

مطالعه گرده شناسی جنس زبان در قفا (تیره آللاه ایان) در ایران

منیژه پاکروان

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چکیده. دانه‌های گرده از ۳۴ جمعیت متعلق به ۱۶ گونه از زبان در قفاهای ایران توسط میکروسکوپ نوری و میکروسکوپ الکترونی نگاره مورد بررسی قرار گرفت. چهار ویژگی طول محور قطبی (P)، طول محور استوایی (E)، نسبت طول محور قطبی به محور استوایی (P/E) اندازه گیری شدند. دانه‌های گرده پخت یا تقریباً پخت بوده کوتاه‌ترین محور قطبی متعلق به *C. tehranica* (Boiss.) Rech.f. بوده و بلندترین آن به *C. trigonelloides* (Boiss.) Munz (۳۷/۳-۲۸/۱۵ میکرومتر) تعلق داشت. همچنین کوتاه‌ترین محور استوایی به *C. stocksiana* (Boiss.) Nevski. و بلندترین آن به *C. orientalis* Schrödinger (۲۵/۲-۱۷/۵ میکرومتر) تعلق داشت. بر اساس تزیینات آگزین که با میکروسکوپ الکترونی نگاره مشاهده شده دو نوع تیپ دانه گرده مشخص شده است. تیپ ۱: آگزین به طور مشخص در قطبین ضخیم و برآمده، شیارها پهن و تزیینات با خارچه‌های متراکم. تیپ ۲: آگزین در قطبین نوک کند، شیارها باریک و تزیینات خارچه‌های پراکنده. تصاویر تمام گونه‌ها و ویژگی‌های ساختار دانه گرده ارائه شده است. نتایج ما نشان داد که شکل دانه گرده و تزیینات آن ویژگی‌های متمایز کننده‌ای برای گونه‌ها هستند. اگر چه برای حل پیچیدگی‌های جنس کافی نیستند اما نتایج این مطالعه قرار گیری گونه‌های *Aconitella* در *Consolida* را تایید کرد زیرا هر دو تیپ دانه گرده در گونه‌های *Aconitella* دیده می‌شود.

واژه‌های کلیدی. آگزین، ایران، خارچه، دانه گرده، میکروسکوپ الکترونی نگاره

Palynological study of the genus *Consolida* (Ranunculaceae) in Iran

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Abstract. The pollen grains of 34 populations, representing 16 species of *Consolida* (DC.) Gray, have been examined by LM and SEM. The polar axis (P), equatorial diameter (E), P/E ratio and exine patterns were measured. The pollen grains were found out to be 3-zonocolpate, euprolate to subprolate. The shortest polar axis to belong to *C. tehranica* (Boiss.) Rech.f. and the longest to belong to *C. trigonelloides* (Boiss.) Munz (28.15-37.3 μm); the shortest equatorial axis to belong to *C. stocksiana* (Boiss.) Nevski. and the longest to *C. orientalis* Schrödinger (17.5-25.2 μm). Based on exine ornamentation observed under SEM, two types of pollen grains were recognized. Type I, exine distinctly thickened at poles with broad colpi and strongly micro-echinate sculpturing, and type II, with exine obtuse at poles, narrow colpi and weakly micro-echinate sculpturing. Pictures of all species and characteristics of pollen grain structure were presented. Our results showed that pollen shape and sculpturing were diagnostic characters for distinguishing the species. Although they did not suffice enough to resolve taxonomic conflicts in the genus, our results confirmed embed of *Aconitella* in *Consolida* due to the occurrence of *Aconitella* species in two pollen groups.

Keywords. exine, Iran, micro-echinate, pollen, SEM

INTRODUCTION

The genus *Consolida* (DC.) Gray (Ranunculaceae) belongs to tribe Delphinieae. It comprises approximately 52 species, including the members of the genus *Aconitella* Spach. Iran is one of the richest countries for the genus in South-West Asia, since it has 24 species (Iranshahr *et al.*, 1992). *Consolida* has been separated from *Delphinium* by De Candolle based on single spurred petals, one follicle and annual life cycle and has occurred in separate section. Finally, it introduced as a separate genus by Gray in 1821 (Triffonova, 1990). Based on phylogenetic studies of Jabbour & Renner (2011), *Aconitella* is part of *Consolida*, both being embedded in *Delphinium*. The Jabbour & Renner (2011) results showed that *Consolida* diverged from *Delphinium* relatives in the Early to Middle Miocene, a period of increasing aridity, caused primarily by decrease in sea level in the Mediterranean (Rögl, 1999; Peryt, 2006; de Leeuw *et al.*, 2010) and desertification in Asia (Guo *et al.*, 2002). Investigations of pollen morphology in the Ranunculaceae have been essential to aid the classification within this family. Ranunculaceae is a europalynous family and the pollen grains include representatives of a number of classes, most of which are tricolpate, and pantocolpate or pantoporate. Pollen grain ornamentations show a variety of forms, including echinate and reticulate (Erdtman, 1952; Clarke *et al.*, 1991). However, the pollen morphology of the genus *Consolida* is poorly known, for only a limited number of previous studies have been conducted on it (Noor *et al.*, 2004; Oberschneider, 1998). Only brief notes with no description and a very limited number of taxa in *Consolida* have been studied by Erdtman *et al.* (1963), Petrov & Borrisova-Ivanova (1980), Moor *et al.* (1991), and Clark *et al.* (1991).

One of the pollen types of pollen grains in Ranunculaceae family is *Consolida ambigua*, in which *Consolida* and *Delphinium* species occur (Clark *et al.*, 1991). Pollen grains in this type are 3-zonocolpate, with weakly micro-echinate ornamentations. The objectives of this paper are to provide a detailed account of the pollen morphology of *Consolida* as a whole by light microscopy (LM) and scanning electron microscopy (SEM), and to determine the extent to which these palynological data can be used as a taxonomic character in the genus.

MATERIAL AND METHODS

The present study was carried out on the 17 species as mentioned in Table 1. Pollen samples were obtained from the herbarium of Alzahra University (ALUH) and herbarium of Research Institute of Forest and Rangelands (TARI). For scanning electron microscopy, pollen grains were prepared from herbarium material with no special treatment. Anthers were broken to release the pollen directly onto aluminum stubs, sputtered with gold, and then observed and photographed using a Hitachi S-800 SEM unit. The values of P (polar axis length) and E (equatorial diameter) were measured, and means were calculated based on the examination of 20 pollen grains. For LM studies, pollen samples were stored in Farmer's solution, then mounted in glycerol jelly on glass slides and studied by means of an Olympus Bx51 microscope and photographed by a digital camera. Measurement of grains was based on approximately 25-35 grains per sample and each sample was measured using Image Tools V.3 software (Donald *et al.*, 2007). Descriptive terminology follows Erdtman (1966) and Clarke *et al.* (1991).

RESULTS AND DISCUSSION

Representative pollen grains are shown in Figures 1 to 4; size and shape measurements are summarized in Table 2.

The grains are euprolate to subprolate; the shortest polar axis belongs to *C. tehranica* (Boiss.) Rech.f. (Fig. 2. a); the longest belongs to *C. trigonelloides* (Boiss.) Munz (28.15-37.3 μm) (Fig. 2.d, Fig. 3.a, Table 2); the shortest equatorial axis belongs to *C. stocksiana* (Boiss.) Nevski (Fig. 2.b, 3.c) and the longest equatorial axis belongs to *C. orientalis* (Gray) Schrödinger (17.5-25.2 μm) (Table 2). The pollen grains are also trizonocolpate, the colpi long, broad or narrow, sunken, margins indistinct, ends acute or linear, membranes coarsely granular or indistinct, exine distinctly thickened at poles or obtuse, weakly or strongly micro-echinate or rough and punctate/perforate. Based on (Clarck *et al.*, 1991), the pollen grains in the Ranunculaceae family could occur in 17 types, and *Consolida* species in *Consolida ambigua* type. One of the characters of this type is distinctly thickened poles, while only some of the studied species had this character (*C. anthoroidea* (Boiss.) Schrödinger, *C. paradoxa* Nevski, *C. regalis* Gray, *C. stocksiana* Nevski, *C. rugulosa* Schrödinger, *C. orientalis* and *C. ambigua* (L.) Ball. & Heywood) (Fig. 1).

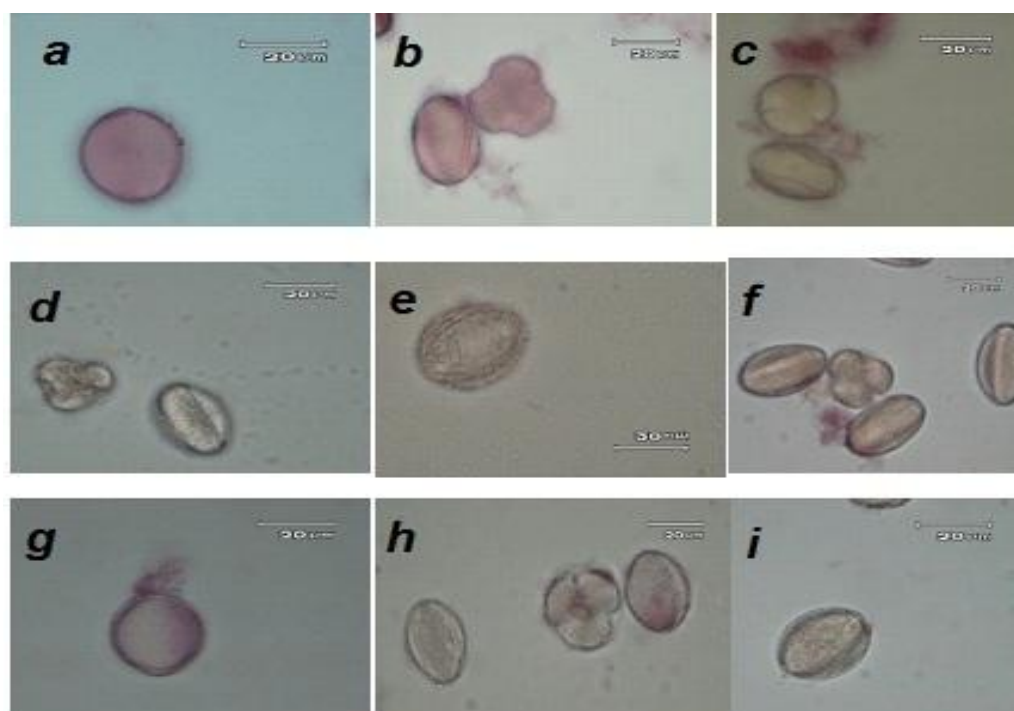
Table 1. List of species studied, localities and voucher specimens.

| Species | Locality | voucher specimen | Collector & No. |
|--|---|------------------|-------------------------|
| <i>C. camptocarpa</i> (Fisch. & C.A.Mey.) Nevski | Khorassan: Jajarm road | ALUH | Poorhabibian 1599 |
| <i>C. camptocarpa</i> (Fisch. & C.A.Mey.) Nevski | Semnan: 58 km of Shahrud to Sabzevar | ALUH | Poorhabibian 35379 |
| <i>C. camptocarpa</i> (Fisch. & C.A.Mey.) Nevski | Khorassan: Sarakhs, 12 km to Mozduran | ALUH | Poorhabibian 1603 |
| <i>C. leptocarpa</i> Nevski | Golestan: Golestan national park, Mirzabailoo | ALUH | Poorhabibian 1590 |
| <i>C. leptocarpa</i> Nevski | Khorassan: Sarakhs road | ALUH | Poorhabibian 1605 |
| <i>C. leptocarpa</i> Nevski | Khorassan: Sarakhs, 14 km to Mozduran | ALUH | Poorhabibian 1600 |
| <i>C. persica</i> (Boiss.) Grossh. | Hamedan: Khan Abad | ALUH | Poorhabibian 1555 |
| <i>C. persica</i> (Boiss.) Grossh. | Tehran: Firuzkuh | ALUH | Poorhabibian 1556 |
| <i>C. persica</i> (Boiss.) Grossh. | Azarbayejan: Tabgriz, Ahar road | ALUH | Poorhabibian 1606 |
| <i>C. rugulosa</i> Schrödinger | Golestan: Golestan national park, Mirzabailoo | ALUH | Poorhabibian 1597 |
| <i>C. rugulosa</i> Schrödinger | Khorassan: Mashhad | ALUH | Poorhabibian 1557 |
| <i>C. rugulosa</i> Schrödinger | Hamedan: Khan Abad | ALUH | Poorhabibian 1558 |
| <i>C. paradoxa</i> Nevski | Khorassan: Neyshabur, Sharif Abad village | ALUH | Poorhabibian 1598 |
| <i>C. paradoxa</i> Nevski | Khorassan: Ferdowsi University Campus | ALUH | Poorhabibian 18570 |
| <i>C. anthoroidea</i> (Boiss.) Schrödinger | Hamedan: Almaghlagh village | ALUH | Poorhabibian 1586 |
| <i>C. anthoroidea</i> (Boiss.) Schrödinger | Hamedan: Nahavand road, Garo Mt. | ALUH | Pakravan 1595 |
| <i>C. anthoroidea</i> (Boiss.) Schrödinger | Markazi: Kuhe Chepeghli | ALUH | Mahdavi 2783 |
| <i>C. tehranica</i> (Boiss.) Rech.f. | Tehran: Between Karaj and Eshtehard | TARI | Assadi & Maassoumi 1701 |
| <i>C. tehranica</i> (Boiss.) Rech.f. | Mazandaran: Pol Sefid | HNBG | Zarre & Amini 5077 |
| <i>C. stocksiana</i> Nevski | Khorassan: Neyshabur | ALUH | Poorhabibian 1598a |
| <i>C. hohenackeri</i> (Boiss.) Grossh. | Hamedan: Kuhe Garo | ALUH | Poorhabibian 1587 |
| <i>C. hohenackeri</i> (Boiss.) Grossh. | Fars: Bamo national park | TARI | Mozaffarian 71498 |
| <i>C. aucheri</i> (Boiss.) Iranshahr | Khorassan: Sarakhs, 14 km to Mozduran | ALUH | Poorhabibian 1600a |
| <i>C. ambigua</i> (L.) Ball & Heywood | Kermanshah: Ghasreshirin | TARI | Seraj 24663 |
| <i>C. ambigua</i> (L.) Ball & Heywood | Tehran: Rudehen | ALUH | Poorhabibian 1580 |
| <i>C. orientalis</i> (Gray) Schrödinger | Mazandaran: Sari | ALUH | Poorhabibian 27543 |
| <i>C. orientalis</i> (Gray) Schrödinger | Mazandaran: Nowshahr | HNBG | Zarre & Amini 5075 |
| <i>C. orientalis</i> (Gray) Schrödinger | Mazandaran: Polsefis | ALUH | Zarre & Amini 5086 |
| <i>C. oliveriana</i> (DC.) Schrödinger | Kermanshah: 31 km to Ghasreshirin | TARI | Mozaffarian 24900 |
| <i>C. oliveriana</i> (DC.) Schrödinger | Hamedan: Abbas Abad | ALUH | Pakravan 45532 |
| <i>C. flava</i> (DC.) Schrödinger ex Hand.-Mazz. | Khuzestan: Ramhormoz | TARI | Mozaffarian 87128 |
| <i>C. flava</i> (DC.) Schrödinger ex Hand.-Mazz. | Khuzestan: Behbahan | TARI | Mozaffarian 87148 |
| <i>C. trigonelloides</i> (Boiss.) Schrödinger | Fars: Abadeh | ALUH | Pakravan 6709 |
| <i>C. oligantha</i> Schrödinger | Kermanshah: Harsin | TARI | Mozaffarian 1914 |
| <i>C. regalis</i> Gray | Azarbayejan: Ajabshir, Khanian village | ALUH | Poorhabibian 1607 |
| <i>C. regalis</i> Gray | Azarbayejan: 35 km to Tabriz, Ahar road | ALUH | Poorhabibian 1606 |
| <i>C. regalis</i> Gray | Golestan: Near Katul | ALUH | Pakravan 1763 |

Abbreviations: No. = herbarium number, ALUH = Alzahra University Herbarium; TARI= Herbarium of Research Institute of Forests and Rangelands.

Table 2. Pollen morphological data of *Consolida* species.

| Species | Polar axis length (μm) | Equatorial axis length (μm) | P/E | Total shape | Colpus shape | Thickened poles |
|--------------------------|-------------------------------------|--|------|-------------|--------------|-----------------|
| <i>C. ambigua</i> | 26, (28.85)32 | 20.02, (22.01),24 | 1.20 | subprolate | broad | + |
| <i>C. anthoroidea</i> | 25.97, (29.01), 33 | 20, (22.57),25.02 | 1.13 | subprolate | broad | + |
| <i>C. aucheri</i> | 29.70,(32.90),37.30 | 19.4,(19.60),20 | 1.67 | euprolate | narrow | - |
| <i>C. camptocarpa</i> | 30.4, (31.72), 34 | 16.60, (21.6)24.8 | 1.46 | euprolate | narrow | - |
| <i>C. flava</i> | 30.4,(31.72),34 | 17.4,(21.1), 24.1 | 1.59 | Euprolate | narrow | - |
| <i>C. hohenacker</i> | 30. 01, (30. 3), 31.3 | 21.02,(23.01)21 | 1.31 | subprolate | narrow | - |
| <i>C. leptocarpa</i> | 29.8,(31.7),34.40 | 21.80, (22.40), 23 | 1.42 | euprolate | broad | + |
| <i>C. oligantha</i> | 27.1, (30. 2), 35.70 | 21.05, (22.40), 23.02 | 1.34 | euprolate | narrow | - |
| <i>C. oliveriana</i> | 25.1, (32.90), 40.50 | 17.05, 21.40),26.40 | 1.5 | euprolate | narrow | - |
| <i>C. orientalis</i> | 29.70,(29.90),30.20 | 22.80,(25.23),26.31 | 1.18 | euprolate | broad | + |
| <i>C. paradoxa</i> | 26.02,(27.95),30.40 | 19.05,(20.80),23.40 | 1.34 | euprolate | broad | + |
| <i>C. persica</i> | 33.03,(36.97),43.01 | 18.04,(19.40),21.03 | 1.90 | euprolate | narrow | - |
| <i>C. regalis</i> | 29.02,(32),35. 05 | 20. 03,(20.11),23. 05 | 1.59 | euprolate | broad | + |
| <i>C. rugulosa</i> | 26. 05,(30.9),33.80 | 16,(20.80),27 | 1.48 | euprolate | broad | + |
| <i>C. stocksiana</i> | 27,(29.70),31.05 | 16. 05,(17.5),19.03 | 1.69 | euprolate | broad | + |
| <i>C. tehranica.</i> | 27.40,(28),28.70 | 21.60,(22.10), 23.05 | 1.27 | subprolate | narrow | - |
| <i>C. trigonelloides</i> | 31.50, (37.30), 47.10 | 21,(21.85), 23.10 | 1.70 | euprolate | broad | + |

**Fig. 1.** LM micrographs of pollen grains in *Consolida* species: **a:** *C. paradoxa*; **b:** *C. regalis*; **c:** *C. ambigua*; **d:** *C. aucheri*; **e:** *C. oliveriana*; **f:** *C. persica*; **g:** *C. orientalis*; **h:** *C. hohenackeri*; **i:** *C. anthoroidea*

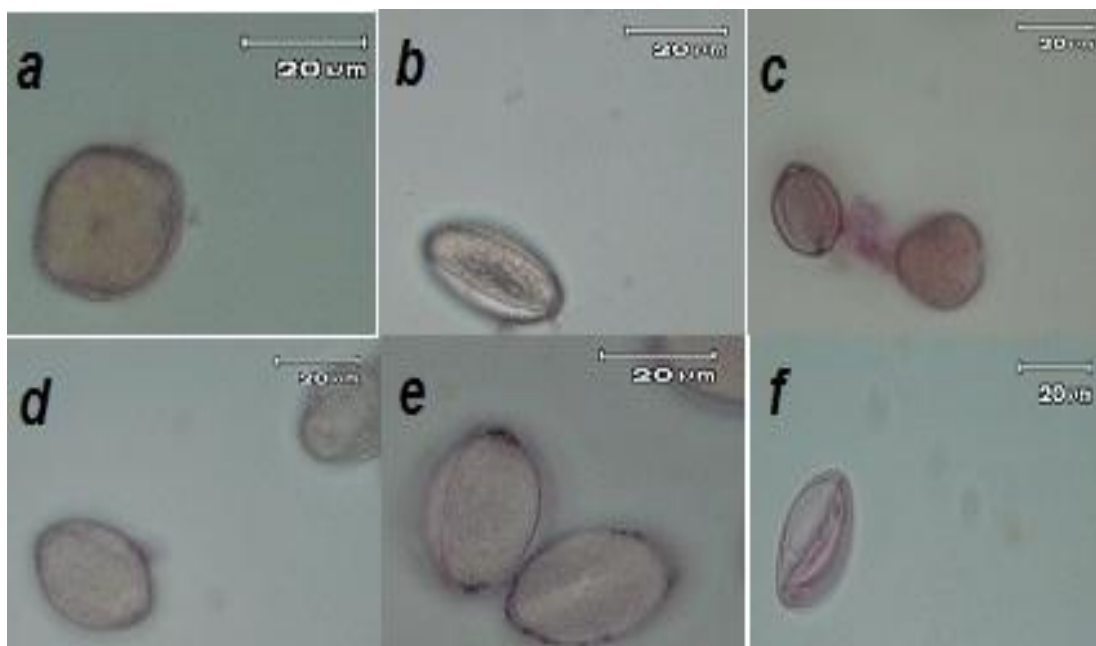


Fig. 2. LM micrographs of pollen grains in *Consolidida* species. **a:** *C. tehranica*; **b:** *C. stocksiana*; **c:** *C. flava*; **d:** *C. trigonelloides*; **e:** *C. leptocarpa*; **f:** *C. rugulosa*.

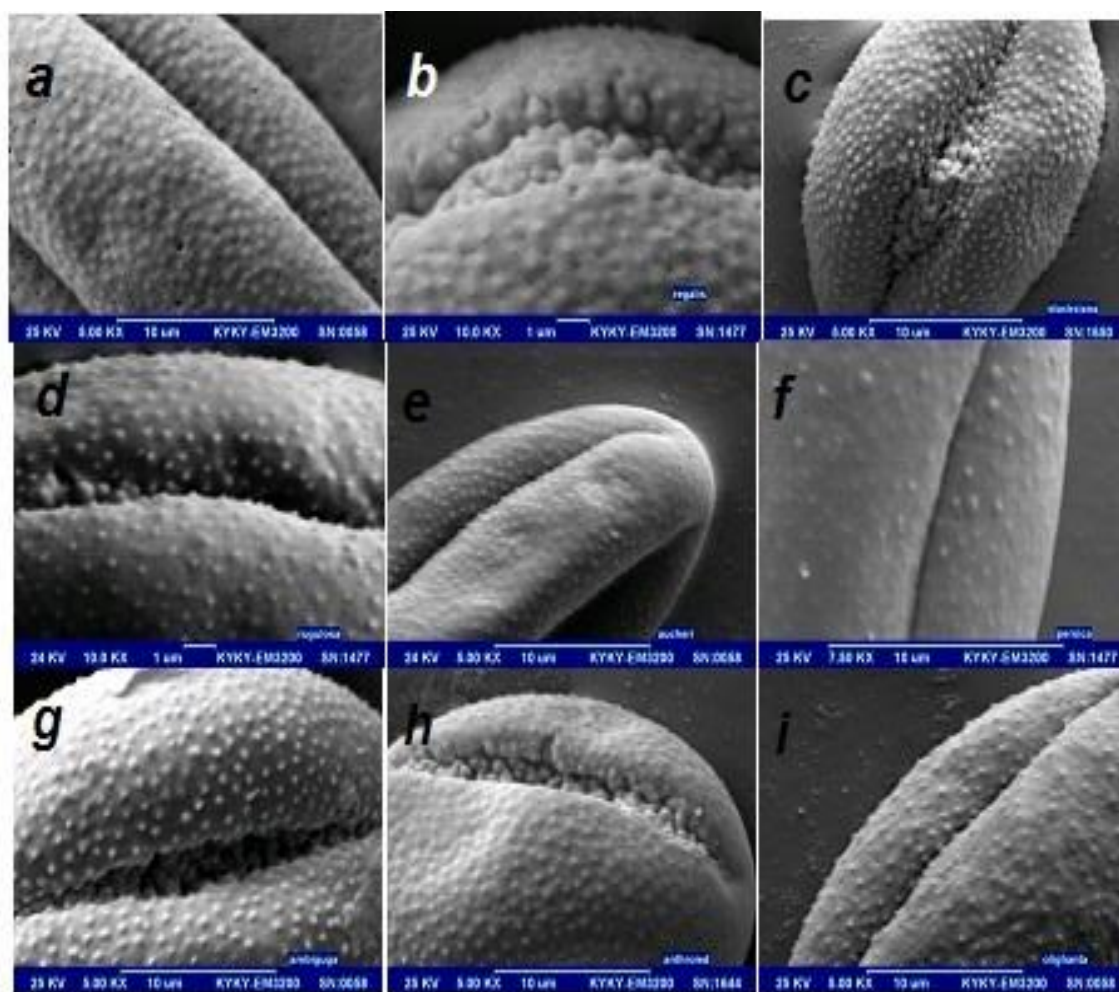


Fig. 3. SEM micrographs of pollen grains in *Consolidida* species. **a:** *C. trigonelloides*; **b:** *C. regalis*; **c:** *C. stocksiana*; **d:** *C. rugulosa*; **e:** *C. aucheri*; **f:** *C. persica*; **g:** *C. ambigua*; **h:** *C. anthoroidea*; **i:** *C. oligantha*.

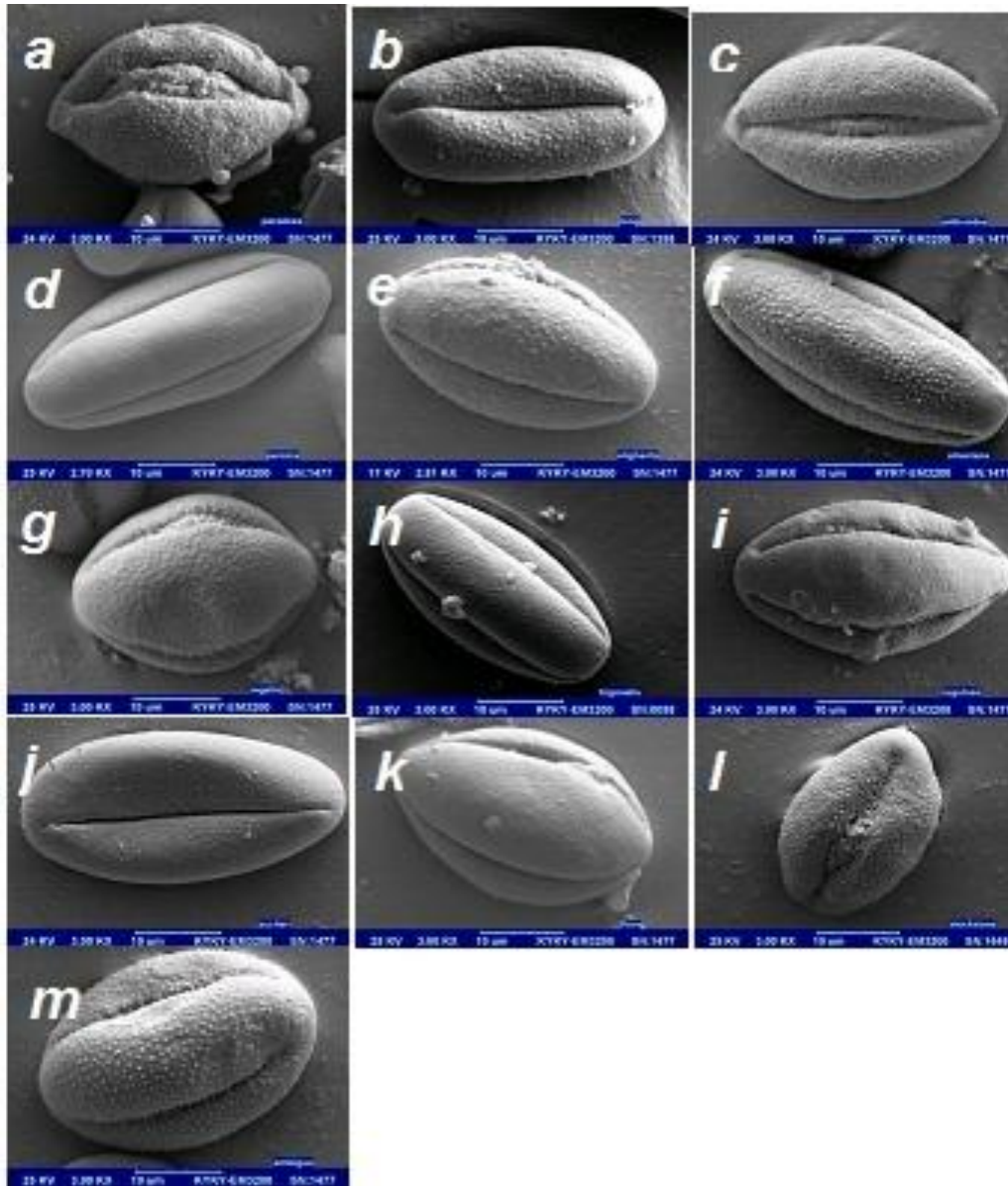


Fig.4. 2. SEM micrographs of pollen grains in *Consolida* species. **a:** *C. paradoxa*; **b:** *C. Camptocarpa*; **c:** *C. anthoroidea*; **d:** *C. persica*; **e:** *C. oligantha*; **f:** *C. oliveriana*; **g:** *C. regalis*; **h:** *C. trigonelloides*; **i:** *C. rugulosa*; **j:** *C. aucheri*; **k:** *C. flava*; **l:** *C. stocksiana*; **m:** *C. ambigua*.

Another character described by Clark *et al.* (1991) is broad colpus, while some of the species had narrow colpi with sunken margins. Based on some of the pollen characters, Iranian species of the *Consolida* were close to the *Adonis annua* type, because of the narrowness of the colpus. Obtuse poles is a character that is not found in *Adonis annua* type but occurs in *Caltha palustris* type. (Faegri & Iversen, 1975) and (Moore & Webb, 1978) could not differentiate pollen of the genera *Aconitum* L., *Adonis* L., *Caltha* L. and *Consolida*. Therefore, not all of the Iranian species of the *Consolida* could occur in one type (*Consolida ambi-*

gua type) but could be divided into two groups. First group species have broad colpi with coarsely granular membranes and thickened exine at poles (*Consolida ambigua* type). Second group species have narrow colpi and obtuse poles, not having been recorded previously from pollen grains of Ranunculaceae. The exine ornamentations are very variable. The scabrate, weakly or strongly microechinate forms could be found in various species. The perforated exine has been observed in *C. oligantha* Schrödinger, *C. persica* (Boiss.) Grossh., *C. regalis* Gray, *C. trigonelloides* (Boiss.) Munz and *C. oliveriana* (DC.) Schrödinger (Fig. 4).

According to SEM images, pollen shape and sculpturing are diagnostic characters to distinguish the species, and maybe essential to draw significant conclusions on the relative closeness and distance of the various taxa. However, they are not enough to resolve taxonomic conflicts in the genus (not as Hasani *et al.* (2011) have recorded). Our results confirmed the embeded of *Aconitella* in *Consolida* as proposed before (Jabbour & Renner, 2011, 2012). Because the *Aconitella* species are occurred in two pollen groups. When the variation in pollen morphology in *Consolida* is compared with in certain gross morphological characters, such as tepal, leaf blade and petiole morphology, the existence of various type of pollen may be part of an inherent variability.

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