

A taxonomic revision of the genus *Glaucium* (Papaveraceae) in Iran

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Abstract – A taxonomic revision of the genus *Glaucium* (Papaveraceae) in Iran is presented. It reveals the presence of 10 species including 4 subspecies and 14 varieties. Two new taxa are described: *G. yazdianum* and *G. vitellinum* var. *pilosum*. *G. yazdianum* is related to *G. calycinum* in general, but is differentiated by shape and cellular structure of trichomes on young fruits and sepals, the shape of filaments and stem leaves and finally the length of siliquae and buds. Pollen and leaf epidermis morphology of these two species are compared, keeping this criterion in mind. *G. pulchrum*, *G. elegantissimum* and *G. goletanicum* are treated here as synonyms of *G. oxylobum*. An identification key to the genus *Glaucium* in Iran and for each taxon a morphological description and notes on their distribution and habitats are presented.

Keywords: *Glaucium*, Iran, new taxa, nomenclature, synopsis, taxonomy

Introduction

Papaveraceae s. str. was formerly divided into four subfamilies: Chelidoniodeae Ernest, Eschscholziodeae Ernest, Papaveroideae Ernest and Platystemonoideae Ernest (Ernest 1962–Kadereit 1993). Later on, Kadereit et al. (1994) included the subfamily of Platystemonoideae in Papaveroideae as well. The monophyly of two groups, Eschscholziodeae and Papaveroideae (including Platystemonoideae), was supported in phylogenetic analyses of Papaveraceae based on a combination of molecular and morphological data by Hoot et al. (1997). *Glaucium* Mill. and *Dicranostigma* Hook. f. et Thoms were also included as a part of Chelidoniodeae while the morphological analysis of Kadereit et al. (1994) represented *Glaucium* and *Dicranostigma* as a sister group to Papaveroideae.

Glaucium is mainly distributed from Atlantic Europe to Central Asia (Kadereit 1993). The genus comprises two sections and 23 species: sect. *Acropetala* Mory with four species, four subspecies and two varieties and sect. *Glaucium* with 19 species, eight subspecies and 16 varieties (Mory 1979). In Iran, it was represented by 11 (Cullen 1966) to 13 (Mobayen 1985; Gran and Sharifnia 2008) species, of these, five are endemics: *G. calycinum* Boiss., *G. contortuplicatum* Boiss., *G. elegantissimum* Mobayen, *G. mathiolifolium* Mobayen and *G. goletanicum* Gran & Sharifnia. *G. vitellinum* Boiss. & Buhse

was reduced to the synonymy of *G. oxylobum* Boiss. & Buhse and *G. calycinum* by Cullen (1966) and Mory (1979), respectively. Mobayen reduced this species to the ranks of variety and subspecies (1985): *G. flavum* Crantz var. *vitellinum* (Boiss. & Buhse) Mobayen and *G. flavum* subsp. *vitellinum* (Boiss. & Buhse) Mobayen, while it was introduced as a distinct species by Gran and Sharifnia (2008). *G. leiocarpum* Boiss. and *G. elegans* Fisch. & C. A. Mey. var. *integerrima* Mobayen were placed as synonymous with *G. flavum* and *G. elegans* var. *elegans*, respectively (Tavakkoli 2016).

Trichomes morphology and their frequency and distribution have shown that they provide valuable characters for delimitation of taxa at sectional level (Vafadar et al. 2010). The structure and shape of trichomes are taxonomically significant for identification of *Glaucium* species as demonstrated by Mory (1979) but have not been studied in Iran so far.

The aims of this paper are to revise different taxa of *Glaucium* growing in Iran and to provide a revised synopsis and a diagnostic key for the genus in Iran.

Materials and methods

Most of the plant specimens were collected during the flowering period from natural populations of central, south

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and north Iran. Deposited herbarium specimens in TARI, IRAN and FAR were also studied. Abbreviations are according to their B. index herbarium. In this study, leaves, stamens, young fruits and buds were collected from individuals in their natural habitats and herbarium dried specimens.

Trichomes were taken from young fruits and sepals. Materials were cleared in 0.1% sodium hypochlorite, stained with 0.1% fuchsine and mounted in glycerin jelly. The shape and cellular structure of about 50–60 trichomes were studied under a light microscope, using a Jenus microscope 32× to 400× magnifications with a Nikon camera.

The mature leaves of each taxon were macerated in 30% KOH for about 3–4 hours. Then leaf epidermis samples were removed from the middle parts of the leaves, stained with 0.1% fuchsine and fixed in glycerin. Mostly three or more leaves were selected for each species and at least 3–5 slides prepared for each taxon. The stomata type, epidermal cells shape and pattern of anticlinal wall, length and width of stomata and stomata density per square millimeter of the leaf surface were recorded by light microscopy.

Pollen grains were prepared by means of the standard method of acetolysis (Erdtman 1986) and mounted on slides in glycerin jelly. Polar (P) and equatorial (E) axes and shape (P/E) of 30–50 pollen grains for each taxon were measured by Jenus microscope.

Measurements of trichomes, pollen grains and stomatal complexes for specimens were obtained using Micro Measure 1.04 software.

The terminology of pollen grains follows Hesse et al. (2009). The terminology of Payne (1978) and Van Cotthem (1970) were used for trichome morphology and leaf epidermis morphology, respectively.

Results

In this paper, 28 taxa of the genus *Glaucium* were recognized: 10 species, 4 subspecies and 14 varieties. As a result of this revision, *G. vitellinum* var. *pilosum* is reported as new for the flora of Iran. *G. yazdianum* is described as a new species from central Iran. *G. pulchrum*, *G. elegantissimum* and *G. golestanicum* are regarded as synonyms of *G. oxylobum*.

Synopsis of the genus *Glaucium* Mill. in Iran

Morphological description of the genus: Annual, biennial or perennial herbs. Stems with corymbose branches. Leaves lobed, pinnatifid or pinnatisect to pinnapartite and sometimes entire. Flowers solitary, axillary or terminal. Sepals 2, caduceous, with or without hair. Petals 4, yellow or orange, reddish orange, dark red, with or without spot. Stamens yellow or orange and numerous; anthers linear to oblong; filaments variable. Ovary linear, tuberculate, hairy or glabrous. Capsules siliquiform, linear to cylindrical, up to 28 cm long, with spongy septum, dehiscent by two valves. Stigma two lobed; lobes divergent, horizontal or curved. Seeds numerous, without appendages.

Identification key to Iranian species of the genus *Glaucium*

1. Capsules dehiscent from base to apex.....*G. elegans*
Capsules dehiscent from apex to base2
2. Ovaries or young siliquae densely pilose, villous or with adpressed or nearly spreading, soft and white hairs3
Ovaries or young siliquae tuberculate or with squamiform hairs or glabrous.....4
3. Sepals 0.5–4 cm long; petals 1–4.5 cm long; fruiting pedicels exceeding the leaves subtending them
.....*G. grandiflorum*
Sepals and petals 1.5–3 cm long; fruiting pedicels shorter than the leaves subtending them*G. corniculatum*
4. Young siliquae tuberculate, papillate or with conical squamiform hairs, occasionally glabrous; sepals 0.5–3 (– 3.5) cm long; petals yellow, reddish orange or deep red, with or without spot5
Young siliquae glabrous or hairy; sepals 1.5–5 cm long; petals yellow, with or without basal orange spot7
5. Stems with densely corymbose branches; sepals 0.5–1.5 (– 1.8) cm long; petals 0.5–1.5 (– 1.8) cm long, yellow, with orange basal spot; siliquae mostly strongly contorted.....
.....*G. contortuplicatum*
Stems without densely corymbose branches; sepals up to 3 cm long; siliquae erect, arcuate or occasionally contorted6
6. Young siliquae densely covered with white tubercles; sepals hairy; petals yellow, reddish orange, with or without violet spot; mature siliquae erect or arcuate, glabrescens or occasionally with remote tubercles.....*G. flavum*
Young siliquae tuberculate, papillate or with conical squamiform hairs or glabrous; sepals mostly glabrous; petals reddish orange, deep red or rarely yellow, with or without spot; mature siliquae arcuate or contorted and thickened at base, glabrescens or hairy*G. oxylobum*
7. Young siliquae glabrous, sometimes with scattered hairs near the apex; sepals up to 5 cm long.....*G. vitellinum*
Young siliquae with squamiform hairs and often all along young siliqua, rarely glabrous; sepals up to 4 cm long8
8. Plants grey or dark grey; stems, branches and pedicels with patent hairs; young siliquae covered with long or very short and adpressed hairs; mature siliquae glabrescens, erect or arcuate*G. mathiolifolium*
Plants green or glaucous; stems, branches and pedicels glabrous; young siliquae often covered with patent hairs, rarely hairs near the apex; mature siliquae hairy or glabrescens, arcuate or sometimes contorted9
9. Sepals up to 4 cm long; petals up to 4.5 cm long; mature siliquae up to 20 cm long, with remote and nearly patent hairs or sometimes glabrescens; fruiting pedicels up to 10.5 cm long*G. calycinum*
Sepals up to 2.5 cm long; petals up to 3.5 cm long; mature siliquae 10–13 cm long, hairy, erect or arcuate; fruiting pedicels up to 6 cm long*G. yazdianum*

1. *G. corniculatum* (L.) Curtis, Fl. Londin. 6: t. 32 (1780) (On-line Suppl. Tab. 1).

Type: Linnaeus 668/4 in Hungaria, Bohemia, Monspeli (Hb).

Synonyms: *Chelidonium corniculatum* L., Spec. Plant. 506 (1753); *G. corniculatum* (L.) Rudolf, Fl. Jen. Pl. 13 (1781).

Description: Biennial herbs, 12–38 cm high. Stems hairy. Stem leaves pinnatisect, semi-amplexicaul. Buds 1.5–3 cm long; sepals villous. Petals 1.5–3 cm long, red, yellow and orange at the base, with or without violet to blackish basal spot and sometimes spots with white margin. Anthers 1.5–3 mm long; filaments monotonic at upper half, broadened at lower part and gradually narrowed towards the base. Young siliquae covered with densely adpressed and white villous. Fruiting pedicels erect, 1.5–5 cm long. Mature siliquae 12–19 cm long, erect or arcuate, covered with semi-adpressed and white hairs; stigma 5–8 mm broad.

Phenology: Flowering in mid-May; with mature fruits in late June to late July.

Distribution and habitats: Europe, Turkey, Iran, Caucasus and Iraq. In fields, roadsides, steppe, weedy stony regions at 350–2000 m a. s. l.

Petals red, with black basal spot..... var. *corniculatum*

Petals yellow, orange at the base, with or without violet to black basal spot..... var. *flaviflorum*

G. corniculatum var. *corniculatum*

Synonyms: *Glaucium phoeniceum* Crantz, Stirp. Austr., ed. 1, 2: 133 (1763); *Chelidonium phoeniceum* Lam., Fl. Fr., 1, 33: 169 (1778); *G. corniculatum* (L.) J. H. Rudolph var. *phoeniceum* (Crantz) DC., Syst. II.,: 97(1821); *G. corniculatum* (L.) J. H. Rudolph var. *tricolor* Loret & Barrandon, Fl. Montp., 2: 22(1886) non Bernh; *G. corniculatum* (L.) J. H. Rudolph b. *braunianum* O. Kuntze, Acta Horti Petrop., 10: 149 (1887); *G. corniculatum* (L.) J. H. Rudolph α. *phoeniceum* var. *pilosum* f. *pinnatifidum* O. Kuntze, 1. c., 147; *G. corniculatum* (L.) J. H. Rudolph var. *purpureum* Reverchon Pl. Andal., (1889); *G. corniculatum* (L.) J. H. Rudolph β. *aurantiacum* Rouy & Fouc., Fl. Fr., 1 –2: 64 (1893–1895).

G. corniculatum var. *flaviflorum* DC. Syst., 2, 97 (1821).

Type: Steven, in litt.

Synonyms: *Glaucium aureum* C. Koch, Linnea, 19: 49 (1846); *G. luteum* Curtis, Fl. Matrit., 114 (1861); *G. corniculatum* (L.) J. H. Rudolph var. *mauritanicum* O. Kuntze, Acta Horti Petrop., 10: 140 (1887); *G. corniculatum* (L.) J. H. Rudolph β. *caricum* (Stapf) O. Kuntze, 1. c. p. 148; *G. corniculatum* (L.) J. H. Rudolph d. *flavum* (Crantz) O. Kuntze, 1. c. p. 148; *G. corniculatum* (L.) J. H. Rudolph δ. *flavum* (Crantz) var. *pilosum* f. *pinnatifidum* O. Kuntze, 1. c. 148.

2. *G. grandiflorum* Boiss. & Huet in Boiss., Diagn. Pl. Or. Nov. Sre 2 (5): 15 (1856) (Fig. 1A; On-line Suppl. Tab. 1)

Type: P. Huet, 7. 1853, Turkey: Erzeroum (P00739101).

Synonym: *G. haussknechtii* Bornm. & Fedde in Engler, Pflanzenr. 40 (IV. 104) 227 (1909).

Description: Herbaceous biennial, 6–40 cm high, with one main stem or more. Stems branched, with moderate to rather dense hairs. Stem leaves pinnatifid or pinnatisect, semi-amplexicaul. Buds 0.5–4.5 cm long; sepals hairy. Petals 1–4.5 cm long, reddish orange or dark yellow, with a violet basal spot or darkish at the base. Stamens numerous; anthers 1–4 mm long; filaments monotonic in upper half, broadened in lower part and gradually narrowed towards the base. Young siliquae covered with densely adpressed or nearly spreading and soft hairs. Fruiting pedicels up to 9 cm long, erect or contorted, hairy. Mature siliquae 6–28 cm long, erect or contorted; stigma 4–9 mm broad.

Phenology: Flowering in late April, with mature fruits in mid-June to late July.

Ecology: Growing in dry stony places and hillsides at 180–2500 m a. s. l.

Siliquae and fruiting pedicels erect or arcuate.....

.....subsp. *grandiflorum*

Siliquae contorted and fruiting pedicels refracted.....

.....subsp. *refractum*

G. grandiflorum subsp. *grandiflorum*

Buds 2–4.5 cm long; petals reddish orange, 2–4.5 cm long..

.....var. *grandiflorum*

Buds 0.5–2 cm long; petals dark yellow, 1–2 cm long.....

.....var. *iranicum*

G. grandiflorum subsp. *grandiflorum* var. *grandiflorum*

Distribution: Distributed in Europe, Turkey, Iran, Caucasus, Iraq, Syria and northern Africa.

G. grandiflorum subsp. *grandiflorum* var. *iranicum* Mory, Feddes Rep. 9–10: 576 (1979).

Type: Haghghi s. n., 5. 8. 1964, Iran: Kurdistan, Boukan (W).

G. grandiflorum subsp. *refractum* (Nab.) Mory, Feddes Rep. 9–10: 580 (1979).

Type: Noe 199, Iraq: Kurdistan; L. Baree s. n., 1852, Iran: Lorestan (syntype: JE00018920).

Synonyms: *Glaucium grandiflorum* Boiss. & Huet var. *hellisopelma* Fedde in Engler, A., Das Pflanzenr., 4, 104: 227 (1909); *G. refractum* Nab., Publ. Fac. Sci. Univ. Masaryk, Brno, 35: 22 (1923); *G. corniculatum* (L.) J. H. Rudolph subsp. *refractum* (Nab.) Cullen, not Roy. Bot. Gard. Edinb., 25: 41 (1963).

Distribution: Turkey, Iran, Caucasus and Iraq.

3. *G. calycinum* Boiss., Ann. Scienc. Nat. ser. 2, 16: 375 (1841) (Figs. 1B; On-line Suppl. Figs. 1M–Q, 2C–D).

Type: Aucher –Eloy 4042 A, Iran: Esfahan (P00739085).

Description: Biennial herbs, 18–40 cm high. Stems branched, glabrous or with sparsely hairs at lower part. Stem leaves entire, pinnatifid or sometimes pinnatisect. Buds 1.5–4 cm long; sepals hairy or sometimes glabrous. Petals 2–4.5 cm

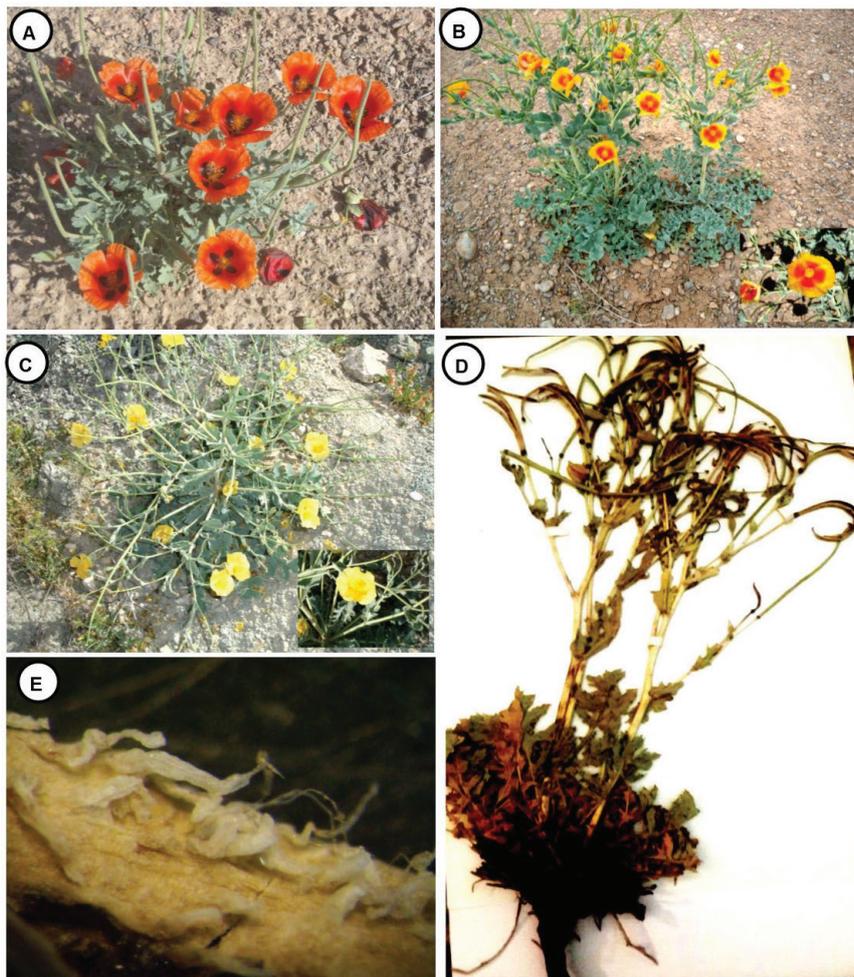


Fig. 1. Photographs of *Glaucium* species. (A) *G. grandiflorum*, (B) *G. calycinum*, (C) *G. mathiolifolium*, (D) *G. yazdianum*, (E) *G. yazdianum*: young siliqua trichomes.

long, yellow and orange at lower part. Stamens numerous; anthers 2–3.5 mm long; filaments broadened at the middle part and narrowed towards the apex and base. Young siliquae with squamiform hairs or sometimes glabrous. Fruiting pedicels up to 10.5 cm long erect or refracted. Mature siliquae up to 20 cm long, erect, arcuate or contorted, with remote and nearly spread hairs or glabrescens; stigma 4–9 mm broad.

Phenology: Flowering in mid-May to mid-June and fruiting in early July to late August.

Distribution and habitats: This endemic species is observed from some localities in central, northern and north-western Iran where it grows on roadsides, hillsides and clayey and bare slopes at 280–2000 m a. s. l.

Mature siliquae erect or arcuate..... subsp. *calycinum*
 Mature siliquae torulose and contorted.....
 subsp. *aserbaidshanicum*

G. calycinum subsp. *calycinum* (On-line Suppl. Tab. 1)

G. calycinum subsp. *aserbaidshanicum* Mory, Feddes Rep. 9–10: 553 (1979) (On-line Suppl. Tab. 1).

4. *G. mathiolifolium* Mobayen, Iran. J. Bot. 2: 166 (1984) (Fig. 1C; On-line Suppl. Tab. 1).

Type: S. Mobayen 9268, 25. 4. 1973, 880 m a. s. l., Iran (TARI).

Description: Biennial herbs, 25–52 cm high, dark grey. Stems branched, hairy. Stem leaves entire or lobed, hairy, semi-amplexicaul. Buds 1.5–2 cm long; sepals hairy. Petals up to 2.5 cm long, yellow and sometimes orange at the base. Stamens numerous; anthers 1.5–3.2 mm long; filaments broadened at the apex, gradually narrowed towards the base. Young siliquae covered with short and long and adpressed hairs. Fruiting pedicels 1.5–2 cm long. Mature siliquae 6–14 cm long, glabrescens and torulose; stigma 3 mm broad.

Phenology: Flowering in late March to early April and fruiting in early May.

Distribution and habitats: This endemic species distributed in southwestern Iran on roadsides, dry clayey and calcareous grounds at 500–950 m a. s. l.

5. *G. yazdianum* Tavakkoli & Assadi sp. nov. (Figs. 1D-E; On-line Suppl. Figs. 1A-F, 2A-B; On-line Suppl. Tab. 1).

Type: Iran. Yazd province: Yazd to Taft and Shirkuh, 1200 m a. s. l., 23 April 1996, Mozaffarian 77379 (holotype TARI!); paratype: Yazd province: Abarkuh, Hossein abad, village, 1400–1600 m a. s. l., 17 June 2015, Zeraatkar 59935 (FAR); (isotype T!).

Diagnose: Biennial. Stems several. Stem middle leaves broadly oblong, pinnatisect; the segments oblong to lanceolate, lanceolate or triangular, decreasing gradually towards the leaf base. Buds 1.5–2.5 cm long (not up to 4 cm); sepals hairy (not with or without hairs). Peduncle 2–6 cm long, erect (vs 1–10.5 cm, erect or refracted). Filaments monotonic at the upper half and narrowed towards the base (vs broadened at the middle and narrowed towards the apex and base). Young siliquae hairy; hairs multicellular and terminally uniseriate, at lower part oblong and elliptic at the base (vs elliptic or elliptic to oblong at lower part). Mature siliquae 10–12 cm long (not up to 20 cm); stigma 6–7 mm broad (not 4–9 mm).

Description: Herbs biennial, 30–35 cm high. Stems erect, several, light green to whitish, branching from 10–15 cm above the base towards the apex, glabrous. Basal leaves 10–18 × 2–6 cm, with rather moderate and crisp flattened hairs on both surfaces, lyrate-pinnatisect to pinnatifid; the lower segments triangular, lanceolate, oblong to lanceolate, entire, acute and with apical hairs; the upper segments oblong, oblanceolate, lobed; lobes ovate to triangular, acute, with apical hairs; the terminal segment trilobed; lobes oblong, bi-tridentate at the apex; petioles 2.5–3 cm long, ribbed, hairy and broadened at the base; stem leaves 1–8 × 0.5–6 cm, glabrous or with scattered to rather dense hairs, sessile, semi-amplexicaul or with short petiole at lower leaves; upper leaves ovate, ovate-oblong, entire, dentate or pinnatifid; lobes triangular, acute and with apical hairs; middle leaves broadly oblong or obovate, pinnatisect; the segments oblong to lanceolate, lanceolate, triangular, entire or dentate, acute and with apical hairs; the size of segments decreasing gradually towards the leaf base; the terminal segment obovate, trifid, mostly with short lobes at the base; lobes ovate, ovate to lanceolate or triangular, acute and with apical hairs; the lower leaves similar to basal leaves. Buds 1.5–2.5 × 0.7–1 cm, ovate, attenuate at the apex; sepals with rather dense and crisped hairs. Petals 2–2.5 × 2–4 cm, yellow and with basal orange spot. Stamens numerous, shorter or longer than ovary; anthers 3–5.2 mm long, cylindrical to oblong; filaments monotonic at the upper half, broadened at the middle part and gradually narrowed towards the base. Young siliquae covered with hair and glabrous at the base; hairs multicellular, multiseriate and terminally uniseriate, flattened and somewhat crisped, 0.48–2.58 mm long. Fruiting pedicels 2–6 cm long, erect. Mature siliquae 10–12 cm long and 2–3 mm in diameter, gradually narrowed towards the apex, hairy; stigma 6–7 mm broad.

Phenology: Flowering occurs in late April to June with fruiting during June–July.

Etymology: The specific epithet refers to the type locality in Yazd province.

Distribution and habitats: *Glaucium yazdianum* is known from central Iran in Yazd province in two populations sites. The locality is considered an element of the Irano-Turanian floristic region. The species grows on hills and flat areas of clay and stone and roadsides at altitudes of 1400–1600 m a. s. l.

Conservation status: *G. yazdianum* has been collected from two localities in Yazd province, Iran. The known area of occupancy is less than 500 km² (criterion B₂) and estimated number of mature individuals is fewer than 2500 (criterion C). Therefore, according to IUCN categories (IUCN 2017) we propose the conservation status of the species as endangered.

Similar species: *G. yazdianum* is similar to *G. calycinum* in habit, petal color and shape of basal leaves, but differs from it by cellular structure, length and shape of trichomes on Young siliquae (Fig. 1E, Online Suppl. Fig. 2A) and sepals (On-line Suppl. Fig. 2B), siliqua and bud length, the shape of stem leaves and filaments (On-line Suppl. Tab. 2, On-line Suppl. Fig. 1B–F). The two species are compared in On-line Suppl. Tab. 2.

Leaf anatomy: The main features of leaf epidermis of the examined species are studied. The shape of epidermal cells on the adaxial and abaxial surfaces is polygonal and nearly irregular with anticlinal walls of straight to curved or nearly undulate in *G. yazdianum* and *G. calycinum*. These two taxa show differences in the length and width of stomata on both surfaces: the average of the stomata size of adaxial surface is 45.84 × 37.2 μm in *G. yazdianum* and 39.4 × 32.48 μm in *G. calycinum*, while on the abaxial surface it is 47.18 × 38.9 μm and 38.2 × 25.27 μm in *G. yazdianum* and *G. calycinum*, respectively. Anomocytic stomatal and anisocytic types occur on the both sides of leaves, which are more numerous on the abaxial side (On-line Suppl. Figs. 4A–D).

Palynology: Pollen grains of *G. yazdianum* and allied species are single, radially symmetrical, isopolar and tricolpate. The shape of pollen grains ranges from sub-prolate in *G. yazdianum* to prolate-spheroidal in *G. calycinum*. The size of pollen grains (polar axis × equatorial axis) is 34.81 (31.4–38.53) × 29.99 (20.08–31.75) μm in *G. yazdianum* and 32.79 (28.82–44.43) × 31.26 (21.82–41.64) μm in *G. calycinum* (On-line Suppl. Figs. 4E–H).

6. *G. contortuplicatum* Boiss., Ann. Scienc. Nat. ser. 2, 16: 376 (1841) (Fig. 2A).

Type: Aucher–Eloy 4042, 1889, Iran: Gilan (type: W0077474).

Description: Herbaceous biennial, 12–50 cm high. Stems pale green to purplish, with dense and corymbose branches. Stem leaves entire, dentate to pinnatifid or sometimes pinnatisect. Buds 0.8–1.7 cm long; sepals glabrous or hairy. Petals 0.8–1.8 cm long, yellow and orange at the base. Stamens numerous; anthers 1–2 mm long; filaments slender and attenuate towards the base. Young siliquae covered with hairs 0.13–0.82 mm long. Fruiting pedicels 1–6 cm long, contorted. Mature siliquae 4.5–18 cm long, with remote hairs or gla-

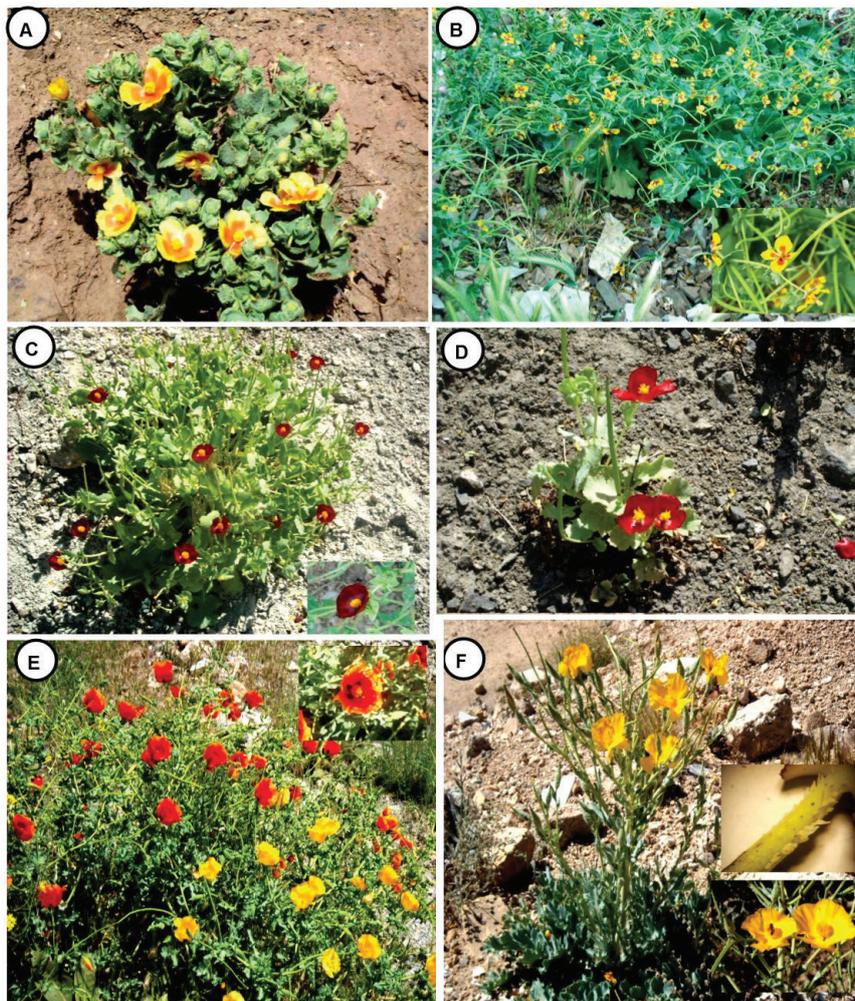


Fig. 2. Photographs of *Glaucium* species. (A) *G. contortuplicatum*, (B) *G. elegans* var. *elegans*, (C), (D) *G. oxylobum*, (E) *G. flavum*, (F): *G. vitellinum* var. *pilosum*.

brescens, torulose, contorted or strongly contorted; stigma 4–7 mm broad.

Phenology: Flowering and fruiting in late May to early July.

Distribution and habitats: Endemic to Iran, distributed in northern, northwestern, central Iran where it grows in fields, on roadside slopes and wet or salty soils at 220–2630 m a. s. l.

Young siliquae hairy at the apexvar. *contortuplicatum*
 Young siliquae totally hairy var. *hirsutum*

Glaucium contortuplicatum var. *contortuplicatum* (On-line Suppl. Tab. 1).

Glaucium contortuplicatum var. *hirsutum* Tavakkoli & Assadi, Nova Biol. Reperta 3: 169 (2016) (On-line Suppl. Tab. 1).

Type: Z. Tavakkoli 54331, 27. 6. 2013, 520 m a. s. l., Iran: Gilan, 95 km Rasht (FAR).

7. *G. elegans* Fisch. & C. A. Mey., Ind. Sem. Hort. Petrop. 1: 29 (1835) (Fig. 2B; On-line Suppl. Tab. 1).

Type: Fischer and Meyer s. n., northern Iran (LE).

Description: Annual herbs, 5–38 cm high, green or glaucous. Stems branched. Stem leaves entire, dentate to lobed or pinnatisect. Buds 6–26 mm long; sepals glabrous or hairy. Petals 11–22 mm long, yellow to orange and with black basal spot. Anthers 1–1.5 mm long; filaments monotonic in upper half and broadened in lower part. Young siliquae hairy. Fruiting pedicels 0.5–4 cm long. Mature siliquae 7–16 cm long, torulose, arcuate or slightly contorted at the apex, with nearly patent hairs; stigma 2 mm broad.

Phenology: Flowering in late April with mature fruits in mid-June to mid-July.

Distribution and habitats: Iran, central Asia, Afghanistan and Pakistan. *G. elegans* is the most widespread species in Iran with a distribution on dry slopes, wet or gypsiferous soils and weedy stony localities at 180–3000 m a. s. l.

Plants covered with hairs; young and mature siliquae hairy
 var. *elegans*
 Plants glabrous; young and mature siliquae glabrous.....
 var. *bornmulleri*

Glaucium elegans* var. *elegans

Synonyms: *G. pumilum* Boiss., Ann., Sc. Nat., 2. Ser., 16: 374 (1841); *G. elegans* var. *integerrima* Mobayen, Fl. Iran, Vas. Pl. 155 (1985).

Glaucium elegans* var. *bornmulleri Fedde, Feddes Rep. 3, 215: (1909).

Type: Bornmuller 6087 b, 13. 6. 1900, 2200 m, northern Iran: Elburz mountain, Shahrestanak valley (type: JE 00018896).

8. ***G. oxylobum*** Boiss. & Buhse, Nouv. Mem. Soc. Nat. Mosc. 12: 12 (1860) (Figs. 2C, D, On-line Suppl. Fig. 3A; On-line Suppl. Tab. 1).

Type: Buhse 1140, 8. 1848, Iran: Radkan (LE 00012800).

Description: Biennial herbs, 5–35 cm high. Stems glaucous, glabrous or hairy at lower part. Stem leaves glabrous or with scattered to moderate hairs, dentate, pinnatifid or sometimes pinnatisect. Buds 1–3.5 cm long; sepals glabrous or sometimes with scattered hairs. Petals 1–4.5 cm long, dark red to violet, reddish orange or sometimes yellow, with or without black middle spot. Stamens numerous; anthers 1–4 mm long; filaments broadened at the apex, gradually attenuate towards the middle and base. Young siliquae with tubercles, papillose, tubercles narrowed at the apex, conical hairs or glabrous; trichomes at the apex or all along young siliqua. Fruiting pedicels 1–6 cm long, erect or contorted. Mature siliquae 8–28 cm long, strongly thickened at the base, erect, arcuate or contorted, with remote and nearly patent hairs or glabrous; stigma 3–10 mm broad.

Phenology: Flowering in late April to early June and fruiting in mid-June to late July.

Young siliquae glabrous; mature siliquae up to 15 cm long..
 var. *paucilobum*

Young siliquae covered with tubercle or hair; mature siliquae up to 28 cm long var. *oxylobum*

Glaucium oxylobum* var. *oxylobum

Synonyms: *G. pulchrum* Stapf, Donkschr. Akad. Wiss. Wien Math. -Nat. Kl., 51: 295 (1886)

syn. nov.

Type: T. Pichler, 23. 4. 1882, northern Iran: Rostamabad (syntype: WU0067323); T. Pichler s.n. 1882, northern Iran: Pachonar (syntype: WU0067324). *G. elegantissimum* Mobayen, Iran J. Bot. 2: 163 (1984) **syn. nov.** **Type:** T. Hewer, 3834, 22. 5. 1976, 650 m a. s. l., Iran: Golestan: 22 km Marave Tappeh on road to Gonabad (TARI). *G. golestanicum* Gran & Sharifnia, Iran, J. Bot. 14: 26 (2008) **syn. nov.** **Type:** A.

Gran 44265, 15. 4. 2006, 153 m a. s. l., Iran: Golestan, Marave Tappeh to Gonabad, Chad zone (TARI).

Distribution and habitats: Distributed in Europe, Iran and Central Asia. This taxon is found in north, northeastern and central Iran in the semi-desert zone, on clayey slopes, stony mountains, hillsides and on the wet or gypsiferous soils at 180–2740 m a. s. l.

Glaucium oxylobum* var. *paucilobum (Freyn) Parsa, Fl. Iran, 2: 444 (1986).

Type: –Sintenis, P. E. E., Turkmenistan: Kisil Arwat, Karakaia, Joldere valley (LE 00018946).

Synonym: *G. paucilobum* Freyn, Bull. Herb. Boiss. ser. 2, 3: 366 (1903).

9. ***G. flavum*** Crantz, Stirp. Austr., ed. 1, 2: 133 (1763) (Fig. 2E, On-line Suppl. 3B–D).

Type: Anon. s. n. (Lectotype LINN–668–3).

Synonyms: *Chelidonium glaucium* L., Sp. Pl., ed. 1: 506 (1753); *G. luteum* Scop., Fl. Carn., ed. 2, vol. 1: 369 (1772); *G. leiocarpum* Boiss., Fl. Or. 1: 122 (1867).

Description: Biennial herbs, 28–65 cm high. Stems whitish, glabrous and branched. Stem leaves pinnatifid to pinnatisect. Buds 0.8–3 cm long; sepals covered with crisped hairs or sometimes glabrous. Petals 1.5–4.5 cm long, yellow, yellow to orange, orange red, with or without spot. Stamens numerous; anthers 1–3 mm long; filaments broadened at the apex and gradually narrowed towards the base. Young siliquae covered with white tubercles at over most of length or upper part. Fruiting pedicels 1–5 cm long, erect. Mature siliquae 8–19 cm long, glabrescent or sometimes with remote and white tubercles, torulose or not, erect or arcuate; stigma 2.5–5.5 mm broad.

Phenology: Flowering in late May with mature fruiting in mid-June to mid-August.

Distribution and habitats: Europe, Turkey, Iran, Caucasus, Syria and northwestern Africa in roadsides, clayey and rocky slopes and hillsides at 1350–3100 m a. s. l.

The varieties of this species have been described on the base of flower color:

Petals yellow and without spot..... var. *flavum*

Petals yellow and orange at lower part or reddish orange, with violet basal spot and spot, with or without yellow margin..... var. *serpieri*

Glaucium flavum* var. *flavum (On-line Suppl. Tab. 1).

Glaucium flavum* var. *serpieri (Heldreich) Halacsy, Consp. Fl. Graec., 1: 41 (1901) (On-line Suppl. Tab. 1).

Type: Heldreich s. n., Greece, Attica in Surrotimis Lanruz (Laurium) (K 000653298).

Synonym: *G. serpiery* Heldreich, In: Regel, Gartenfl., 22: 323 (1873`).

10. *G. vitellinum* Boiss. et Buhse, Fl. Or. 1: 122 (1867) (Fig. 2F)

Type: Buhse s. n., Iran: Yazd (type: P00739088).

Synonyms: *G. flavum* var. *vitellinum* (Boiss. & Buhse) Mobayen, Fl. Iran, Vac. Pl. 158 (1985) nom. inval.; *G. flavum* subsp. *vitellinum* (Boiss. & Buhse) Mobayen, Fl. Iran, Vasc. Pl. 168 (1985,) nom. inval.

Description: Herbaceous biennial, 27–75 cm high, stems glaucous or whitish, glabrous or with scanty hairs on lower part, branched. Stem leaves dentate, pinnatifid to pinnatisect. Buds 1.5–5 cm long; sepals with or without hair. Petals 2–3.5 cm long, yellow, luteous, with or without orange basal spot. Stamens numerous; anthers 2–4 mm long; filaments broadened at the apex and gradually narrowed towards the base, sometimes broadened at the lower part. Young siliquae glabrous or sometimes hairy. Fruiting pedicels 1–10 cm long, erect. Mature siliquae 8–24 cm long, glabrous or sometimes with scattered and short hairs; stigma 5–9 mm broad.

Phenology: Flowering and fruiting occurs in May–July.

Distribution and habitats: *G. vitellinum* is distributed in Fars, Yazd, Kerman and Hormozgan provinces, Iran. It is an Irano-Turanian and Sahara–Sindian geoelement and grows in clayey and stony flat areas, on roadsides and on dry hills at altitudes of 500–2200 m a. s. 1.

Young and mature siliquae glabrous var. *vitellinum*
Young and mature siliquae hairy at the apex var. *pilosum*

Glaucium vitellinum var. *vitellinum* (On-line Suppl. Tab. 1).

Glaucium vitellinum var. *pilosum* Tavakkoli & Assadi var. nov. (On-line Suppl. Figs. 1G–L, 3E–F).

Holotype: Iran. Fars province. 30 km on the road from Firoozabad to Gheer, 1260 m a. s. l., 23 April 2005, Safavi 87623 (TARI!).

The distinctive feature of the variety is the occurrence of hairs on the young siliquae near the apex. We observed the specimens of var. *pilosum* along with type variety in a population.

Discussion

This study documents the occurrence of 10 species, 4 subspecies and 14 varieties belonging to the genus *Glaucium* that have been found in Iran. Some of the species are synonymous (*G. pulchrum*, *G. golestanicum* and *G. elegantissimum*). Two new taxa are recognized, including one new species (*G. yazdianum*) and one new variety (*G. vitellinum* var. *pilosum*). *G. fimbriigerum* is not found in Iran. The taxonomically most valuable characters in the genus are: the shape and cellular structure of trichomes on young fruits and sepals, the shape of stem leaves and filaments, the length of siliquae, anther and buds (On-line Suppl. Tab. 2).

G. corniculatum subsp. *refractum* (Nab.) Cullen with refracted fruiting pedicels and contorted siliquae was reported from western Iran (Cullen 1966). One of the diagnostic characteristics of *G. corniculatum* is fruiting pedicels that are shorter than their subtended leaves while a reported speci-

men in Flora Iranica (Farahbakhsh 5956; deposited in IRAN herbarium) has fruiting pedicels longer than their subtended leaves as *G. grandiflorum*. Hence, similar to Mory's view, *G. grandiflorum* subsp. *refractum* (Nab.) Mory is used.

G. haussknechtii was described as a distinct species possessing numerous short stems (up to 15 cm long). Based on a study of herbarium and collected materials (deposited in TARI, FAR and IRAN) (Cullen 1966) we observed some specimens with a main stem and a height up to 15 cm long and plants with numerous stems with a height of 22–28 cm. Therefore, our studies support Mory's hypothesis that *G. haussknechtii* is a synonym of *G. grandiflorum*.

Regarding *G. yazdianum*, micromorphological characters including stomata size and the shape and size of pollen grains inform the separation of this species from *G. calycinum*.

The main characteristics of *G. oxylum* have been reported to be: ovaries tuberculate–papillate and petals yellow (Cullen 1966); ovaries (young siliquae) with tubercles narrowed at the apex and petals dark red to violet (Boissier 1867); ovaries with conical hairs and petals pale red with black basal spot (Mory 1979).

G. pulchrum Stapf was separated from *G. oxylum* by its height up to 20 cm long (vs up to 50 cm) and glabrous sepals (vs hairy sepals) and dark red–violet petals (vs yellow) as well as by siliquae covered with patent and short hairs (vs tuberculate–papillate or glabrescens) by Cullen (1966). Mory (1979) described this species with a height up to 20 cm long and pale red petals with a black basal spot and ovaries covered with bristles 0.5–1 mm long and siliquae with a length of up to 15 cm long.

G. paucilobum Freyn was reported as a distinct species that is glabrous in all parts and has petals that are yellow in dry stage (Cullen 1966).

G. elegantissimum with glabrous siliquae and dilute red petals and *G. golestanicum* possessing hairy siliquae and red petals with a black basal spot and maculate leaves were accepted as new species by Mobayen (1985) and Gran and Sharifnia (2008), respectively. Our observations on the type materials showed that both species have tuberculate young siliquae and orange red petals with a black middle spot.

Based on field observations and studies of many herbarium specimens, we found many intermediate forms that had a height up to 20 cm long or more. In all of these specimens, young siliqua trichomes were tubercular or tubercles narrowed at the apex or a triple indumentum consisting of conical hairs mixed with tubercles and tubercles narrowed at the apex. They had dark red or reddish orange petals (with or without spot) or yellow and glabrous sepals (rarely hairy). Mature siliquae were glabrescens or with nearly spreading hairs with the length of 8–28 cm, strongly thickened at the base and erect, arcuate or contorted. On the other hand, plants with glabrous ovary and siliqua were found in the populations of *G. oxylum*.

Based on the mentioned variations, the specimens of *G. oxylum* fall into two groups with respect to young siliqua

indumentum, which is either glabrous or hairy with petal color variations in each group. Hence, the separation of the species *G. pulchrum*, *G. elegantissimum* and *G. golestanicum* from *G. oxylobum* is not possible and we suggest their synonymy with *G. oxylobum* here. We agree with Parsa's suggestion (1986) to regard *G. paucilobum* as a variety of *G. oxylobum*.

Diagnostic characteristics of *G. fimbriigerum* Traut & Buhse are maculate orange petals and sepals with the length of 20 mm long and they possess long and adpressed hairs on the siliquae (Cullen 1966). A detailed examination of the species *G. fimbriigerum* (deposited in W herbarium-No. 0004645-Afghanistan: Chord Kabul, 2070 m, 6. 8. 1951, Gilli 866) with a particular focus on the trichome cellular structure of young siliquae, provides strong support for the proposal that this species has not been found in Iran so far.

Glaucium vitellinum was mainly characterized by glabrous siliquae (young siliquae) and yellow petals from Yazd (Boissiera 1867). Among investigated herbarium specimens, we recognized the specimens of the genus *Glaucium* with glabrous or sometimes hairy siliquae and buds. They had yellow petals and with or without orange basal spot. Filaments were broad at the apex (sometimes at lower part) and gradu-

ally attenuate towards the base but abruptly narrowed below the anthers. Sometimes these specimens were observed on a single sheet together. On the other hand, we encountered individuals that had either glabrous or hairy siliquae in a single population in the fieldwork in Fars and Yazd provinces. Buds of these specimens were glabrous or hairy and they possessed yellow petals, with or without orange basal spot. Thus we regard the specimens with hairy siliquae as a new variety as *G. vitellinum* var. *pilosum*. Mory (1979), Cullen (1966) and Mobayen (1985) respectively reduced *G. vitellinum* as a synonymy of *G. calycinum*, *G. oxylobum* and the variety of *G. flavum*. Although hairy or glabrous siliquae were observed among the members of the species *G. calycinum*, *G. oxylobum* and sometimes *G. flavum*, the morphological and micro-morphological investigations of trichomes reveal clear differences among the mentioned species and *G. vitellinum*. Although *G. flavum* and some of the specimens of *G. oxylobum* have tubercular trichomes on their young siliquae, the trichome micro-morphological characteristics of *G. vitellinum* var. *pilosum* (on young siliquae and sepals) show considerable differences from the other species of *Glaucium* here (On-line Suppl. Tab. 2, On-line Suppl. Figs. 2A–D, 3A–F). *G. vitellinum* is also characterized by the shape of its leaves and filaments (On-line Suppl. Tab. 2, On-line Suppl. Figs. 1G–L).

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