

# TAXONOMIC IMPLICATION OF TRICHOMES ON PEDICELS AND SILICULES IN *ALYSSUM* L. (BRASSICACEAE) SPECIES IN IRAN

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The trichomes of silicules and pedicels in 37 *Alyssum* species of Iran were studied. The shapes of trichomes vary from star-shape to simple and dendroid. The star-shape is the most common type. Section *Alyssum* has the most diversity in its trichomes. Some of species have two kinds of trichomes on their silicules. The form of trichome in some species like *A. hirsutum* and *A. heterotrichome* separate them from the other species. Therefore, the trichome shapes in *Alyssum* species can be used as a taxonomic tool to some extent.

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کاربرد تاکسونومیکی کرکهای دمگل و خورجینک در گونه‌های *Alyssum* L. (Brassicaceae) ایران

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کرک‌های خورجینک و دمگل ۳۷ گونه از جنس *Alyssum* در ایران مورد بررسی قرار گرفت. شکل کرکها از ستاره‌ای تا ساده و درختی تغییر می‌کند. فرم ستاره‌ای معمول‌ترین شکل است. Section *Alyssum* بیشترین تنوع را در کرک‌هایش دارد. بعضی از گونه‌ها دارای دو نوع کرک بر روی سیلیکول‌هایشان هستند. شکل کرک در گونه‌هایی مانند *A. hirsutum* و *A. heterotrichome* آنها را از سایر گونه‌ها متمایز می‌نماید. در مجموع، شکل کرک‌ها در گونه‌های جنس *Alyssum* بعنوان یک ابزار تاکسونومیکی در بعضی موارد می‌تواند مورد استفاده قرار گیرد.

## INTRODUCTION

Trichomes are as simple tools of morphology. They are useful because of ease with which they may be examined and because of their almost universal occurrence, particularly in the ferns and flowering plants (Payne, 1987)

The Brassicaceae comprises of 49 tribes, 321 genera, and 3660 species. Of these, 20 genera and 34 species remain to be assigned to tribes (Al-Shehbaz 2012). The genus *Alyssum* L. consists of about 170 – 195 species worldwide, native to Europe, Asia and northern Africa (Al-Shehbaz 1987; Appel & Al-Shehbaz 2003; Warwick & al. 2006; Li & al. 2014). Most of them grow in northern Hemisphere (Al-Shehbaz 2006). The major centers of distribution of the family in SW. Asia are in the Irano-Turanian, Mediterranean, and Saharo-Sindian Regions (Hedge

1976). Boissier (1867) introduced 64 species of *Alyssum* in 6 sections in Flora Orientalis area. Rechinger (1968) introduced 5 sections, 28 species and 7 varieties of *Alyssum* for Iran. These sections are including: *Alyssum* L., *Gamosepalum* (Hauskn.) Dudley, *Psilonema* (C. A. Mey) Hooker, *Odontarrhena* (C. A. Mey) Hooker, *Meniocus* (Desv.) Hook.

The genus *Alyssum* comprises annual and perennial herbaceous plants or (rarely) small shrubs, growing 5–50 (100) cm tall, with entire leaves and yellow or white flowers (Rechinger 1968). Trichomes are stellate, dendroid or sessile, with 2–6 minute basal branches from which passing to 30, simple or branched rays, sometimes trichomes are lepidote, rarely mixed with simple and forked hairs (Shue 2001).

Trichomes morphology, structure and taxonomic significance of 82 species belonging to 9 tribes of

Brassicaceae from Egypt were studied using Light Microscopy (LM) and Scanning Electron Microscopy (SEM) (Khalik 2005). According to this paper three species which are also present in Iran including *Alyssum desertorum* Stapf, *A. homalocarpum* (Fisch. & C.A.Mey.) Boiss. and *A. marginatum* Steud. ex Boiss. were studied and their trichomes were classified as stellate trichomes (Khalik 2005). The leaf and silicule trichomes of 18 species of *Alyssaeae* were studied by Scanning Electron and Light Microscopy (Ancev & Goranova 2006). They distinguished four trichome types: (1) simple, (2) stalked 2- to 5-armed, (3) stellate and (4) dendroid trichomes

Leaves, stems and fruits of 12 species of *Alyssum* were studied by Oran (1996) to identify trichome types. In this study 16 types of trichomes were recognized. Also, more details in trichomes were discussed. For *A. iranicum* Hausskn. ex. Baumg. three kinds of lepidote were recognized: slightly webbed, webbed and widely webbed.

The structure, ontogeny, classification and taxonomic significance of trichomes in 35 species of the Brassicaceae were studied by Inamdar & Rao, (1983). In this research trichomes fall under glandular category only which are classified in unicellular, bicellular and multicellular trichomes on the basis of number of the cells. Totally 11 types of eglandular trichomes were noticed. Light and scanning electronic microscope studies of trichomes helped in delimiting the taxa under investigation.

To estimate the evolutionary history of the Mustard family (Brassicaceae or Cruciferae), they sampled 113 species of 110 genera of the family (Beilstein, 2006). Trichome morphology correlates with phylogeny better than does fruit morphology, although trichome branching has a complex pattern of evolution in the Brassicaceae in contrast to the general phenomenon of trichome branching. Results of studies indicate that stellate trichomes may have a single evolutionary origin. Stellate trichomes occur in lineage I in *Alyssum* and *Physaria* A.Gray and are strongly correlated with arid habitats. Stellate trichomes also occur in *Alyssum canescens*. The genus *Alyssum*

contains numerous species with stellate trichomes, and future studies addressing stellate trichome evolution should consider these species as well (Beilstein et al. 2006)

Results from *ndhF*, *PHYA* and *SEM* indicate that dendritic and medifixed trichomes evolved numerous times in the history of the family, while stellate trichomes may have a single origin (Beilstein 2007). Ancev (2000) investigated 55 species of *Alyssum* genus. Stellate trichomes and singled celled hairs of varying complexity are most common. On stem, leaves, pedicels and silicules of some annual species dendroid, simply branched, fasciculate and/or dendroid trichomes are present.

The aim of this research is to study the variation of silicule and pedicel's trichomes of *Alyssum* species and possible use of it in the taxonomy of the genus.

## MATERIALS AND METHODS

The trichomes on silicules and pedicels of 27 *Alyssum* species were studied by electronic microscope and 10 species studied by light microscope (LM).

Silicules of dry samples were selected for scanning by electronic microscope. They were mounted on the stub using double adhesive tape and coated with gold-paladium. After coating specimens were viewed with a SU 3500 Electron microscope at 15kv. The investigation is based on herbarium materials deposited in TARI as listed in table1.

### Characters:

- 1-Symmetry in rays of trichome on pedicel: symmetric, asymmetric
- 2-Presence of trichome on silicule: absent, present
- 3-Variation in trichomes: one kind, two kinds.
- 4-Kinds of trichome: common star, star with inflated center, simple, lepidote.
- 5-The number of rays: 1 ray, 6-8 rays, 6-10 rays, 10-16 rays, lepidote, dendroid & 6-10 rays.
- 6-Compression: compressed, not compressed.
- 7-Trichome of style: absent, present, trichome at the base or glabrous.

Table1. List of selected taxa, sections, herbarium numbers and locations used in current investigation.

Species	Section	Collecting data
<i>A. persicum</i> Boiss.	Alyssum	Chaharmahal- e Bakhtiari: Lordegan, N. slope KuhrRig from the village Chaman Bid, 2100-2900 m. 8.7.1986, Mozaffarian 57570- TARI.
<i>A. lanceolatum</i> Baumg.	Alyssum	Khorassan: 42 km to Birjand, on the road from Ghayen, 2000m. 19.5.2003, Assadi & Amirabadi 84741-TARI.
<i>A. iranicum</i> Hausskn. Ex Baumg.	Alyssum	Mazandaran: Ca. 30 km S. of Ramsar between Khash-e Chal Mountain and Miankuh, 3100m. 12.7.1984, Assadi & Maasoumi 51249-TARI.

Table 1. Continued.

Species	Section	Collecting data
<i>A. muelleri</i> Boiss. & Buhse	Alyssum	Yazd: S. of Deh-Bala, Shirkuh Mountain, 3000 m. 22.6.1975, Foroughi & Assadi 17999-TARI.
<i>A. hirsutum</i> M. B.	Alyssum	Tehran: Tehran-Karaj, the valley of Kan, 1800 m. 10.4.1977, Runemark & Varnecke 25487-TARI.
<i>A. strigosum</i> Banks & Soland.	Alyssum	Mazandaran, Kelardasht, Mejel, 2800m. 11.5.2012, Mirzadeh 97864-TARI.
<i>A. turkestanicum</i> Regel & Schmalh. ex Regel	Alyssum	Mazandaran:Kojour, Between Lashkenareh and Gandiskal village. 1158 m. 12.6.2012, Mirzadeh 102809-TARI.
<i>A. minus</i> (L.) Rothm. var. <i>micranthum</i> (C. A. Mey.) Dudley	Alyssum	Tehran: Karaj, 1350 m. 20.4.1972 Musavi 5937- TARI.
<i>A. stapfii</i> Vierh.	Alyssum	Ardebil: Asalem to Khalkhal, 1990 m. 5.6.2012, Mirzadeh 101580-TARI.
<i>A. marginatum</i> Steud. ex Boiss.	Alyssum	Tehran: Qom to Tehran. SwW of Daryache (Qom lake), 900m. 16.5.1974, Wendelbo & Foroughi 11561-TARI.
<i>A. szowitsianum</i> Fisch. & C. A. Mey.	Alyssum	Tehran: 65 km Darzan, 1800m. 19.3.1972, Babakhanlou 22949-TARI.
<i>A. contemptum</i> Schott & Ky.	Alyssum	Lorestan: 38 km to Shulabad on the road from Aligodarz, 2200 m. 24.5.1998, Assadi 79043-TARI.
<i>A. strictum</i> Willd.	Alyssum	Hamadan: Hamadan university, 2100m. 31.5.2012, Mirzadeh 97866-TARI.
<i>A. minutum</i> Schlecht. ex DC.	Alyssum	Baluchestan: Ca 40 km N of Kash, Torsh-Ab at TaftanMmountain, 2000- 2300 m. 26.4.1977, Assadi 22882-TARI.
<i>A. desertorum</i> Stapf	Alyssum	Tehran: Alborz, Sirachal, 2850m. 30.5.2013, Mirzadeh 97860- TARI.
<i>A. repens</i> Baumg.	Alyssum	Gilan: Asalem to Khalkhal, above Sefidposhteh, 1900-2100 m. 17.7.1975. Wendelbo & Assadi 18531-TARI.
<i>A. baumgartenarum</i> Bornm. In Baumg.	Gamosepalum	Azerbaijan: 20 km to Siahруд on the road from Kharvana, 900m. 5.6.2004, Assadi 86744-TARI.
<i>A. heterotrichom</i> Boiss.	Meniocus	Chaharmahal-e Bakhtiari: Broijen, Research Institute protected area, 2200 m. 13.5.1987, Mozaffarian 59867-TARI.
<i>A. meniocoides</i> Boiss.	Meniocus	Semnan: Between Shahpassand and Shahrud, 2200m. 19.5.1978, Wendelbo & Assadii 29723-TARI.
<i>A. linifolium</i> Steph.	Meniocus	Khorasan: 68 km on the road to Gifan from Bojnoord, after Amirabad, 1200m. 22.5.1984, Assadi & Massoumi 50286-TARI.
<i>A. inflatum</i> Nyarady	Odontarrhena	Fars: 20 km from Estahbanat to Niriz, S. of Daryacheye-Bakhtegan, 1750 m. 8.6.1983, Mozaffarian 47108-TARI.
<i>A. singaresnse</i> Boiss. & Hausskn.	Odontarrhena	Tehran: Kalak, 1350m. 31.5.1972, Foroughian 5942-TARI.
<i>A. sibiricum</i> Willd.	Odontarrhena	Azerbaijan: SalavatGolidDaragh village, GoliDaragh mountain, 1500-1850 m. 24.6.1980, Mozaffarian & Nowrozi 35041-TARI.
<i>A. bracteatum</i> Boiss. & Buhse	Odontarrhena	Azerbaijan: Meshkinshahr, 1400m. 26.5.1971, Foroughi 1591-TARI.
<i>A. mozafarianii</i> Kavousi	Odontarrhena	Tehran: Kandavan (Gajereh), 2000m. 6.7.1970. Babakhanlou 6593-TARI-.
<i>A. constellatum</i> Boiss.	Odontarrhena	Lorestan: on the road from Nahavand, Islamabad, KuheGarrin, 2600-3100 m. 31.6.2005, Assadii & Mehregan 89025-TARI.
<i>A. murale</i> Waldst. & Kit.	Odontarrhena	Lorestan: Oshtorankuh, above the village Tihun, 2000-2500 m. 12.7.1981, Assadi & Mozafarian 37122-TARI.

Table 1. Continued

Species	Section	Collecting data
<i>A. longistylum</i> (Sommier & Levier) Grossh. & Schischk.	Odontarrhena	Tehran: Kandavan-Chalus, 2480 m. 20.6.1972, Amin & Musavi 6125 –TARI.
<i>A. polycladum</i> Rech. f.	Odontarrhena	Tehran: CickarudJovestanTalegan, 1850,m. 13.6.1974 Amin & Bazargan 19604 -TARI.
<i>A. penjuwiense</i> Dudley	Odontarrhena	Kermanshah: Paveh, the hill above SarabHouli. 1500-1800m. 18.6.1987, Hamzehee 1231-TARI.
<i>A. lanigerum</i> DC.	Odontarrhena	Tehran: Karaj, KuheDashteh, 2550 m. 16.8.1972, Riazi 4474-TARI.
<i>A. kurdicum</i> (Boiss) Nyarady	Odontarrhena	Kordestan: 42 km. S. of Sanandaj, GardanehMorvarid, 1800-1970m. 17.6.1987, Hamzee 1168-TARI.
<i>A. condensatum</i> Boiss. & Hausskn.	Odontarrhena	Tehran: on the road from Damavand to Tar lake, highest pass, 3100 m. 11.6.1997. Assadi, Pakravan, Amini & Nikchehreh76642-TARI.
<i>A. turgidum</i> Dudley	Odontarrhena	Hamadan: 16 km from Avaj to Ab-e garm, 1800m. 1.6.1988, Mozaffarian 64425-TARI.
<i>A. dasycarpum</i> Steph. ex Willd.	Psilonema	Tehran: SorkkehHesar, 1700m. 31.5.1972, Arazm 6321-TARI.
<i>A. alyssoides</i> (L.) L.	Psilonema	Mazandaran: Kelardasht, Mejel, 2800m. 11.5.2012, Mirzadeh 97863-TARI.
<i>A. homalocarpum</i> (Fisch. & C. A. Mey.) Boiss.	Psilonema	Baluchetan: Khash, 1400m. 12.4.1983, Mozaffarian 42762TARI.

## RESULTS

The observations of this study showed that trichomes on silicles are mostly sessile and star-shaped. The pedicels have two kinds of trichomes including stellate type with equal rays and unequal rays (figs. 1-4). *A. muelleri*, *A. iranicum*, *A. persicum* and *A. lanceolatum* belonging to section *Alyssum* have lepidote trichomes similar to *A. baumgarteniarum* of sect. *Gamosepalum* (fig. 2. f-i & l, fig. 3. a-b). Some of the stellate trichomes have inflation at the centers. These species are from the sect. *Odontarrhena* (*A. murale*, *A. longistylum*, *A. polycladum*, *A. lanigerum*, *A. bracteatum*, *A. singarense* and *A. inflatum*) and sect. *Alyssum* (*A. strictum*, *A. contemptum*, *A. szowitsianum* and *A. marginatum*) that all have inflated pedicels as well (fig.1. i-k, fig. 2. c-d, fig. 3.j-k & fig.1.a). All of these species are characterized with trichomes at the base of style, 10-16 in trichomes of silicule and symmetric rays on pedicel. A few numbers of species belonging to sect. *Alyssum* including *A. stapfii*, *A. strigosum*, *A. hirsutum* and *A. minus* have dendroid and stellate trichomes with 6-10 rays (fig. 4g-i, fig. 1g-h & fig. 3.h-I & l). *A. dasycarpum* from sect. *Psilonema* has the same pattern for its trichomes while stellate trichomes with 10-16 rays. *A. turgidum*, *A. penjuwiense*, *A. mozafarianii*, *A. constellatum* and *A. sibiricum* from section *Odontarrhena* have inflated center of trichomes, glabrous style, symmetric rays in trichomes on pedicel and compressed trichomes on silicule (fig. 2. a-b & j-k, fig. 3. d-g). *A. alyssoides* and

*A. turkestanicum* are close to each other with symmetric rays in trichomes on pedicel, incompact trichomes on silicles and presence of trichomes at the base of style (fig. 4. a-b & fig.1. b-c). *A. condensatum* and *A. kurdicum* belonging to section *Odontarrhena* are close to *A. minutum* of *Alyssum* section. The only difference between them is compression of trichomes on silicule that in *A. minutum* is incompact and in the other two species is compact. Although *A. Linifilium* (sect. *Meniocus*), *A. desertorum* (sect. *Alyssum*), *A. meniocoides* (sect. *Meniocus*) and *A. homalocarpum* (sect. *Psilonema*) are from different sections but glabrous silicles is their similarity (fig. 4. l, fig. 1. f & l, fig. 2. e). *A. heterotrichum* from sect. *Meniocus* has simple trichomes that make it different from the others.

## DISCUSSION

Scanning Electronic Microscope (SEM) of the trichomes on silicles and pedicels of *Alyssum* species was conducted. Ancev & Goranova, (2006), recognized 4 types of trichomes in *Alyssae* tribe. Three of mentioned types including: simple, dendroid and stellate were found in *Alyssum* species (Shu, 2001). In sect. *Alyssum* glabrous and lepidote trichomes of silicles occur in different species. Ancev (2000) found lepidote trichomes in *A. baumgartnarium* from the sect. *Gamosepalum*, and a group of the related species in sect. *Alyssum* which is supported by this research. *Alyssum penjuwiense* is morphologically distinct from the other species of the *Odontarrhena* section, this



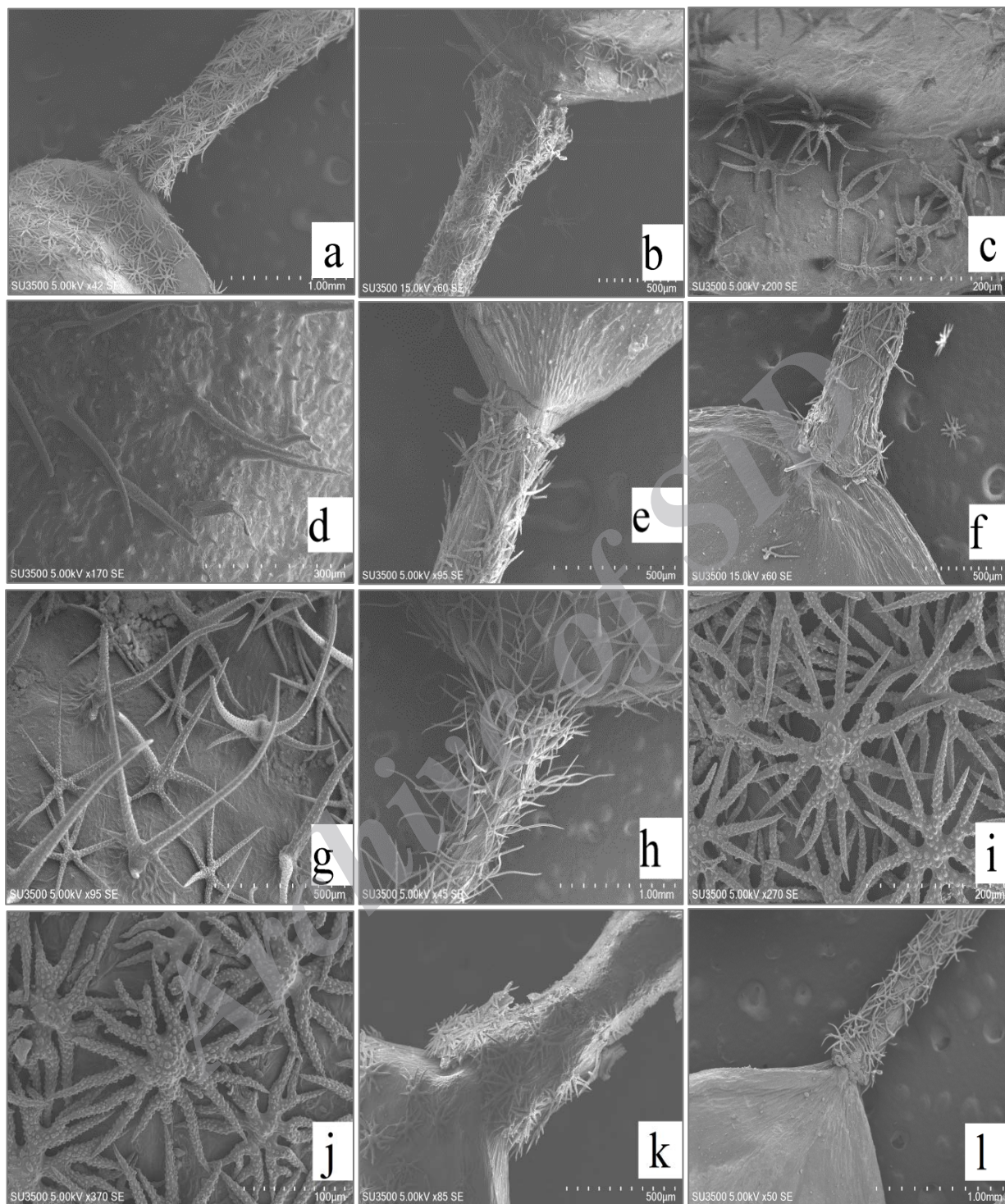


Fig. 1. (a): *A. szowitsianum* (symmetrical rays on pedicel); (b, c): *A. turkestanicum* (Star with 6-8 rays on silicule and symmetric rays on pedicel); (d, e): *A. heterotrichome* (simple trichome and symmetric rays on pedicel); (f): *A. homalocarpum* (glabrous silicule and symmetric rays on pedicel); (g, h): *A. strigosum* (Star with 6-10 rays and dendroid trichome on silicule and asymmetric rays on pedicel); (i): *A. szowitsianum* (Star with 10-16 rays with inflated center on silicule); (j, k): *A. marginatum* (Star with 10-16 rays with inflated center on silicule and symmetric rays on pedicel); (l): *A. meniocoides* (glabrous silicule and symmetric rays on pedicel).



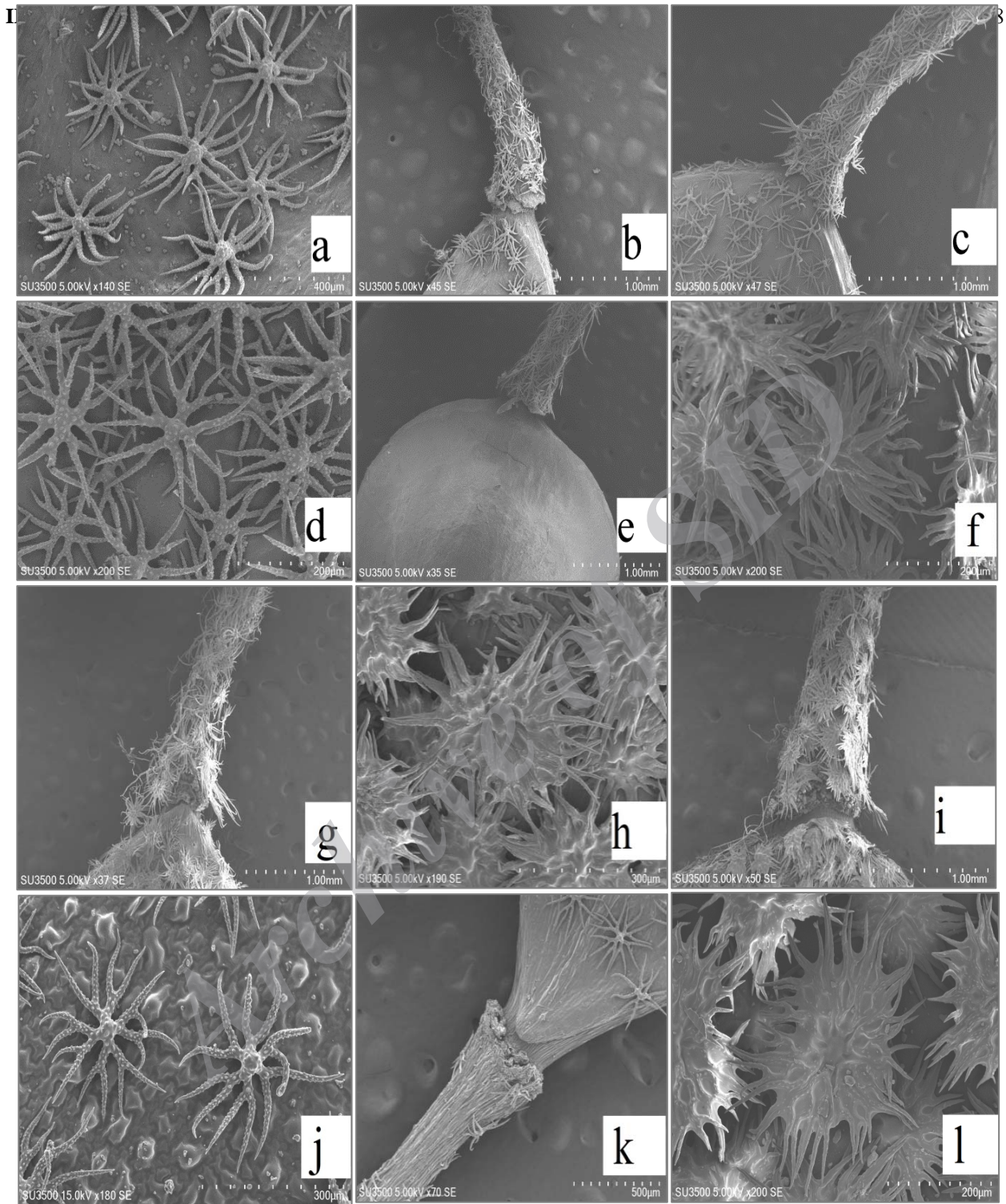


Fig. 2. (a, b): *A. constellatum* (Star with 10-16 rays with inflated center on silicule); (c, d): *A. contemptum* (Star with 10-16 rays with inflated center on silicule); (e): *A. desertorum* (glabrous silicule); (f, g): *A. iranicum* (lepidote); (h, i): *A. lanceolatum*(lepidote); (j, k): *A. mozafariani* (lepidote); (l): *A. baumgarterianum* (lepidote).

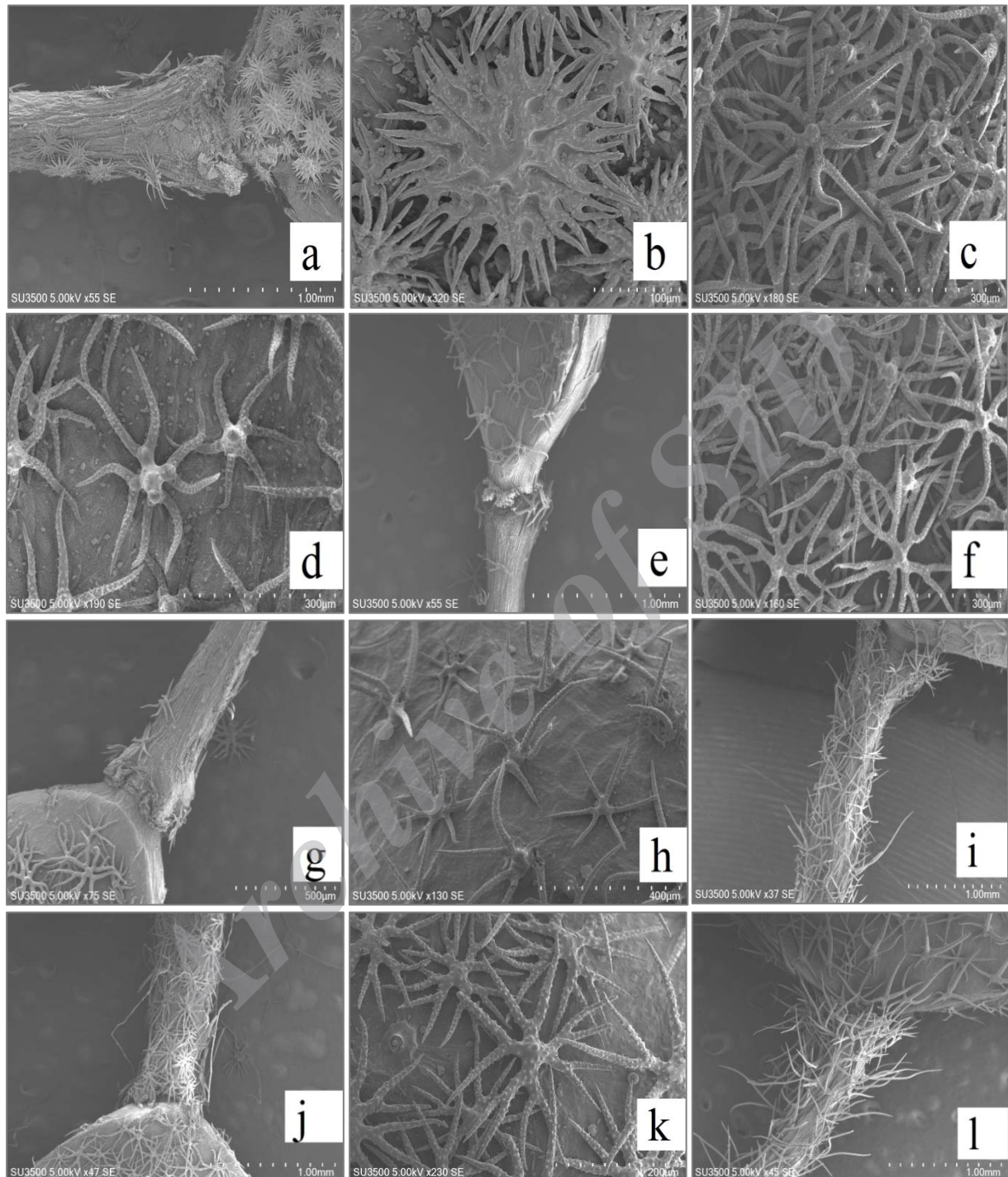


Fig. 3. (a, b): *A. mulleri* (lepidote trichome on silicule and symmetric rays on pedicel); (c): *A. murale* (Star with 10-16 rays with inflated center on silicule); (d, e): *A. penjuwiens* (Star with 6-8 rays with inflated center on silicule and asymmetric rays on pedicel); (f, g): *A. sibiricum* (Star with 10-16 rays with inflated on silicule and center symmetric rays on pedicel); (h, i): *A. stapfii* (Star with 6-10 rays and dendroid trichome on silicule and asymmetric rays on pedicel); (j, k): *A. strictum* (Star with 10-16 rays with inflated center on silicule and symmetric rays on pedicel); (l): *A. strigosum* (asymmetric rays on pedicel).



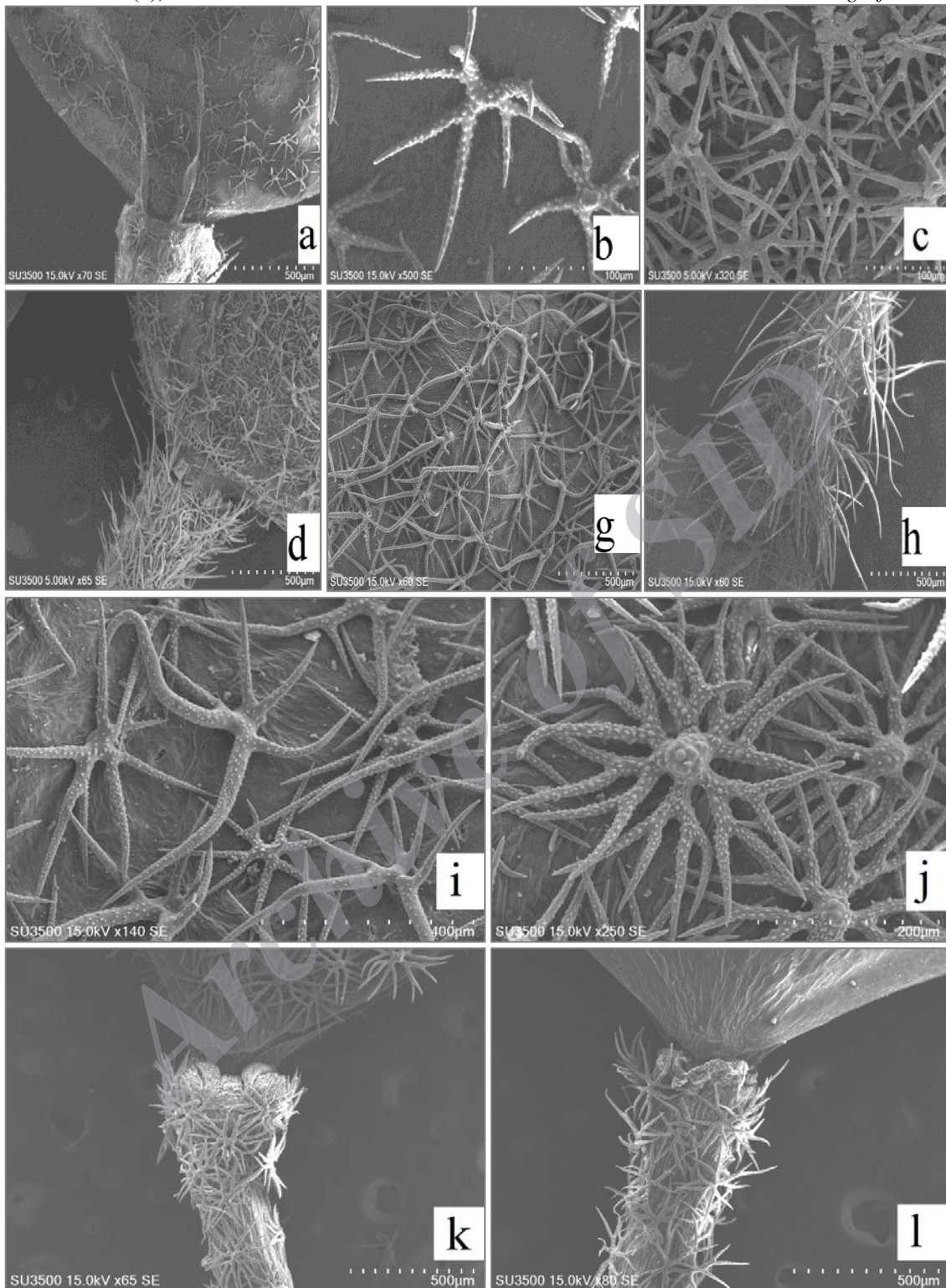


Fig. 4. (a, b): *Alyssum alyssoides* (Star with 6-8 rays on silicle and symmetric rays on pedicel); (c, d): *A. dasycarpum* (Star with 10-16 rays, dendroid trichome on silicle and asymmetric rays on pedicel); (g, h, i): *A. hirsutum* (Star with 6-10 rays, dendroid trichome on silicle and symmetric rays on pedicel); (j, k): *A. lanigerum* (Star with 10-16 rays with inflated center on silicle and symmetric rays on pedicel); (l): *A. linifolium* (glabrous silicle and symmetric rays on pedicel).



species has 6-8 rays in each of the trichome, while the other species have 10-16 rays in each trichome (fig. 3. d-e). *A. dasycarpum* and *A. alyssoides* from sect. *Psilonema* have so similar trichomes to species of sect. *Alyssum* like *A. strigosum* and *A. hirsutum*. *Alyssum* section has more diversity in its trichomes than the other sections. Some species like *A. heterotrichome*, *A. hirsutum*, *A. strigosum*, *A. penjuwiens*, *A. stapfii* and *A. hirsutum* are distinct from the other species with their especial form in silicules' trichomes. They are easily recognized from the other species by this taxonomic tool. Consequently shapes of trichomes provide important diagnostic characters for some species.

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