from 800–3000 m altitudes (Levichev 1999).

Except for the taxonomic study conducted in the framework of Flora of Iraq (Wendelbo 1985), no comprehensive study has so far been conducted on this genus in Iraq. Therefore, in the present study, this genus has been investigated in the Kurdistan region of Iraq.

## Materials and Methods

Plant samples were collected from different regions of Iraqi Kurdistan during the winter and spring of 2023 at altitudes ranging from 800–3000 m above sea level. The identification was done based on the Flora of Iraq (Wendelbo 1985), Flora Iranica (Wendelbo & Rechinger 1990) Flora of Turkey (Rix 1984), and the relevant references (Wendelbo 1985, Rix 1984, Zarrei & Zarre 2005, Zarrei *et al.* 2007, 2010a, 2011, Heidarnia & Zarrei 2023). The newly collected taxa are deposited in the Guilan University Herbarium (Rasht, Iran). In this study, both morphological and anatomical characteristics of the samples were examined. According to the previous studies (e.g. Zarrei *et al.* 2010b), anatomical features of the genus has a high value for separation of the species, specially the features of basal leaves. Photographs of different parts were taken with digital microscope, Dino-Lite (AN-413T) and stereomicroscope (Feica Wild M3Z). Cross-sections of radical leaves were observed with an optical microscope (Nikon Alphaphot YS) and photographs were taken with camera (iPhone 12 Pro Max). The identified species were compared with specimens of Guilan University Herbarium, Rasht (Iran), Tehran University Herbarium (TUH), Tehran (Iran), and Salahaddin University Herbarium, Erbil (Iraq). The names of all taxa authors were coordinated with POWO (2024) and IPNI (2024). Distribution map of the record species (Fig. 1) and observed specimens of the corresponding Iranian species were presented using DMAP software (Morton 2004).



**Fig. 1.** Distribution map of A: *Gagea bulbifera*, B: *G. vegeta* and C: *G. chomutovae* in Iraqi Kurdistan and Iran based on the observed specimens.

## Results

***Gagea bulbifera*** (Pall.) Salisb., Ann. Bot. (König & Sims) 2: 557 (1806)

Type: Russia (Astrakhan): In aridis limosis ad Wolgam et Jaicum, Pallas s.n., holotype LE; isotype BM.

Plants 8–9 cm tall; basal bulbs flat, drop-shaped, 4–5 mm long, 2–4 mm wide, tunics coriaceous, grey-brown, neck sheath absent, basal bulbils absent; roots thin, thickened roots occasionally present, enveloping the bulb; cauline leaves just above the bulb, densely villous; radical leaf 1 (rarely 2), filiform-linear, non fistulose, semicircular in cross-section, equal to or shorter than inflorescence, 3.5–5 cm long cauline leaves 3–9, alternate, similar to radical leaves, filiform-linear, shorter than inflorescence, and single bulbil present in each axil; inflorescence solitary to raceme, few-flowered (mostly one, sometimes two or three); pedicel 2–4 cm long; tepal 12–14 mm long and 2–4 mm wide, green outside, yellow-margined, golden inside, lanceolate and obovate-oblong, acute apex; stamens 8–9 mm long, style 5–6 mm long; ovary ovate (Fig. 2A-G).

Habitat and Ecology: *Gagea bulbifera* along with *G. vegeta* grow in rocky slope with shallow soil at altitude higher than 1500 m. In the habitat of these species, few stocks of *Quercus* were also observed plus some grasses, namely, *Eryngium*, *Erodium*, *Geranium* *Leontice armeniaca*, etc.

Specimens examined: IRAQ: Kurdistan region, Shnrwe Mts., 11 km southeast of Halabja, 35°8'33" N 46°4'30" E, 1700 m.a.s.l., 24.3.2023, Bakhtyar Abdalla Mohammed Ezamakhshi (9741 Guilan University Herbarium).

Additional specimens examined: IRAN: Ardebil: Saraein, Sabalan Mts., 38°11'342"N 47°53'972"E, 2880 m, 13.3.2005 (35308-TUH); Azerbaijan: near border of Iraq, Dizaj, mountains above village, 37°09'26" N, 44°52'85" E, 2350 m, 15.5.2005 (35713-TUH).

Flowering and fruiting season: Between middle of March and early May, respectively.



**Fig. 2.** *Gagea bulbifera*: A. Herbarium specimen, B. Flower parts, C. Flower, D-E. Bulb and root, F. Axillary bulb (indicated by arrow), G. Basal leaf in cross-section.

*Gagea vegeta* Vved Bot. Mater. Gerb. Bot. Inst. Komarova Akad. Nauk S.S.S.R. 9: 238 (1946)

Type: Tadjikistan: Montes Hissar, in valle fluvii Varsob infra pagum Zigdy, in argillosis, A.I. Vvedensky, Herb. Tashkent.

Plants 7–10 cm tall, solitary or in clumps; bulbs pitcher shaped, 7–8 mm long and 5–6 mm wide, tunics reticulate-papery; neck 2–3 cm, bulbils absent; roots normal, thickened ones present, enveloping the bulb; stem erect; subterranean part 1–1.5 cm; aerial part absent (inflorescence branching at the soil surface); radical leaf solitary, longer than the inflorescence, 10–16 cm and 1–2 mm wide, glabrous; cauline leaves 3–5, verticillate, outer ones linear lanceolate, 6–9 cm long and 1–2 mm wide; bracteoles absent; inflorescence umbel-like, 2–4 flowered; pedicels unequal, erect, 2–4 times longer than flower; tepals 21–27 mm long and 2–3 mm wide, yellow, green outside, linear-lanceolate, acuminate, very acute apex; stamens 11–12 mm long; style 6–8 mm long; ovary obovate (Fig. 3).

Habitat and Ecology: Same as *G. bulbifera* (mentioned above).

Specimens examined: IRAQ: Kurdistan region, Shnrwe Mts., 11 km southeast of Halabja, 35°8'33" N 46°4'30" E, 1700 m.a.s.l., 24.3.2023, Bakhtyar Abdalla Mohammed Ezamakshshi (9746 Guilan University Herbarium).

Additional specimens examined: IRAN: Golestan: Kalaleh, Ajan-Sangarly village, 230 m, 15.3.2002, Ajani (29292-TUH); Golestan: Golestan National Park to Bojnourd, 37°25'46" N 56° 37'55" E, Zarrei (29188-TUH).

Flowering and fruiting season: Between middle of March and early May, respectively.



**Fig. 3.** *Gagea vegeta*: A. Herbarium specimen, B-C. Flower parts, D. Neck sheath and root, E-G. Bulbs and neck sheath, H. Basal leaf in cross-section.

*Gagea chomutovae* (Pascher) Pascher Bull. Soc. Imp. Naturalistes Moscou, n. 9: 372 (1907)

Type: Tashkent, Herb. Tashkent

Plants 15–16.5 cm tall, bulbs drop shape, 7–8 mm long and 5–6 mm wide, tunics coriaceous, grey to dark-brown; neck sometimes present, short, with tunics grey to dark-brown, coriaceous; roots thin, thickened roots occasionally present. aerial part 2–2.5 cm; radical leaf linear, circular-fistulose, 20–23 cm long, 2–3 mm wide, longer than the inflorescence, glabrous; cauline leaves 4–8 in number, the lowest one linear-lanceolate, long-acuminate, 5.5–6.5 cm long, shorter than the inflorescence; inflorescence 4–9 flowered, cymose, usually dichotomously branched; pedicels glabrous, tepal 10–14 mm long, 2–3 mm wide, elliptic-obovate, acute to obtuse, outer part green, inner part yellow; stamens 8–11 mm long; style 3–5 mm long; ovary ovate to cylindrical (Fig. 4).

Habitat and Ecology: *Gagea chomutovae* grows in rocky slopes with shallow soil at altitude higher than 3000 m. In the habitat of this species, no trees were observed. However, some perennial taxa such as *Helichrysum* and *Fritillaria* were present.

Specimens examined: IRAQ: Kurdistan region, Hasary Sakran Mts., border of Iran and Iraq, 92 km northeast of Erbil, vicinity of Choman, 36°32'56" N, 44°54'59" E, ca. 3000 m.a.s.l., 22.5.2023, Bakhtyar Abdalla Mohammed Ezamakhshi (9738 Guilan University Herbarium).

Additional specimens examined: IRAN: Khorasan: Ghuchan to Mashhad, Khajeh Morad hill, above holly place, 35°69'01" N, 59°41'42" E, 1100–1130 m, 30.3.2002, Zarrei & Ajani (29205-TUH); Khorasan: Allah Akbar pass, ca. 2300 m, 30.4.1999, Zarrei (22291A-TUH); Khorasan: Ghuchan to Bajgiran, 16 km after Ghuchan, on the pass, 37°14'37" N, 58°48'45" E, 1670–1680 m, 29.3.2002, Zarrei (29199-TUH); Khorasan: Khajeh Morad, on the road towards Neyshabour from Mashhad, above holly place, 36°09' N, 59°41' E, 1080 m, 27.3.2005, Zarrei & Golzarian (35218-TUH); Khorasan: Gonabad, Kakhk town, Kalateh Valley, 1600 m, 21.3.2001, Zarrei (30041-TUH); Khorasan: between Kashmar and Rivash (Kouhe-e Sorkh), 13 km after Kashmar, just on the pass, 35°22' N, 58°22' E, 1240 m, 28.03.2005, Zarrei &

Golzarian (35234-TUH); Khorasan: Ghuchan, 4.1999, Attar *et al.* (28269-TUH); Khorasan: Robot-e Sang towards Kadkan, Roudkhaneh village deviation, 35°35' N, 59°05' E, 1660 m, 27.3.2005, Zarrei & Golzarian (35214-TUH).

Flowering and fruiting season: Between middle of April and July, respectively.



**Fig. 4.** *Gagea chomutovae*: A. Herbarium specimen, B & D. Flower parts, C. inflorescence, E-F. Bulbs, G. Bulbils and tunic, H. Basal leaf in cross-section.

#### Identification key of *Gagea* species of Iraq based on the morphological characteristics

1. Bulbils present in axils of cauline leaves or bracts ..... 2
- Bulbils absent in axils of cauline leaves or bracts ..... 3
2. Ovary pyriform, apex of tepal obtuse to acute, bulbs elongated, onion-shaped ..... 1. *G. gageoides*
- Ovary ovate, apex of tepal acute, bulbs flat, drop-shaped ..... 2. *G. bulbifera*
3. Tepal linear-lanceolate, acuminate, very acute apex ..... 4
- Tepal not linear-lanceolate, non-acuminate, apex not acute ..... 6
4. Radical leaf 1, ovary ovate ..... 3. *G. vegeta*
- Radical leaves 1–2, ovary cylindrical ..... 5
5. Bulb wide elliptic with reticulate to fibrous tunic, radical leaves 1–4 mm wide ..... 4. *G. commutata*
- Bulb narrow elliptic with reticulate tunic, radical leaves 1–2 mm wide ..... 5. *G. reticulata*
6. Basal bulbils present, radical leaf solitary ..... 7
- Basal bulbils absent, radical leaves 1–2 or 2 ..... 8
7. Plant height 8–11.5 cm, radical leaf 7–12 cm, cauline leaf solitary ..... 6. *G. confusa*
- Plant height 20–23 cm, radical leaf 20–23 cm, cauline leaves 4 ..... 7. *G. chomutovae*
8. Radical leaves 2, without neck sheath ..... 9

- Radical leaves 1–2, with neck sheath ..... 10
- 9. Tepal linear-oblongate ..... 8. *G. luteoides*
- Tepal narrowly elliptic-oblong ..... 9. *G. dubia*
- 10. Tepal oblanceolate to elliptic-lanceolate, apex obtuse or subacute ..... 10. *G. fragifera*
- Tepal narrowly lanceolate or oblong, apex obtuse to rounded ..... 11
- 11. Basal leaves 1–2; lowest leaves equaling to or longer than inflorescence ..... 11. *G. chlorantha*
- Basal leaf 1; lowest leaves shorter than inflorescence ..... 12. *G. uliginosa*

## Discussion

Anatomical characters of basal leaves the genus *Gagea* proved to be useful for delimitation of species (Zarrei *et al.* 2010b). Some of the anatomical diagnostic characters of basal leaves consist of presence or absence of pith (fistulose or non-fistulose), outline of basal leaves on cross-section (some shapes such as pentagonal, triquetrous or flattened), presence or absence of collenchyma, arrangement of vascular bundles (on a row or on a circle).

The three new records of *Gagea bulbifera*, *G. vegeta*, and *G. chomutovae* were described in the Flora Iranica (Wendelbo & Rechinger 1990), Flora of Turkey (Tekşen & Erkul 2015), and the study on the Iranian *Gagea* conducted by Zarrei *et al.* (2010a). These new taxa are classified in the subgenus *Platyspermum* (Wendelbo & Rechinger 1990) of which *G. bulbifera* is a member of sect. *bulbiferae* identified by its diagnostic characters such as single bulbil in axils of bracts (Tekşen & Erkul 2015, Fig. 2F), filiform-linear, non fistulose radical leaves with semicircular shape in cross-section (Fig. 2G). This species grows mainly in the temperate biome, especially Altay, E European Russia, Iran, Kazakhstan, Kirgizstan, N Caucasus, Romania, Transcaucasus, Turkey, W Himalaya, W Siberia, and Xinjiang (POWO 2024). *Gagea vegeta* is a member of sect. *Platyspermum* (Zarrei *et al.* 2011) distinguished by some characters such as flattened or pentagonal basal leaves in cross-section, verticillate cauline leaves and umbellate inflorescence (Tekşen & Erkul 2015), linear-lanceolate and acute-acuminate tepals (Wendelbo 1985). This section further consists of *G. commuata*, *G. reticulata*, and *G. vegeta* in Iraq. *G. vegeta* is diagnosed from other two species of the section by having single basal leaf (versus one or two basal leaves) and short stem (versus long stem). In addition, *G. vegeta* and *G. commuata* are diagnosed from *G. reticulata* by having flattened triquetrous basal leaf in cross-section (versus pentagonal basal leaf). *G. vegeta* native range is Afghanistan, Iran, Kyrgyzstan, Tajikistan, Transcaucasia, and Uzbekistan (Wendelbo & Rechinger 1990, POWO 2024). *G. chomutovae* is a member of sect. *Stipiatatae* diagnosed by having circular and fistulose basal leaf (Tekşen & Erkul 2015, Fig. 4H), elliptic-obovate tepal with acute to obtuse apex (Fig. 4B-D), and 20–23 cm radical leaf length. It grows mainly from southeastern Turkey to Iran, Afghanistan, and Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, and Transcaucasia) (Wendelbo & Rechinger 1990, POWO 2024).

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