

MICRO-MACROMORPHOLOGICAL STUDIES OF THE GENUS *GLAUCIUM* (PAPAVERACEAE) IN IRAN

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In this study, fourteen species of *Glaucium* Mill. were studied and morphological and micro-macromorphological characters were evaluated. The understudied species assessed by biometric study, and about 28 qualitative and 37 quantitative characters were assessed. Phenetic analysis was carried out using SPSS software, and phenograms of these species were prepared. Furthermore, PCA analysis was carried out and the most variable characters were determined. Finally, the seeds and pollen grains of these species were also investigated using S.E.M electronic microscope, and the tables of characters were formed individually for them. Afterward, phenetic analysis and phenogram preparation were done based on morphological characters of seeds and pollen of the species, and the following results were obtained:

1. Distinction of *G. leiocarpum* Boiss., as a distinct species from *G. oxylobum* Boiss. & Buhse in contrary to what mentioned in Flora Iranica. 2. Synonymy of *G. oxylobum* subsp. *rechingeri* Mory, with the type variety. 3. Synonymy of *G. haussknechtii* Bornm. & Fedde. with *G. grandiflorum* Boiss. & Huet. 4. Introduction of a new species named *G. golestanicum* Gran & Sharifnia. 5. Preparation of the table of characters for pollen and seeds of all taxa.

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Keywords. *Glaucium*, *Papaveraceae*, Micro-macromorphology, phenetic analysis, taxonomy, Iran.

مطالعه میکرو-ماکرومورفولوژی گونه‌های جنس لاله کوهی (*Glaucium* Mill.) در ایران

افسانه گران

فریبا شریف‌نیا،

در این مطالعه ۱۴ گونه از جنس *Glaucium* Mill. مورد مطالعه و بررسی مورفولوژیکی و میکرومورفولوژیکی قرار گرفت. کلیه این گونه‌ها مورد مطالعه بیومتری قرار گرفتند و تعداد بیست و هشت صفت کیفی و سی و هفت صفت کمی مورد سنجش قرار گرفت. آنالیز فنتیکی با استفاده از نرم افزار SPSS انجام شد و فنوگرام گونه‌ها تهیه گردید. همچنین آنالیز P.C.A انجام گرفت و متغیرترین صفات مشخص شدند. در نهایت دانه و گرده‌های این گونه‌ها مورد بررسی با میکروسکوپ الکترونی S.E.M قرار گرفت و جدول صفات جداگانه‌ای برای آنها تشکیل شد، سپس آنالیز فنتیکی و تهیه فنوگرام بر اساس صفات مورفولوژی دانه و گرده گونه‌ها انجام شد و نتایج زیر به دست آمد:

۱. جدا شدن آرایه *G. leiocarpum* Boiss. به عنوان یک گونه مستقل و جدا از گونه *G. oxylobum* Boiss. & Buhse بر خلاف آنچه که در فلورا ایرانیکا آمده است.

۲. مترادف قرار دادن *G. oxylobum* subsp. *rechingeri* Mory با زیر گونه تیپ.

۳. مترادف قرار دادن *G. haussknechtii* Bornm. & Fedde. با *G. grandiflorum* Boiss. & Huet.

۴. معرفی گونه جدید به دنیا با نام علمی *G. golestanicum* Gran & Sharifnia.

۵. تهیه جدول خصوصیات گرده و دانه کلیه آرایه‌ها.

Introduction

The genus *Glaucium* Mill. belongs to *Papaveraceae* family and consists of 25 species, annuals, biennials and perennials. They grow in middle and South West Asia and Europe (Burnie et al. 2004). The basic chromosomal number for them is $x = 6$ (Goldblatt & Johnson 2003). This genus consists of herbaceous plants. Cullen (1966) in Flora Iranica area recognized 11 species, 10 of which occurring in Iran, one including two subspecies. Mobayen (1984) described two new species, namely *G. elegantissimum* Mobayen and *G. mathiolifolium* Mobayen. Later on Mobayen (1985) in Flora of Iran, vascular plants apparently recognized 14 species in Iran, several of them including subspecific taxa. He described apparently three invalid subspecific taxa, *G. elegans* Fisch. & C. A. Mey. subsp. *integerrimum* Mobayen, *G. flavum* Crantz var. *vitellinum* Mobayen, comb. nov. (*G. vitellinum* Boiss. & Buhse) and *G. fimbrilligerum* subsp. *ophycarpum* Mobayen.

In this paper, Micro-macromorphological data was subjected to cluster analysis in order to indicate the species inter-relationship, to evaluate the previous taxonomic treatment of the genus *Glaucium* in Iran, and to provide the evidence for efficacy of micro-macromorphological data in taxonomic treatment of the genus *Glaucium*.

Materials and methods

In order to study morphological characters of plant specimens in each species (at least 3 specimens), we selected about 37 quantitative and 28 qualitative characters. The table of morphological characters was prepared based on these qualitative characters. For statistical analysis, we initially encoded the qualitative characters according to the multi-state method, and the related means were considered for quantitative characters, and then these were standardized. Phenetic analysis was carried out using SPSS, ver. 9 software and Ward method (Norusis 1999). Based on this method, we prepared a phenogram of the species and then hierarchical phenograms of the species were prepared. PCA analysis was performed. For morphological study of pollen grains and seeds, we used herbarium and fresh materials in the field (table 1). Pollen grains and seeds were stabilized on aluminum stocks and coated with a thin layer of gold using coating equipment. Then, the specimens were observed under S.E.M. electronic microscope, model XL 30 at the Tarbiat Modarres University. For each species, about 3 specimens of pollen grains and seeds were studied, and finally the related images and tables of morphological characters of pollen grains and seeds

were prepared. Moore et al. (1991) was used for the terminology of the pollen as a reference and Flora of the U.S.S.R. (Komarov et al. 1937) was used for the terminology of the seeds.

Results and Discussion

According to the phenogram, (fig. 1) in the linkage distances 15.96, two clusters are distinguishable. The first cluster, is divided into two sub clusters, one is larger than the other and including several branches. Smaller sub cluster consists of two taxa, *G. flavum* var. *flavum* and *G. flavum* var. *vitellinum*. In the large sub cluster *Roemeria refracta* is located between the two sub clusters, also *G. paucilobum* and the newly described species *G. golestanicum* are located close to each other. Furthermore, two species of *G. grandiflorum* and *G. haussknechtii* are located adjacent to each other. *G. oxylobum* and *G. leiocarpum* were regarded as synonyms in Flora Iranica (Cullen 1966) are located on different branches. *G. pulchrum* and *G. corniculatum* subsp. *corniculatum* are located adjacent to each other. In the second cluster *G. elegans*, *G. elegans* subsp. *integerrimum* and *G. elegantissimum* are near together.

The ordination of the species based on PCA is also compatible highly with the related phenogram (fig. 1). *G. grandiflorum* and *G. haussknechtii* are overlapped, because they are similar together in all of morphological characters.

In order to study relationship among the species based on pollen morphology, (figs. 4-6) the cluster analysis under Ward method and based on understudied characters was performed and the result is delineated in fig. 2.

According to this phenogram, in the linkage distance 15, two clusters are observed. The first cluster includes two sub clusters 1 and 2. In the first sub cluster there are several branches, *G. grandiflorum* and *G. haussknechtii* are located adjacent to each other, nearly compatible with the morphological phenogram. *G. paucilobum* and *G. golestanicum* are located on different branches. *G. oxylobum* and *G. leiocarpum* are located far from each other on different branches, similar to morphological phenogram.

In the second sub cluster *Roemeria refracta* is located, compatible with morphological phenogram. The second cluster consists of two sub clusters. The first sub cluster consists of *G. contortuplicatum* and *G. pulchrum* and the 2nd sub cluster including *G. elegans* and *G. elegantissimum*.

According to the table of morphological characters of pollen grains (table 2), *G. fimbrilligerum*, *G. fimbrilligerum* subsp. *ophycarpum*, *G. leiocarpum*, *G. corniculatum* subsp. *refractum* and *G. flavum* in the

Table 1. *Glaucium* species, their localities and voucher specimens in pollen and seed studies.

Species	Locality
<i>G. calycinum</i> Boiss.	Esfahan: Esfahan to Shahreza, 1700 m, Iranshahr 5796- IRAN.
<i>G. contortuplicatum</i> Boiss.	Azerbaijan: Mianeh to Khalkhal, 1500 m, Izadyar 31816- IRAN; Gorgan: Touskestan, after Chaharbagh, 2259 m, Gran 4010- AUNT.
<i>G. corniculatum</i> subsp. <i>corniculatum</i> (L.) Rudolph	Azerbaijan: Uromieh Lake, Kaboood Island, 1320 to 1580 m, Moussavi & Zargani 31822- IRAN.
<i>G. corniculatum</i> subsp. <i>refractum</i> (Nab.) Cullen	Kermanshah: Ghasr e Shirin, Sharif 31826- IRAN.
<i>G. elegans</i> Fish. & Mey.	Khorasan: Bojnurd to Esfarayen, Gardaneh Primous, 1300 to 1400 m, Termeh 5752- IRAN; Gorgan: Golestan National Park, 1076 m, Gran 4001- AUNT.
<i>G. elegans</i> subsp. <i>integerrimum</i> Mobayen	Azerbaijan: Mianeh to Kivi, North of Tap Ghara, 1200 to 1250 m, Termeh, Moussavi & Habibi.
<i>G. elegantissimum</i> Mobayen	Semnan: Momen Abad, 1200 to 1350 m, Termeh & Zargani
<i>G. fimbrilligerum</i> Boiss.	Mazandaran: Chalous to Karaj, Pol-e-Zanguleh, 2250 m, Pabot 31848- IRAN.
<i>G. fimbrilligerum</i> subsp. <i>ophycarpum</i> Mobayen	Mazandaran: Marzan Abad to Valash (Valasht), 600 to 700 m, Termeh, Matin & Tehrani 31849- IRAN.
<i>G. flavum</i> Crantz var. <i>flavum</i>	Fars: 54 Km North of Shiraz, 1650 to 1690 m, Pabot 5802- IRAN.
<i>G. flavum</i> var. <i>vitellinum</i> (Boiss. & Buhse) Mobayen	Hormozgan: Said Abad to Chah e Chaghok, Reching, Esfandyari & Aellen 5790- IRAN.
<i>G. grandiflorum</i> Boiss. & Huet	Azerbaijan: Tabriz, Sivan, Damanabi 5781- IRAN; Tehran: Sorkkeh hesar, 1332 m, Gran 4002- AUNT.
<i>G. haussknechtii</i> Bornm. & Fedde	Kermanshah: Ghasr e Shirin, Sharif 5808- IRAN.
<i>G. leiocarpum</i> Boiss.	Tehran: Damavand, Absard, Sabzevari 5788- IRAN.
<i>G. oxylobum</i> Boiss. & Buhse	Ardebil: 7 Km South of Alireza Abad, Ghare Aghaj (Dasht e Moghan), 600 m, Iranshahr 5804- IRAN; Gorgan: Golestan National Park, 1079 m, Gran 4006- AUNT.
<i>G. paucilobum</i> Freyn	Gorgan: Maraveh Tappeh to Gonbad, Chad zone, 153 m, Gran 4011- AUNT.
<i>G. pulchrum</i> Stapf	Ardebil: Pars Abad to Bileh Savar, 90 m, Iranshahr 31854- IRAN.
<i>G. golestanicum</i> Gran & Sharifnia	Gorgan: Maraveh Tappeh to Gonbad, Chad zone, 153 m, Gran 44265- IRAN.
<i>Roemeria refracta</i> DC.	Mazandaran: Hezarjarib to Sefidchah, 1137 m, Gran 4012- AUNT.

first branch (of the first sub cluster in the first main cluster) have similar pollen specifications including similarity in the ornamentation of pollen surface, ornamentation of colpi and orbital pollen shape. *G. paucilobum* is different in the ornamentation of pollen surface, thus located far from the other taxa.

In the second branch *G. corniculatum* subsp. *corniculatum*, *G. oxylobum*, *G. golestanicum* and *G. calycinum* are near together, they have similarity in ornamentation of pollen surface, ornamentation of colpi and orbital pollen shape.

In the third branch, *G. elegans* subsp. *integerrimum* and *G. flavum* var. *vitellinum* bear common characters on the ornamentation of pollen surface, ornamentation of colpi, colpi position and orbital pollen shape.

In the fourth branch *G. grandiflorum* and *G. haussknechtii* are near together and they have common characters on the ornamentation of pollen surface,

ornamentation of colpi, colpi position and orbital pollen shape.

In the second sub cluster (in the first main cluster), *Roemeria refracta* has basic differences in pollen characters, therefore occurs on a single branch between the two main clusters.

In the second main cluster, there are two sub clusters (sub cluster 1 and 2). In the first sub cluster, *G. contortuplicatum* and *G. pulchrum* have common characters on the ornamentation of pollen surface, colpi position and orbital pollen shape and in the second sub cluster *G. elegans* and *G. elegantissimum* have common characters on the ornamentation of colpi and orbital pollen shape.

The ordination of species based on PCA is also comparable highly with the pollen morphological phenogram (fig. 2).

Table 2. Pollen characters in *Glaucium* species.

NO.	Characters	Numerical code
1	Length of polar axis (P)	µm
2	Diameter of equatorial axis (E)	µm
3	P/E Ratio	In.no
4	Colpi length	µm
5	Apocolpium length	µm
6	Mesocolpium length	µm
7	Diameter of ornamentation pore	µm
8	Diameter of microechinatus	µm
9	Ornamentation of surface in pollen grains	0- Regularly microechinate 1-Irregularly microechinate
10	Colpi position	0- Open 1- Close
11	Ornamentation of colpi surface	0- Regularly microechinate 1-Irregularly microechinate
12	Orbital shape of pollen grain	0- Prolate 1- Hemispher
13	Pollen shape	0- Unlayered 1- Layerd

The seed morphology of *Glaucium* species were studied (figs. 7-11). Cluster analysis using Ward method and based on understudied seed characters was also carried out. The result of these analyses is shown on phenogram 3.

According to this phenogram in the linkage distance 23.15, two main clusters are observed. The first cluster includes two sub clusters which in the first sub cluster *G. corniculatum* subsp. *corniculatum*, *G. corniculatum* subsp. *refractum*, *G. contortuplicatum*, *G. grandiflorum* and *G. leiocarpum* are close together. In the second sub cluster *G. fimbrilligerum* subsp. *ophycarpum*, *G. paucilobum*, *G. fimbrilligerum*, *G. elegantissimum*, *G. elegans* and *G. elegans* subsp. *integerrima* are close to each other.

The second cluster includes two sub clusters which in the first sub cluster *G. pulchrum*, *G. golestanicum*, *G. haussknechtii*, *G. oxylobum*, *G. calycinum*, *G. flavum* and *G. flavum* var. *vitellinum* are located. In the second sub cluster there is *Roemeria refracta*.

Comparing to table 3, *G. corniculatum* subsp. *corniculatum* and *G. corniculatum* subsp. *refractum* are near together, they have common characters in seed shape, raphe shape, hilum shape and inner surface ornamentation of seeds. *G. contortuplicatum*, *G. grandiflorum* and *G. leiocarpum* have common characters in hilum, raphe and seed shape, therefore they are located adjacent to each other. *G. paucilobum* and *G. golestanicum* are located far from each other on different branches. *G. flavum* and *G. calycinum* have common characters in seed shape, hilum and inner

surface ornamentation of seeds. *G. oxylobum* and *G. leiocarpum* differs in many characters and located on different clusters. *Roemeria refracta* is located in one branch distinctly, it has different characters in seed.

Based on habit, pollen and seed morphology the specimen Gran 44265 clearly differs from the other species therefore is described as a new species.

***Glaucium golestanicum* Gran & Sharifnia, sp. nov.**

Typus. Iran. Golestan: Maraveh Tappeh to Gonbad, Chad zone, 37°52'N, 55°45'E, 153m, A. Gran 44265 (holotypus, TARI; isotypus, IRAN).

Planta biennis vel perennis, viridis vel flavovirens, 4.5-18.5 cm alta. Caules 1-3, 1-4 mm diametro, erecti, ad basis pilosi, supra sparsim pilosi vel glabri. Folia basalia 5-19 cm longa, 1.2-6.5 cm lata, lyrata vel pinnatisecta, lobis irregulariter dentatis, petiolata, sparsim pilosa. Folia caulina 0.7- 6,5 cm longa, 0.4-3.8 cm lata, pinnatisecta, sessilia, auriculata, in pagina superiore purpureo-maculata, pilosa. Alabastra usque ad 3.9 cm longa et 1.2 cm lata, ovata, acuta, glabra vel sparsim pilosa. Pedicelli 0.2-2.2 cm longi, erecti vel vix arcuati, glabri, 2-22 mm longi, 1-2 m diametro. Pedicelli fructiferi 10-62 mm longi, 1.5-3.5 mm diametro. Sepala ovata, 8-29 mm longa, 4-11 mm diametro, acuta vel vix obtusa, ad marginem membranacea, flovavirens. Petala orbicularia vel elliptica, 15-45 mm longa, 12-38 mm lata, ad bases maculis nigris persistentibus. Stamina numerosa; filamenta filiformes, flava; anthera elliptica, aurantiaca. Stigma flava. Fructus 30-170 mm longus, 1.5-3 mm diametro, erectus vel vix arcuatus, glaber sed sursum apicem sparse pilosa. Semina numerosa, reniformia, reticulata.

Plant biennial or perennial, green to greenish-yellow, 4.5-18.5 cm. high. Stems 1-4 mm in diameter, erect. Radical leaves lyrate-pinnatisect, petioled, with dentate lobes, scattered hairy. Stem leaves elliptic, pinnatisect, sessile, auriculate at base; lobes crenate with bristles on the teeth; upper surface of leaves with purple blotches. Flower bud ovate, 7-39 mm long, 2-12 mm wide. Pedicel erect to slightly arcuate, glabrous, 2-22 mm long, 1-2 mm in diameter. Fruiting pedicle erect, 10-62 mm long, 1.5-3.5 mm in diameter. Sepal ovate, membranous along the margins, acute to slightly blunt, green-yellowish, glabrous, 8-29 mm long, 4-11 mm in diameter. Petal orbicular to elliptic, red, with flame shape basal spot, 15-45 mm long, 12-38 mm wide. Stamens numerous; filament filiform, yellow; anther elliptic, orange. Stigma arrow shape, yellow. Fruits 30-170 mm long, 1.5-3 mm in diameter, slender toward the apex, dehiscing from summit to base, erect to slightly

Table 3. Seed characters in *Glaucium* species.

NO.	Characters	Numerical code
1	Seed length (L)	µm
2	Seed width (W)	µm
3	Seed L/W	In. no
4	Seed shape	0- Obtuse reniform; 1- Acute reniform 2- 0 & 1
5	Raphe shape	0- Linear; 1- Projection linear; 2- Sunken linear
6	Hilum shape	0-Elliptic; 1- Rounded; 2- Tear shape
7	Inner surface ornamentation of seed	0- Undulate linear; 1- Smooth; 2- Undulate reticulate; 3- Gemmate; 4- Micro- gemmate
8	Seed Surface	0- not scale like; 1- Scale like

Table 4. Micro- macro morphological comparison of *Glaucium paucilobum* and *G. golestanicum*.

Characters	<i>G. paucilobum</i>	<i>G. golestanicum</i>
Purple blotch on leaves	Not present	Present
Hairs of ovary	Not present	Present (Multicellular)
Grooves on pedicel	Present	Not present
Shape of pedicel in cross section	Elliptic	Rounded
Number of vascular bundles in pedicel	Two rows	One row
Colpi ornamentation of pollen grain	Irregularly microechinate	Regularly microechinate
Polar axis length of pollen grain (µm)	15.9	28.85
Equatorial diameter of pollen grain (µm)	10.4	25.6
Mesocolpium (µm)	6.27	11.95
Pit diameter of pollen grain (µm)	0.103	0.298
Inner seed surface ornamentation	Smooth	Undulate
Seed length (µm)	1405	524
Seed width (µm)	941	509

arcuate, glabrous, toward the apex with scattered hairs. Seed numerous, reniform, reticulate.

Distribution and habitat. The new species is endemic to northeast of Iran, Golestan province with a limited distribution. It was collected on clay and disturbed soils at the margin of the road. The area dominated by *Calendula* sp. (*Asteraceae*) and *Hordeum marinum* (*Poaceae*).

Relationships. *Glaucium golestanicum* is closely related to *G. paucilobum*, which is distributed in Northeast Iran (Cullen 1966). The two species are compared in table 4.

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Dendrogram using Ward Method

Rescaled Distance Cluster Combine

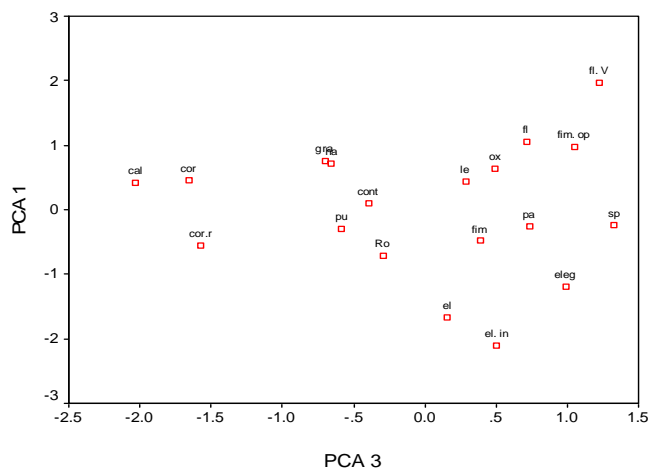
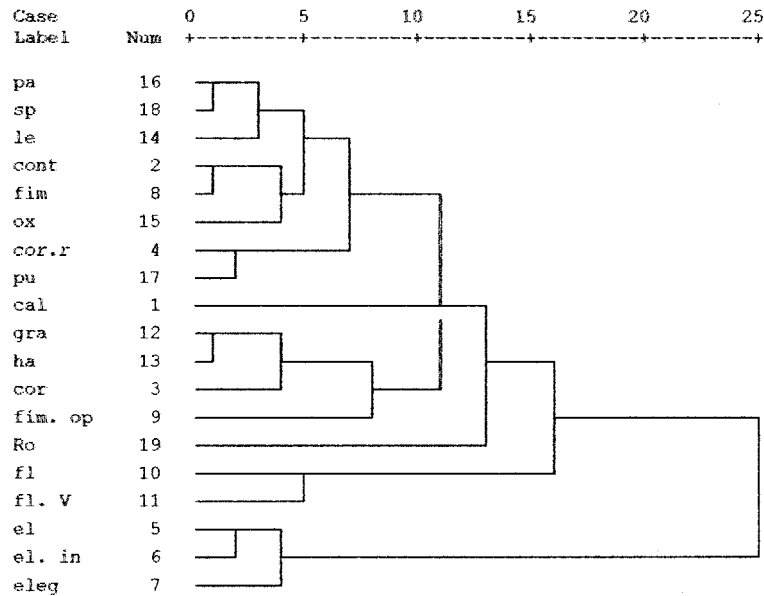


Fig. 1. Phenogram and ordination based on morphological data of *Glaucium* species. -Abbreviations, pa=*G. paucilobum*; gol=*G. goletanicum*; le=*G. leiocarpum*; cont=*G. contortuplicatum*; fim=*G. fimbrilligerum*; ox= *G. oxylobum*; cor.r =*G. corniculatum* subsp. *corniculatum*; pu= *G. pulchrum*; cal=*G. calycinum*; gra=*G. grandiflorum*; ha=*G. haussknechtii*; cor= *G. corniculatum* subsp. *corniculatum*; fim.op=*G. fimbrilligerum* subsp. *ophycarpum*; Ro= *Roemeria refracta*; fl= *G. flavum*; fl.v = *G. flavum* var. *vitellinum*; el=*G. elegans*; el.in= *G. elegans* subsp. *integerrimum*; eleg= *G. elegantissimum*.

Dendrogram using Ward Method

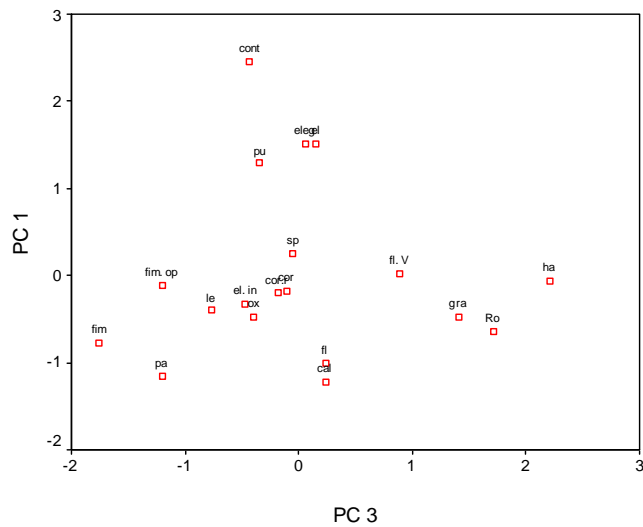
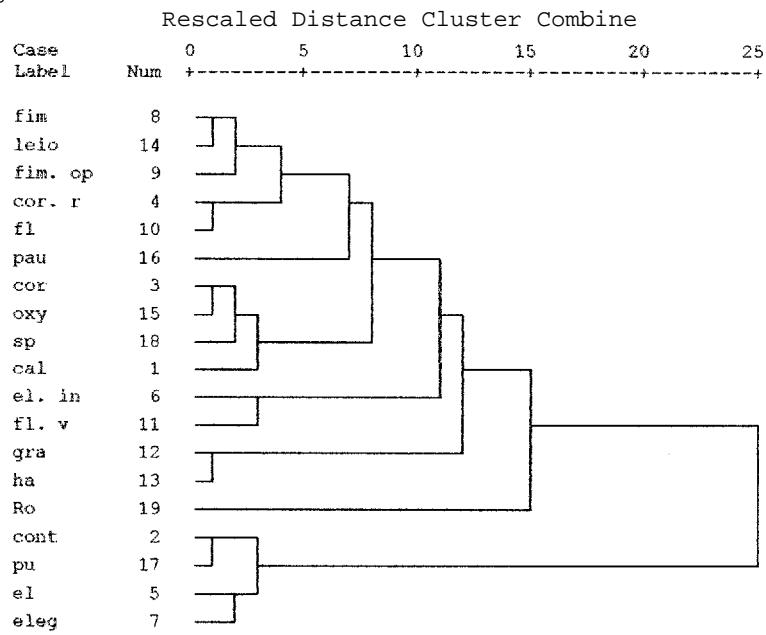


Fig. 2. Phenogram and ordination based on palynological data of *Glaucium* species. Abbreviations as in fig. 1.

Dendrogram using Ward Method

Rescaled Distance Cluster Combine

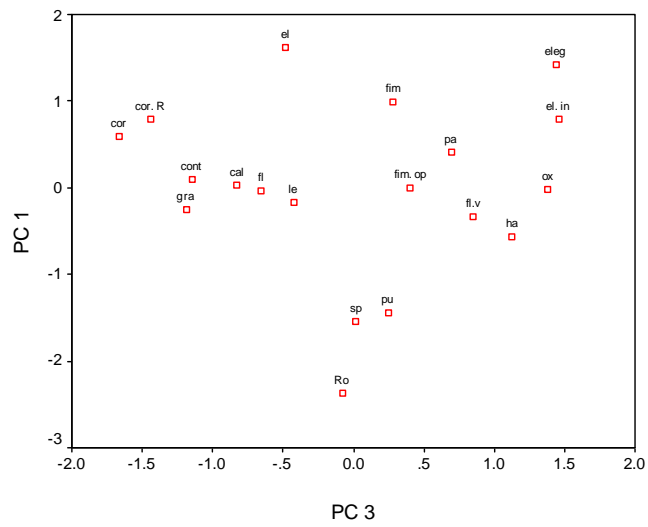
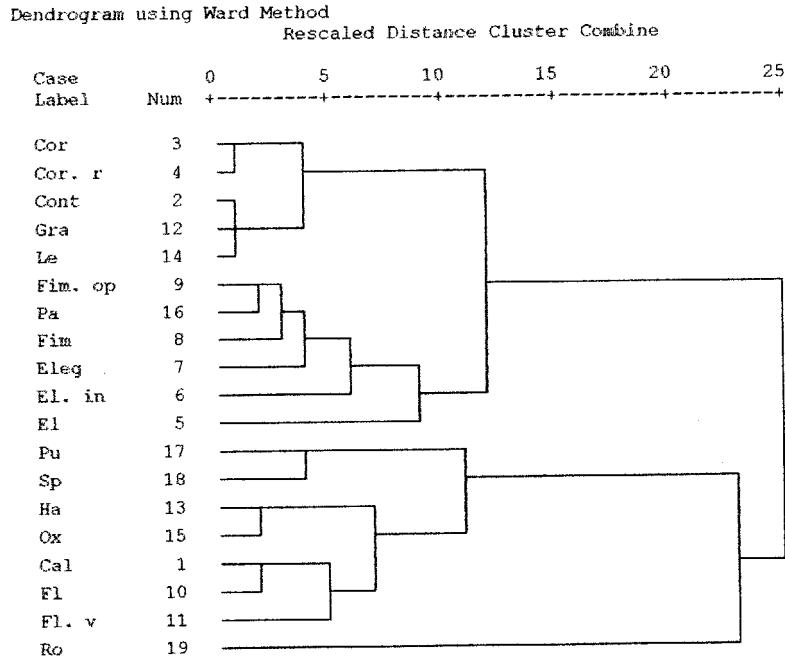


Fig. 3. Phenogram and ordination based on seed characters of *Glaucium* species. Abbreviations as in fig. 1.

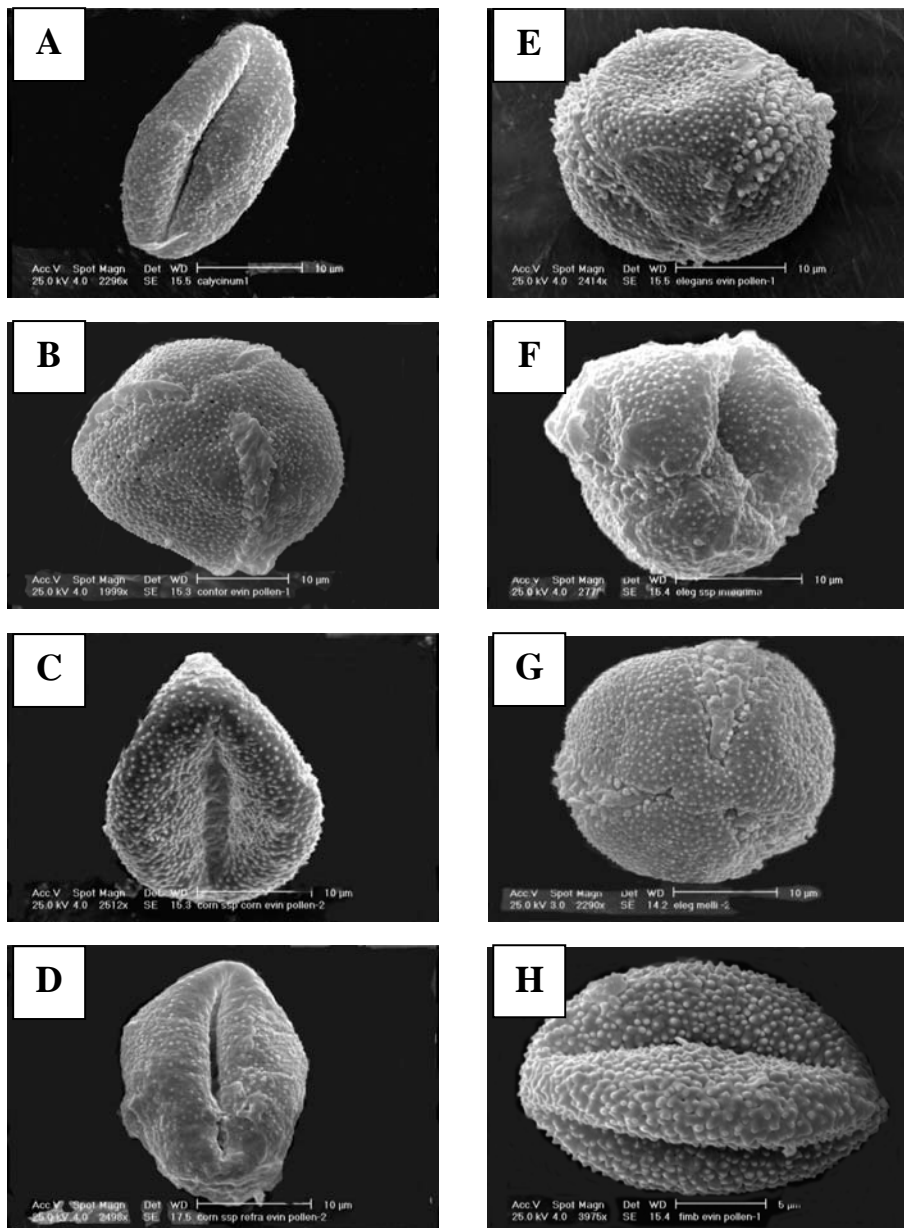


Fig. 4: Pollen grains of *Glaucium* species, A-H. *G. calycinum*: A) Equatorial view; *G. contortuplicatum*: B) Polar view; *G. corniculatum* subsp. *corniculatum*: C) Equatorial view; *G. corniculatum* subsp. *refractum*: D) Equatorial view; *G. elegans*: E) Equatorial view; *G. elegans* subsp. *integerrimum*: F) Polar view; *G. elegantissimum*: G) Polar view; *G. fimbriigerum*: H) Equatorial view.

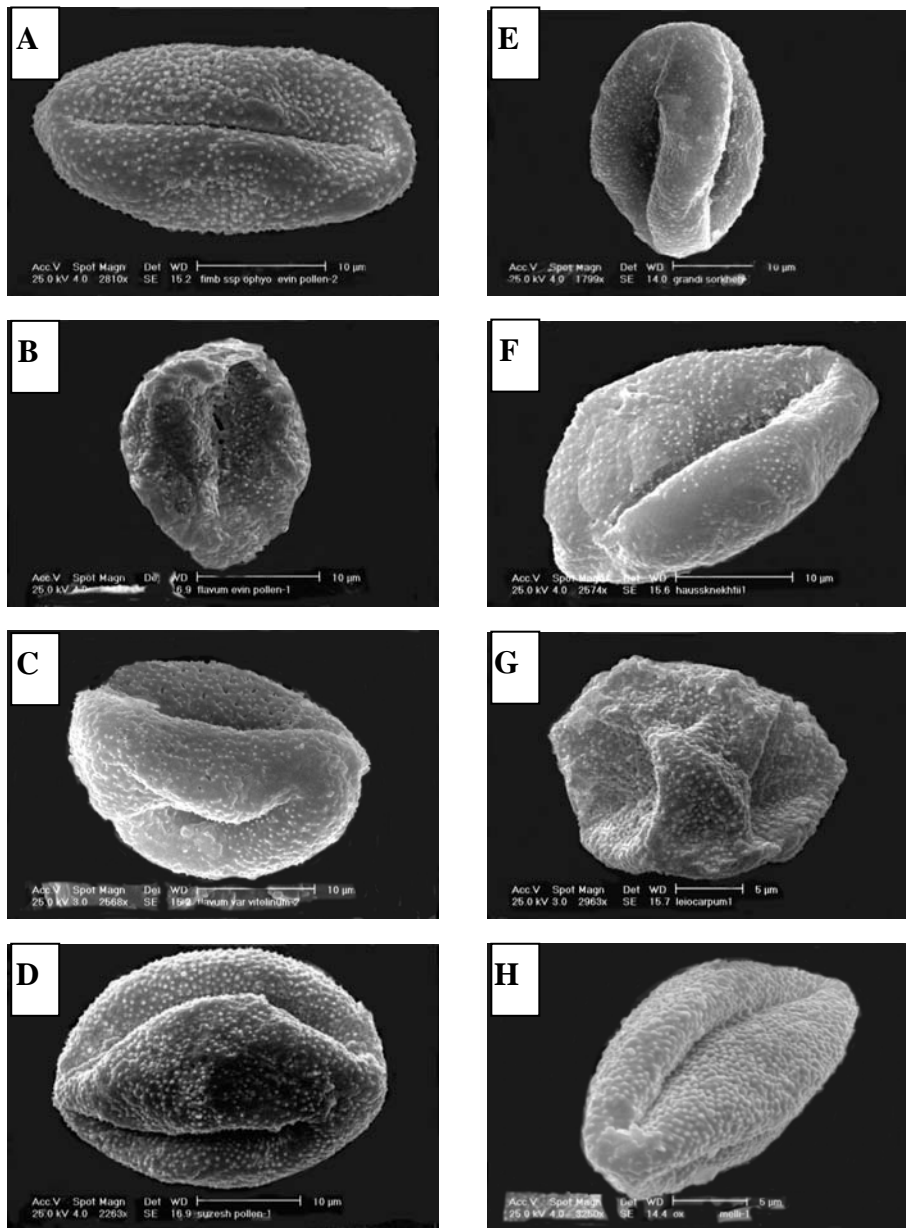


Fig. 5: Pollen grains of *Glaucium* species, A-H. *G. fimbrilligerum* subsp. *ophyocarpum*: A) Equatorial view; *G. flavum*: B) Equatorial view; *G. flavum* var. *vitellinum*: C) Equatorial view; *G. goletanicum*: D) Equatorial view; *G. grandiflorum*: E) Equatorial view; *G. haussknechtii*: F) Equatorial view; *G. leiocarpum*: G) Polar view; *G. oxylobum*: H) Equatorial view.

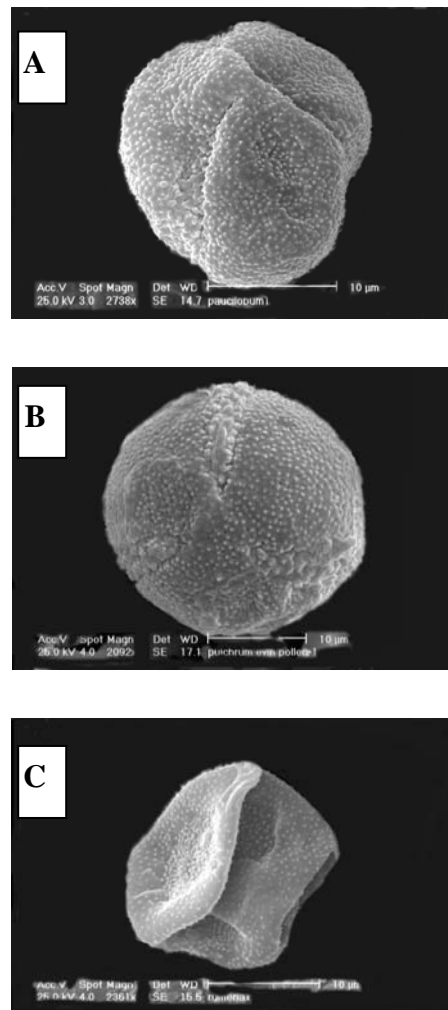


Fig. 6: Pollen grains of *Glaucium* species, A & B. *G. paucilobum*: A) Polar view (X 2738); *G. pulchrum*: B) Polar view (X 2092); Pollen grain of *Roemeria refracta*: C) Equatorial view (X 2361).

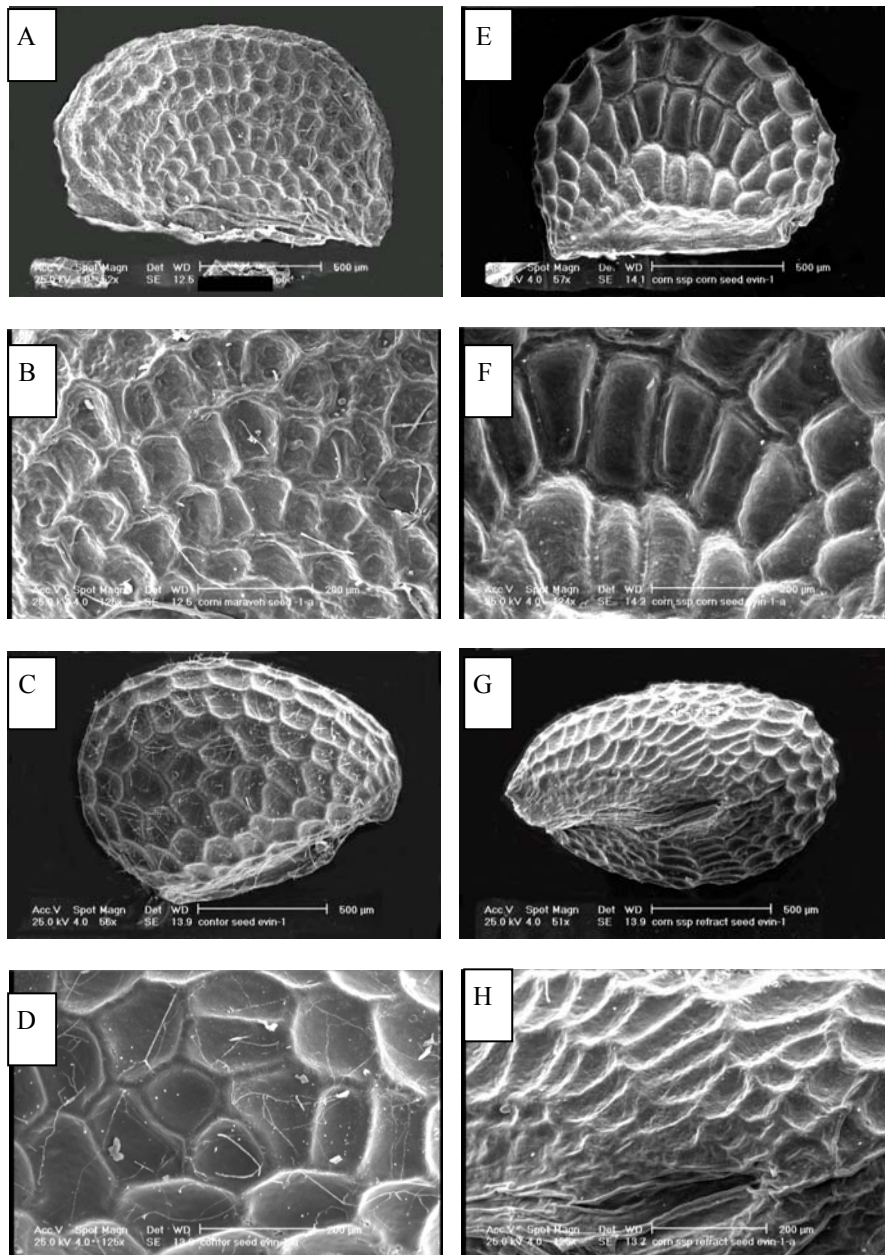


Fig. 7: Seeds of *Glaucium* species, A-H. A) *G. calycinum* (X 52); B) Ornamentation of seed (X 125); C) *G. contortuplicatum* (X 56); D) Ornamentation of seed (X 125); E) *G. corniculatum* subsp. *corniculatum* (X 57); F) Ornamentation of seed (X 124); G) *G. corniculatum* subsp. *refractum* (X 51); H) Ornamentation of seed (X 125).

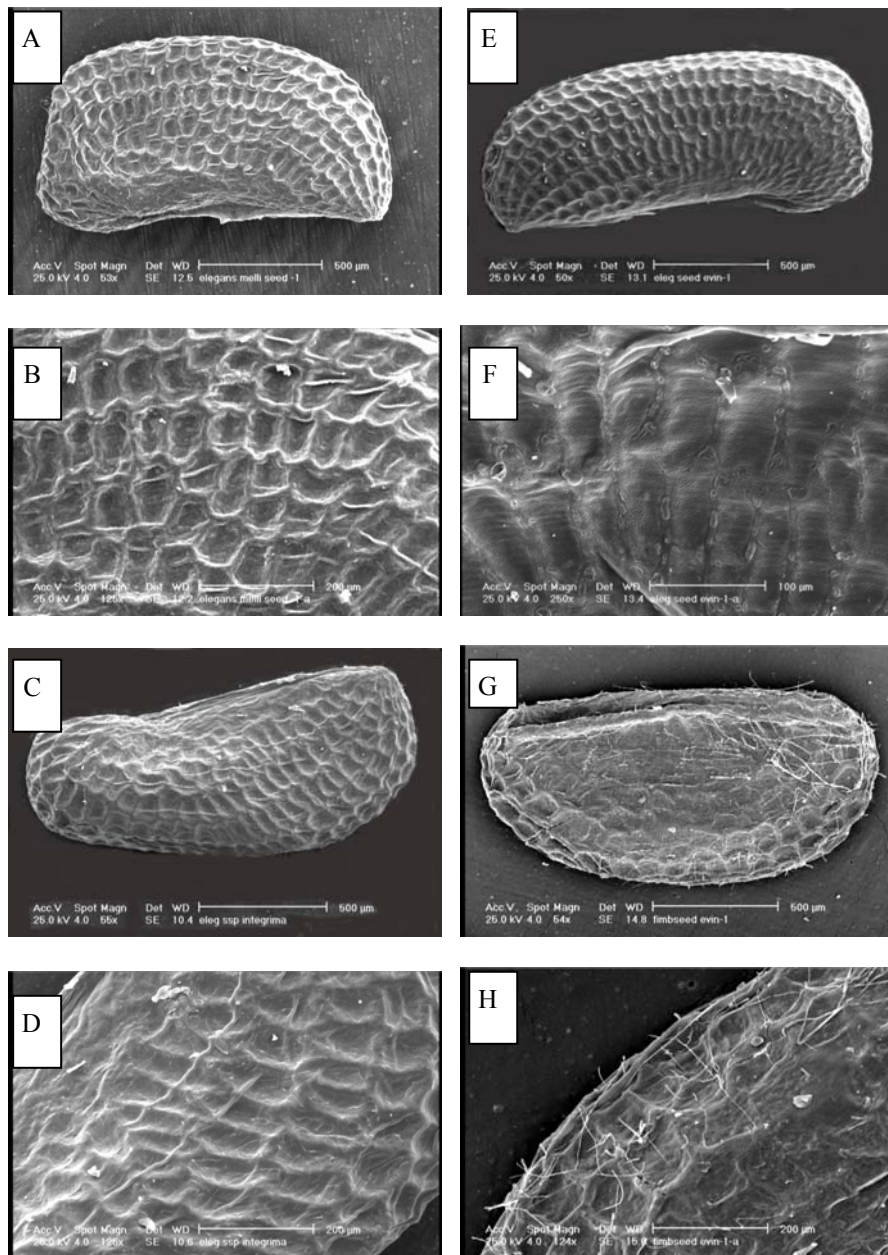


Fig. 8: Seed of *Glaucium* species, A-H. A) *G. elegans* (X 53), B) Ornamentation of seed (X 125); C) *G. elegans* subsp. *integerrimum* (X 55), D) Ornamentation of seed (X 125); E) *G. elegantissimum* (X 50), F) Ornamentation of seed (X 250); G) *G. fimbriigerum* (X 54), H) Ornamentation of seed (X 124).

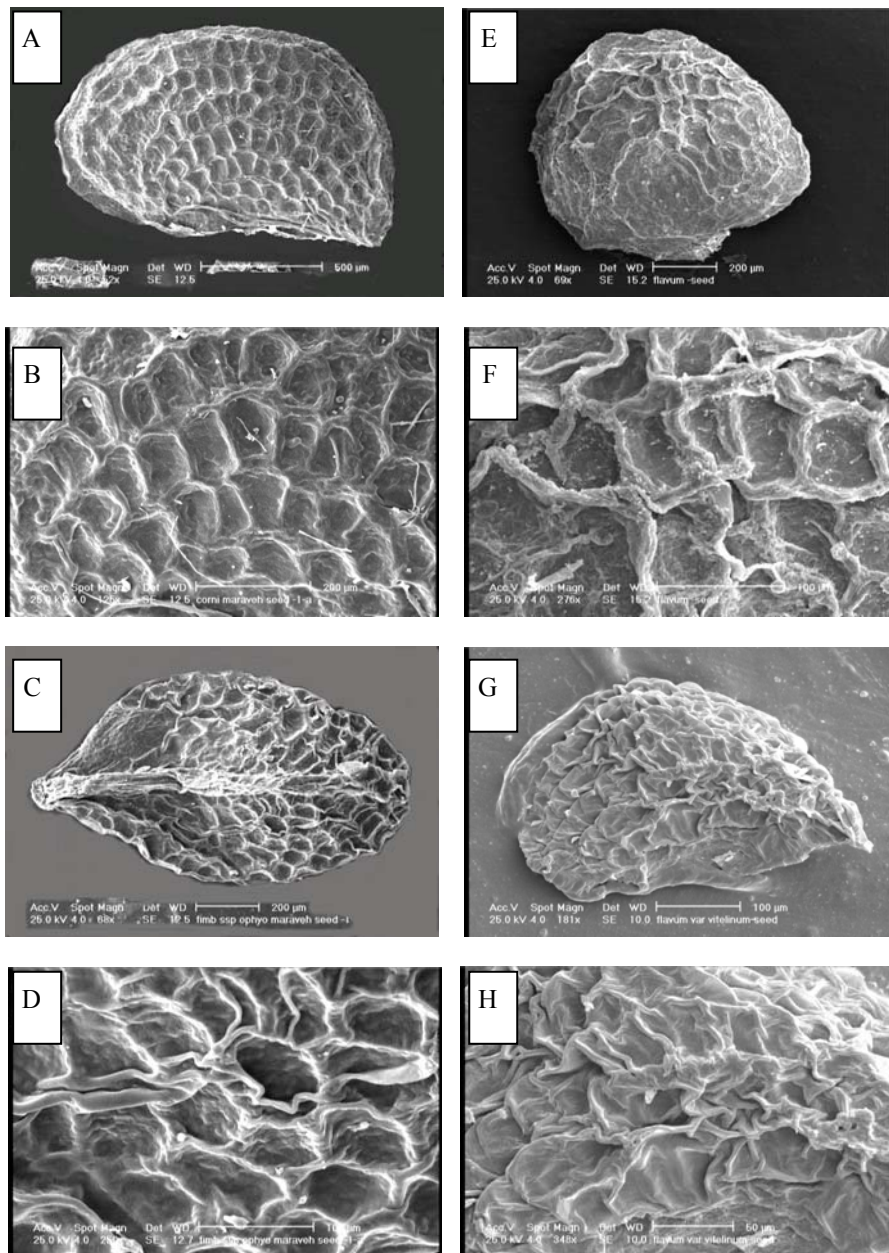


Fig.9: Seed of *Glaucium* species, A-H. A) *G. fimbrilligerum* subsp. *ophycarpum* (X 52), B) Ornamentation of seed (X 125); C) *G. fimbrilligerum* var. *glabrum* (X 68), D) Ornamentation of seed (X 250); E) *G. flavum* (X 69), F) Ornamentation of seed (X 276); G) *G. flavum* var. *vitellinum* (X 181), H) Ornamentation of seed (X 348).

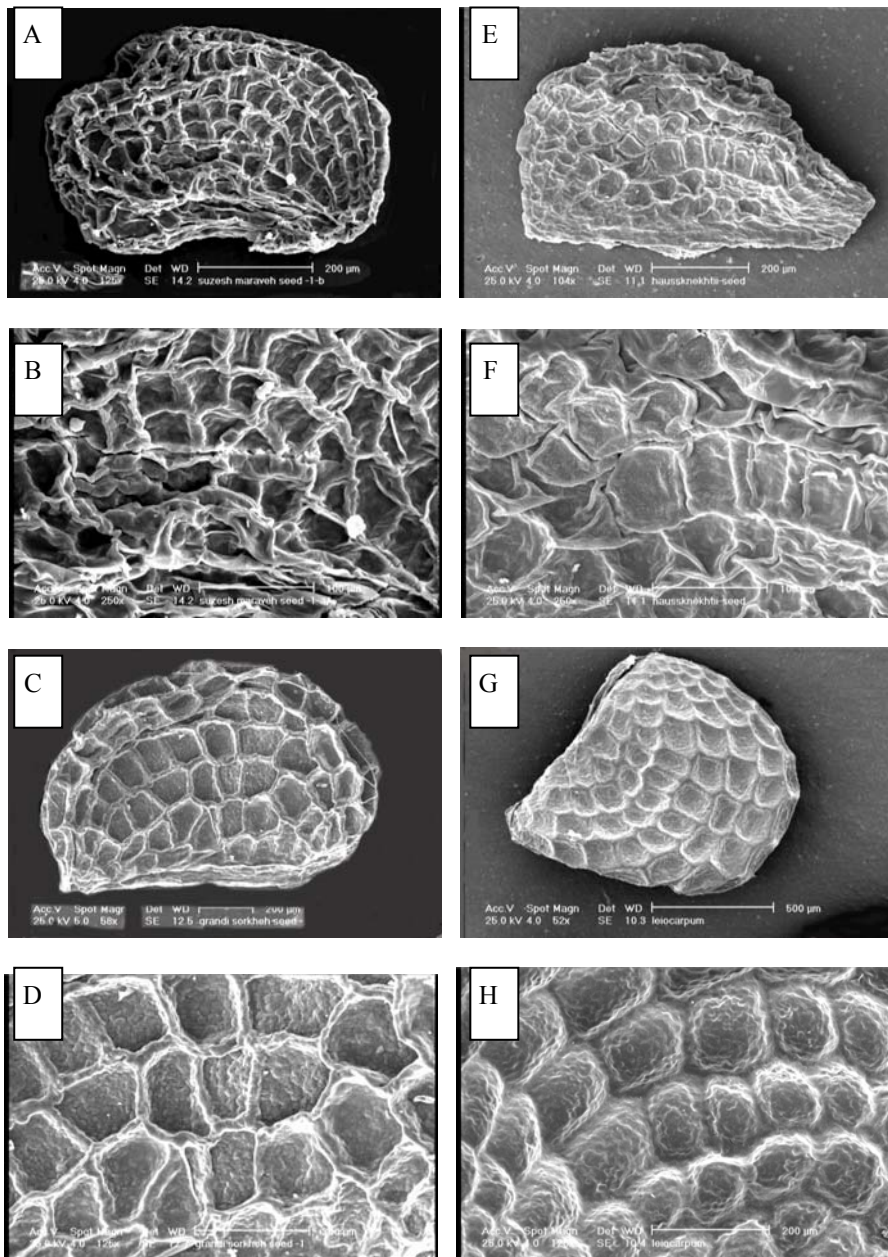


Fig.10: Seed of *Glaucium* species, A-H. A) *G. goletanicum* (X 122), B) Ornamentation of seed (X 250), C) *G. grandiflorum* (X 58), D) Ornamentation of seed (X 125); E) *G. haussknechtii* (X 104), F) Ornamentation of seed (X 250); G) *G. leiocarpum* (X 52), H) Ornamentation of seed (X 125).

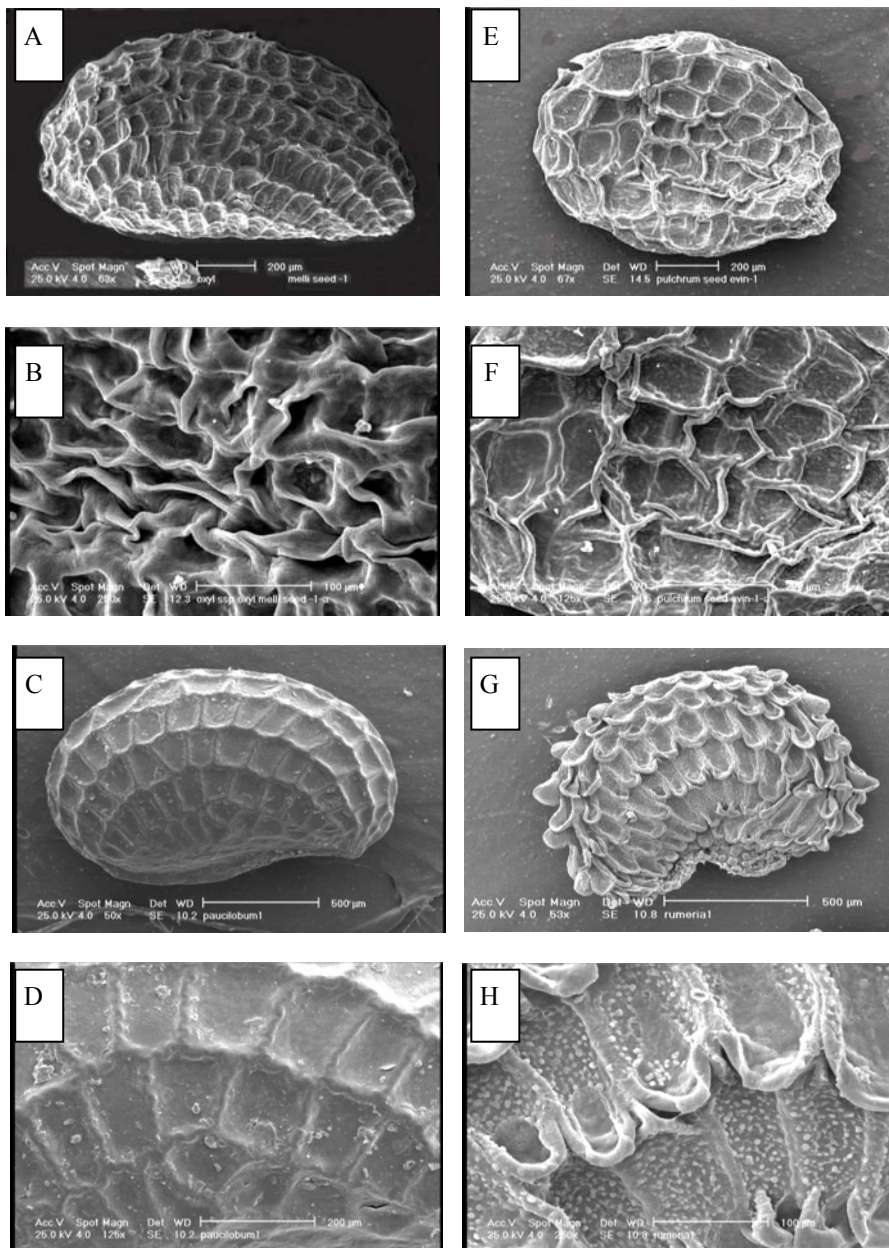


Fig.11: Seed of *Glaucium* species, A-F. A) *G. oxylum* (X 63), B) Ornamentation of seed (X 250); C) *G. paucilobum* (X 50), D) Ornamentation of seed (X 125); E) *G. pulchrum* (X 67), F) Ornamentation of seed (X 125). Seed of *Roemeria* G & H. G) *Roemeria refracta* (X 53), H) Ornamentation of seed (X 250).