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TRICHOME MICROMORPHOLOGY OF SILENE (CARYOPHYLLACEAE) SPECIES IN IRAN

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A comparative trichrome micromorphological study of 24 *Silene* species representing eight sections, was made using light and scanning electron microscopy. To check the consistency of trichome types on different parts of a certain species, micromorphological studies were focused on stem, leaf and calyx surface. Two basic types of trichomes were distinguished: glandular and non-glandular. Two different subtypes were recognized within the non-glandular type representing unbranched non-glandular and branched non-glandular trichomes. The study shows that although trichomes are not useful in delimiting *Silene* sections, they provide a set of reliable characters for separation of species within sections. The presence or absence of trichomes, and trichome types could be used as diagnostic character for identification of some species.

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Key words: Electron microscopy; micromorphology; trichome; Caryophyllaceae; *Silene*; Iran

ریز ریخت‌شناسی کرک برخی از گونه‌های جنس Silene در ایران

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مطالعه مقایسه‌ای ریزریخت‌شناسی کرک ۲۴ گونه از هشت بخشه از سرده Silene با استفاده از میکروسکوپ نوری و الکترونی انجام شد تا تنوع بین گونه‌ای کرک و کارایی آن در شناسایی گونه‌ها و طبقه‌بندی زیرسرده‌ای بررسی گردد. برای اطمینان از ثبات صفات کرک در گونه‌های مورد مطالعه، کرک‌های سطح ساقه‌ها، برگ‌ها و کاسه‌ها از نظر تراکم، اندازه و نوع کرک‌پوش بر روی هر گونه با استفاده از استریومیکروسکوپ بررسی شد. از کرک‌های سطح کاسه تمامی گونه‌ها با استفاده از میکروسکوپ الکترونی، عکسبرداری شد. برای بررسی ویژگی کرک‌های ساقه‌ها و برگ‌ها برش‌های عرضی از ساقه‌ها و برگ‌های گونه‌های مورد مطالعه تهیه شده و پس از رنگ آمیزی با استفاده از میکروسکوپ نوری مورد مطالعه قرار گرفتند. در مجموع دو تیپ اصلی از کرک‌ها شناسایی گردید: کرک‌های غده‌ای و کرک‌های غیر غده‌ای. کرک‌های غیر غده‌ای به دو نوع منشعب و غیرمنشعب قابل تقسیم هستند. نتایج حاصل از مطالعه حاضر نشان می‌دهد که حضور و عدم حضور کرک‌ها و نوع کرک‌ها، به خصوص در سطح کاسه، میتواند یک صفت تشخیصی مناسب در گروه مورد مطالعه بوده و در شناسایی برخی از گونه‌ها مفید باشد.

INTRODUCTION

Silene L. is the largest genus of the Caryophyllaceae with about 700-750 species worldwide (Bittrich 1993; Grueter 1995; Rautenberg & al., 2012), distributed mainly in the northern hemisphere with S Balkan Peninsula and SW Asia as the main centers of diversification (Greuter1995; Oxelman and Lidén 1995; Hoseini & Assadi 2016; Hoseini & al., 2017).

Silene species are commonly annual to perennial herbs, rarely geophytes or subshrubs that prefer alpine, subalpine and subtropical habitats (Bittrich, 1993).

As the largest genus of the carnation family, the circumscription of *Silene* has been controversial and subjected to different taxonomic treatments (e.g., Chowdhuri, 1957; McNeill, 1978; Oxelman & al., 2001). Melzheimer (1988) recognized 23 sections and 141 species of *Silene* for the Flora Iranica area. *Silene* comprises the largest genus of the Caryophyllaceae in flora of Iran, representing 21 sections and 106 species among which 30 are endemics (Hoseini & al. 2017 and references therein). Section *Auriculatae* Boiss. is the largest section of *Silene* with about 47 species. This section is represented in Iran by 35 species that occur in most parts of the country (Melzheimer, 1988).
Morphological characters that have been heavily used for the infrageneric classification of *Silene* cannot be adequately applied for understanding relationships and delimitation of taxa within the genus (Chowdhuri, 1957; Melzheimer, 1988). Recent molecular studies, neither support the current morphological infrageneric classifications (e.g., Oxelman and Lidén 1995; Desfeux and Lejeune 1996; Oxelman & al. 1997, 2001; Popp and Oxelman, 2004, 2007; Popp & al., 2005).

The significance of trichome micromorphology in taxonomic treatment of different genera of Caryophyllaceae has been investigated in recent studies (e.g., Metcalfe and Chalk, 1950; Zarrinkamar, 2001; Yildiz and Minarechi, 2008; Sahreen, 2010; Esfandani Bozchaloyi & Keshavarzi, 2014; Nejad Falatoury & al., 2015a, b). Importance of trichomes in discrimination of *Silene* species has been emphasized in different studies (Metcalfe and Chalk, 1950; Chowdhuri, 1957; Coode and Cullen, 1967). It has been suggested that hair micromorphology provides good characters for delimitation of *Silene* taxa at specific level (Sahreen, 2010). The Iranian species of *Silene* have not yet been studied under a comparative trichome micromorphological study, and the importance of trichome micromorphological variation in delimitation of these taxa has not been evaluated. The objective of the study is therefore to present a detailed description of hair micromorphology using light and scanning electron microscopic studies. The variation of these characteristics is discussed with respect to their potential systematic value at infrageneric level.

MATERIALS AND METHODS

Trichome micromorphological characters of 24 *Silene* species belonging to sects. *Ampullatae* Boiss., *Auricalatae*, *Fimbriatae* Boiss., *Inflatae* Boiss., *Lasiostemones* Boiss., *Schaftae* Boiss., *Sclerocalycinae* Boiss., *Spergulifoliae* Boiss. were investigated. The sectional concept in the present study follows Flora Iranica (Melzheimer, 1988). Samples were removed from herbarium specimens at MSB, SBUH and TUH. A list of voucher specimens used in this study is presented in table 1.

To check the consistency of trichome types in different parts of a certain taxa, trichomes of stem, leaves and calyx were first investigated with stereomicroscope.

For light microscopic (LM) studies, cross sections of leaf and stem were prepared by hand using commercial razor blades. The sections were stained with safranin-fast green according to Gerlach (1977), with some modifications. The cross-sections were dehydrated through an ethanol-xylol gradient (25% xylol: 75% ethanol) in three steps to final incubation in xylol 99.5% and then mounted on slides using Canada balsam. The trichome characters were scored or studied by light microscopy (VANOX AHBS3 Olympus).

Scanning electron microscopic studies were only made on calyx samples. Small pieces of calyces were fixed on aluminum stubs using double-sided adhesive and coated with a thin layer of gold-palladium. Micrographs were taken with EM3200 scanning electron microscope at 25 KV. The descriptive terminology mainly follows Salmaki & al., (2009); Zamfirache & al., (2009); Osman (2012), with some modifications.

Table 1. Collection data of *Silene* specimens used in the present study. * indicates endemic species to Iran.

Taxa	Collection data
	Sect. *Ampullatae* Boiss.
S. ampullata Boiss.	Hamadan: near Avaj, 1580 m, Attar and Dadjou, 16892 (TUH) Kordestan: 25 km after Baneh to Saqez, deviation road of Pir-Omran village, Attar, Maroofi and Zamani 40629 (TUH)
	Sect. *Auriculatae* Boiss.
S. aucheriana Boiss.	Lorestan: Road of Aleshtar, Shpeez pass, Ghahreman, Attar and Ghaffari 21691 (TUH) Tehran: Damavand, Lasem, 1700 m, Attar and Okhovat 21259 (TUH) Tehran: Damavand, Lasem, Attar and Okhovvat 21259 (TUH) Hameadan: Abbas Abad, Ganjname, Arefi 6226 (TUH)
S. commelinifolia Boiss. subsp. *commelinifolia*	Tehran: southern slope of Damavand Mt., Polur, Lar river valley, Talebi, 43216 (TUH)
S. elymaitica Bornm.*	Esfahan: Golestan Kuh,3200 m, Gholipour, 8666 (SBUH)
S. eriocalycina Boiss.	Boyer Ahmad: Yasuj, Bijan pass, 2800 m, Ghahreman, Attar and Mehdigholi (TUH) Fars: Shiraz, Park-e Bamu, Attar, Khatamsaz and Sheikh, 20361 (TUH) Fars: Shiraz, Park-e Bamu, Attar, Khatamsaz and Sheikh, 20372 (TUH)
S. guntensis (B.Fedtsch.) Melzh.	Golestan: Jahan-nama, protected erea, Chaharbagh toward shahkouh, Jafari private Collection
S. gynodioica Ghaz.*	Boyer Ahmad: 48 Km from Gachsaran to Shiraz, 1200 m, Mehregan, 32296 (TUH)
S. indeprensa Schischk.*	Khorasan: Mashhad, Sarakhs, NW of Marzduran (Mozdavand), 1001m, Zarre, Salmaki and Ebrahimi, 38158 (TUH)
S. meyeri Fenzl ex Boiss. & Buhse*	Azarbayejan, Marand, Mishodagh, Jast S. S. W, Ghahreman and Mozaffarian, 9684 (TUH) Azarbayejan: Between Shahindej and Tekab, Mozaffarian, 69869 (TUH) Zanjan: Soltanieh, 2180 m, Gholipour, 8629 (SBUH)
S. microphylla Boiss.	Lorestan: Khorram-Abad, before Gilavand, Gholipour, 27105 (TUH) Esfahan: Esfahan to Shahreza, 25 Km S Esfahan, 6232 (TUH)
S. nizvana Melzh.*	Semnan: Semnan to Firouzkouh, Km 15, Gholipour, 8621 (SBUH)
S. oligophylla Melzh.*	Zanjan: Zanjan to Manjil, Abhar, 2170 m, Gholipour, 8632 (SBUH)
S. palinotricha Fenzl ex Boiss.*	Tehran: Damavand, 3200 m, Gholipour, 8681(SBUH) Tehran: southern slope of Damavand supra Gusfandsara, 3200 m, Talebi, 43219 (TUH)
S. persepolitana Melzh.*	Fars: Shiraz, Park-e Bamu, Attar, Khatamsaz and Sheikh, 20359 (TUH)
S. persica Boiss.*	Yasuj: Sisakht, Dena, 3100m, Gholipour, 8654 (SBUH)
S. sojakii Melzh.*	Tehran: Firouzkouh to Semnan, Gandab, Gholipour, 8625 (SBUH)
	Sect. *Fimbriatae* Boiss.
S. multifida (Adams) Rohrb.	Azarbayejan: Kaleybar to GhalehBabak, Ghahreman, Mozaffarian and Sheikholeslami, 17527 (TUH)
	Sect. *Inflatae* Boiss.
S. odontopetala Fenzl.	Kordestan: Marivan to Pave, Gardane-Tate, 1800-2600 m, Ghahreman and Mozaffarian, 18337 (TUH) Tehran: Firuzkuh, Gaduk, Eslami, 29571 (TUH)
S. pungens Boiss.	Azarbayejan: Marand, Mishodagh, just S.S.W Payam, 1700-2200m, Ghahreman and Mozaffarian, 9673 (TUH)
	Sect. *Lasiostemones* Boiss.
S. marschallii C.A.Mey subsp. *marschalii*	Tehran: Southern slope of Damavand Mt., N Polur, 2550 m, Talebi, 43212 (TUH) Tehran: 5 Km NW above Shemshak, 4 Km E of the Dizin pass, Podlech and Zarre, 55156 (MSB)
	Sect. *Schaftae* Boiss.
S. schafta Gmel. ex Hohen.	Mazandaran: Karaj- Chalus road, Pol-e Zanguleh, Kamarbon, 2950 m, Nazarian, 33219 (TUH) Mazandaran: Toneckabon, JannatRudbar, Ghahreman and Attar, 24330 (TUH)
	Sect. *Sclerocalycinae* Boiss.
S. morganae Freyn	Azarbayejan: Khoy to Qotur, 15km after railroad bridge, 1460 m, Attar, 34568 (TUH)
	Sect. *Spergulifoliae* Boiss.
S. cephalantha Boiss.	Azarbayejan: Marand, between Zunuz and Kuhkamar, 2500 m, Ghahreman and Mozaffarian, 17397 (TUH)
S. spergulifolia (Willd.) M. Bieb.	Azarbayejan: Tabriz, Sperkhan, Sahand, 2400m, Ghahreman and Mozaffarian, 17382 (TUH)

RESULTS

Two basic types of trichomes can be distinguished on stem, leaf and calyx surface of the studied taxa: glandular and non-glandular. The main types of the investigated trichomes and their distribution among the studied species are summarized in tables 2, 3 and 4. Selected SEM and LM micrographs of common trichome types are presented in fig. 1, figs. 2, 3 and 4 respectively show micrographs of trichomes on stem, leaf, and calyx surface of the studies taxa. A number of trichome characters that provide appropriate variation for discrimination of taxa are as follows: presence of

glandular and non-glandular trichomes, number of trichome cells (unicellular or multi-cellular), presence of branched (dendroid) trichomes, presence of vermiform trichomes, and presence of papillae on trichome surface.

Table 2. Some characteristic features of trichomes on stem surface in the examined *Silene* taxa. 1 Species, 2 Density, 3 short, simple unicellular trichome, 4 short, simple multicellular trichome, 5 long, simple multicellular trichome, 6 short glandular trichome, 7 long glandular trichome. (+: Presence, -: Absence, ±: approximately). *Density of trichomes is divided into four categories: very dense, dense, sparse and very sparse.

1	2	3	4	5	6	7
S. ampullata	dense	+	+	-	+	+
S. aucheriana	±dense	+	+	-	-	-
S. commelinifolia subsp. *commelinifolia*	dense	+	+	-	+	+
S. elymaitica	±dense	+	+	-	+	-
S. eriocalycina	very dense	+	+	-	-	-
S. guntensis	±dense	+	+	-	-	-
S. gynodioica	±dense	+	+	-	-	-
S. indeprensa	±dense	+	+	-	-	-
S. meyeri	±sparse	+	+	-	-	-
S. microphylla	±dense	+	+	-	+	-
S. nizvana	±dense	+	+	-	-	-
S. oligophylla	very sparse	+	+	-	-	-
S. palinotricha	±sparse	-	+	-	-	-
S. persepolitana	very dense	-	+	-	-	+
S. persica	very sparse	+	+	-	-	-
S. sojakii	very dense	+	+	+	-	-
S. multifida	±dense	-	+	+	-	-
S. odontopetala subsp. *odontopetala*	very sparse	-	+	+	-	-
S. pungens	dense	+	+	-	-	-
S. marschallii subsp. *marschalii*	±dense	+	+	-	-	-
S. schafta	sparse	+	+	-	-	-
S. morganae	glabrous	-	-	-	-	-
S. cephalantha	±dense	+	+	-	-	-
S. spergulifolia	±dense	+	+	-	-	-

Table 3. Some characteristic features of trichomes on leaf surface in the examined *Silene* taxa.
1 Species, 2 density, 3 short, simple unicellular trichome, 4 short, simple multicellular trichome, 5 long, simple multicellular trichome, 6 short glandular trichome, 7 long glandular trichome (+: Presence, -: Absence, ±: approximately).

1	2	3	4	5	6	7
S. ampullata	±dense	+	+	-	+	+
S. aucheriana	±dense	+	+	-	-	-
S. commelinifolia subsp. *commelinifolia*	dense	+	+	-	+	+
S. elymaitica	±dense	+	+	+	-	+
S. eriocalycina	dense	+	+	-	-	-
S. guntensis	±dense	+	+	-	-	-
S. gynodioica	dense	+	+	-	-	-
S. indeprensa	±dense	+	+	-	+	-
S. meyeri	±sparse	+	+	-	-	-
S. microphylla	±dense	+	+	-	-	-
S. nizvana	±dense	+	+	-	-	-
S. oligophylla	very sparse	+	+	-	-	-
S. palinotricha	±dense	-	-	+	-	-
S. persepolitana	dense	-	+	+	-	+
S. persica	very sparse	+	+	-	-	-
S. sojakii	dense	+	+	+	-	-
S. multifida	±dense	-	+	+	-	-
S. odontopetala subsp. *odontopetala*	very sparse	-	+*	-	-	-
S. pungens	dense	+	+	-	-	-
S. marschallii subsp. *marschalii*	dense	+	+	-	-	-
S. schafta	very sparse	-	+	-	-	-
S. morganae	glabrous	-	-	-	-	-
S. cephalantha	glabrous	-	-	-	-	-
S. spergulifolia	±dense	+	+	-	-	-

Table 4. Some characteristic features of trichomes on calyx surface in the examined *Silene* taxa. 1 species, 2 density, 3 surface, 4 short, simple unicellular trichome, 5 short, simple multicellular trichome, 6 long, simple multicellular trichome, 7 simple branched trichomes, 8 short glandular trichome, 9 long glandular trichome (+: Presence, -: Absence, ±: approximately.)

1	2	3	4	5	6	7	8	9
S. ampullata	±dense	Wavy	+	+	-	-	-	-
S. aucheriana	±dense	papillate	+	+	+	-	+	-
S. commelinifolia subsp. *commelinifolia*	dense	smooth	-	-	-	-	+	+
S. elymaitica	±dense	Smooth	-	-	-	-	-	+
S. eriocalycina	±dense	papillate	+	+	+	-	-	-
S. guntensis	±dense	wavy	+	+	-	-	+	-
S. gynodioica	±dense	wavy	+	+	+	-	-	-
S. indeprensa	±dense	wavy	+	+	-	-	+	-
S. meyeri	±dense	smooth	-	+	+	-	+	-
S. microphylla	±dense	smooth	-	-	-	-	+	-
S. nizvana	±dense	wavy	+	+	-	-	-	-
S. oligophylla	dense	wavy	+	+	+	-	-	-
S. palinotricha	±dense	smooth	-	-	+	-	-	-
S. persepolitana	dense	smooth	-	-	+	-	-	+
S. persica	±dense	papillate	+	+	+	-	-	-
S. sojakii	±dense	smooth	-	-	-	-	-	+
S. multifida	±dense	papillate	+	+	+	-	-	-
S. odontopetala subsp. *odontopetala*	±dense	± wavy to smooth	+	+	+	+	+	+
S. pungens	±dense	wavy	+	+	-	-	+	+
S. marschallii subsp. *marschalii*	glabrous	-	-	-	-	-	-	-
S. schafta	very sparse	wavy	-	+	-	-	-	-
S. morganae	glabrous	-	-	-	-	-	-	-
S. cephalantha	±dense	wavy	+	+	-	-	+	-
S. spergulifolia	sparse	wavy	-	+	-	-	+	-

Glandular trichomes

A considerable variation is observed among the glandular trichomes. Based on the observed variations, glandular trichomes can be divided into two subtypes: short stalked (stalk length up to 100 µ, e.g., *S. microphylla*; fig. 1, 9) and long stalked (stalk length 100 to 450 µ, e.g., *S. sojakii*; fig. 1, 10) with a capitates head. Stalks of the glandular trichomes can be uni-cellular (e.g., *S. microphylla*, fig. 1, 9), bi-cellular (e.g., *S. elymaitica*, fig. 3, 5) or multi-cellular (e.g., *S. sojakii*, fig. 1, 10).

Non-glandular trichomes

Non-glandular trichomes exhibit two different subtypes: branched and unbranched. Branched non-glandular trichomes are only observed in *S. odontopetala* subsp. *odontopetala* (fig. 1, 11). These trichomes possess two arms that arise from apex of the stalk. Most of the non-glandular trichomes in our study group were unbranched.

Some features of unbranched non-glandular trichomes including size, shape, number of cells in trichome body, and presence of papillae on trichome surface provide useful diagnostic characters for recognizing examined taxa.

Size of unbranched non-glandular trichomes varies from short (up to 300 µm, e.g., *S. meyeri*; fig. 1, 1) to long (300 to 900 µm, e.g., *S. palinotricha;* fig. 1, 8). Unbrached trichomes are unicellular (e.g., *S. meyeri*; fig. 1, 1), bi- or multicellular (e.g., *S. ampullata*; fig. 1, 2). Short unbranched non-glandular trichomes are erect (e.g., *S. persica*; fig. 4, 22), curved (e.g., *S. ampullata*; fig. 4, 31, *S. cephalanta*; fig. 4, 36) or appressed (e.g., *S. eriocalycina*; fig. 4, 7, *S. gynodioica*; fig. 4, 8). These trichomes show two different surface types: wavy (e.g., *S. gynodioica*; fig. 4, 8, *S. guntensis*; fig. 4, 9) or papillate (e.g., *S. eriocalycina*, fig. 4,7; *S. persica*, fig. 4, 22). Short unbranched trichomes also differ in shape. Four different shapes seen in the study group are as acicular with an acute apex (e.g., *S. aucheriana*, fig. 3, 2; *S. schfata*, fig. 4, 39), curved towards the tip with an acute apex (e.g., *S.persica*, fig. 4, 22), curved towards the tip and blunt at the apex (e.g., *S. ampullata*; fig. 4, 30), and conical in shape, curved towards the tip and blunt or acute at the apex (e.g., *S. eriocalycina*, fig. 4,7; *S. cephalanta*, fig. 4, 36).

Long unbranched trichomes range from erect (e.g., *S. oligophylla*, fig. 4, 17; *S. multifida*, fig. 4, 29; *S. persica*, fig. 4, 21) to appressed (e.g., *S. palinotricha*, fig. 4,18 and 4,19). These trichomes have wavy (*S. oligophylla*, fig. 4, 17) to papillate (e.g., *S. eriocalycina*. fig. 4, 6; *S. persica*, fig. 4, 21) surfaces. They are curved (e.g., *S. sojakii*, fig. 3, 22; *S. spergulifolia*, fig. 4, 37) or straight at tip (e.g., *S. multifida*, fig. 4, 29). The basal cell of stalk in long unbranched trichomes can be of the same size as the other cells of the stalk (e.g., *S. oligophylla*, fig. 4, 17; *S. palinotricha*, fig. 4, 18 and 4, 19) or broader than the others (e.g., *S. eriocalycina*, fig. 4, 6).

DISCUSSION

The value of trichome morphology in identification of some taxa of Caryophyllaceae has already been highlighted (Metcalfe and Chalk 1950; Chowdhuri 1957; Coode and Cullen 1967; Sahreen 2010). Metcalfe and Chalk (1950) reported various types of trichomes (unicellular, simple, long or short uniseriate, uniseriate with glandular cell at the apex, and branched) in different genera of Caryophyllaceae such as *Gypsophila*, *Saponaria* L., *Stellaria* L. and *Cerastium* L. The taxonomic significance of trichome micromorphology in the genus *Silene* has been investigated by different studies. For example, study of leaf epidermal anatomy of *Silene* by Sahreen (2010) showed that presence and absence of trichomes as well as trichome types provide useful information to identify *Silene* species. Our data are in agreement with previous studies in Caryophyllaceae confirming the usefulness of trichome characters in identification of some *Silene* taxa at infrageneric ranks.

Our investigation also showed that trichome characters are considerably variable among different species of *Silene*, even when assigned to the same section, but are constant among various populations of a certain species. Presence or absence of trichomes as well as trichome types, mainly on the calyx surface, could be used as a useful diagnostic character for characterizing some of the studied species. Different types of non-glandular trichomes are observed in most of the studied taxa and provide useful information for separating some of the investigated species. For example, presence of multi-cellular branched trichomes characterizes *S. odontopetala* from the rest of the examined taxa (see also Chowdhuri, 1957). Vermiform trichomes are only present on calyces of *Silene palinotricha* (Sect. *Auriculatae*) and can easily be used to discriminate this species. *Silene eriocalycina* and *S. gynodioica*, two closely related species from sect. *Auriculatae*, differ from each other by their calyx trichomes. *Silene eriocalycina* possesses short unbranched conical trichomes with an acute apex and papillate surface as well as long papillate trichomes, whereas *S. gynodioica* is characterized by having appressed short and long unbranched trichomes with wavy surface. *Silene meyeri* and *S. Sojakii*, other closely related members of the sect. *Auriculatae*, could also be separated with their calyx trichomes. *Silene meyeri* has short-stalked capitate glandular trichomes on its calyx, while *S. sojakii* possesses long-stalked capitate trichomes.

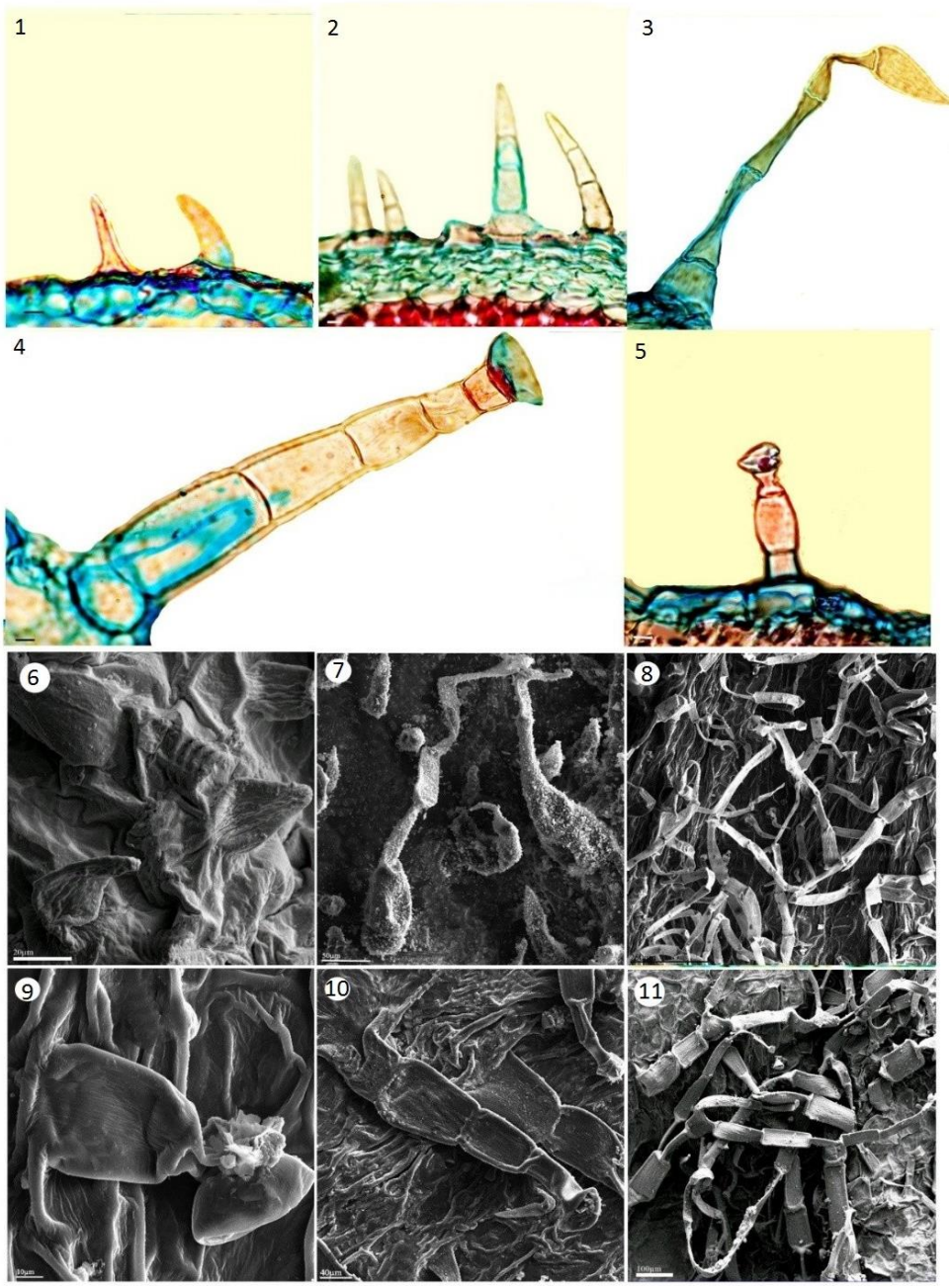

Fig. 1. Trichome types in selected species of *Silene*. 1-5, Light microscopy (scale bar=10µm) with Safranin-Fast green staining. 6-11, SEM micrographs. 1, short, unbranched unicellular trichome in leaf surface of *S. meyeri;* 2, short, unbranched multicellular trichome in stem of *S. ampullata;* 3, long, unbranched multicellular trichome in leaf of *S. sojakii*; 4, long glandular trichome with multicellular stalk in leaf of *S. elymaitica;* 5, short glandular trichome with multicellular stalk in stem of *S. commelinifolia* subsp. *commelinifolia*; 6, short unbranched unicellular trichome on calyx surface of *S. cephalantha* (scale bar=20µm); 7, unbranched multicellular trichomes with densly papillose surface in *S. eriocalycina* (scale bar=50µm); 8, unbranched multicellular and vermiform trichomes in *S. palinotricha* (scale bar=250µm); 9, short glandular trichome with unicellular stalk in *S. microphylla* (scale bar=10µm); 10, long glandular trichome with multicellular stalk in *S. sojakii* (scale bar=40µm); 11, unbranched branched trichomes in *S. odontopetala* subsp. *odontopetala* (scale bar=100µm).

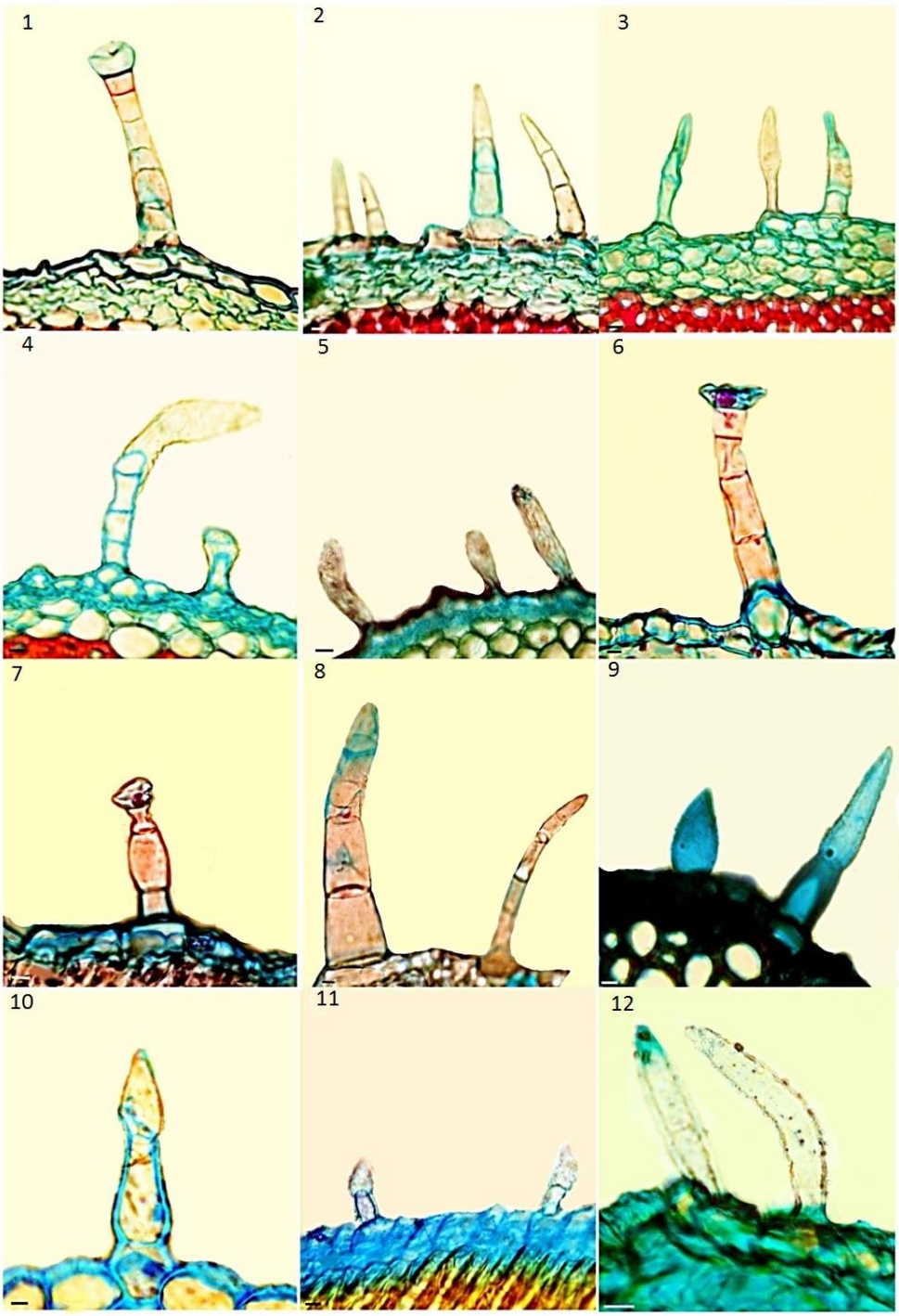

Fig. 2. LM micrographs of trichomes on stem surface in *Silene* species; 1-2, *S. ampullata*; 3, *S. aucheriana*; 4-5, *S. cephalantha*; 6-8, *S. commelinifolia* subsp. *commelinifolia*; 9-10, *S. elymaitica*; 11, *S. guntensis*; 12, *S. gynodioica* (scale bar=10µm).

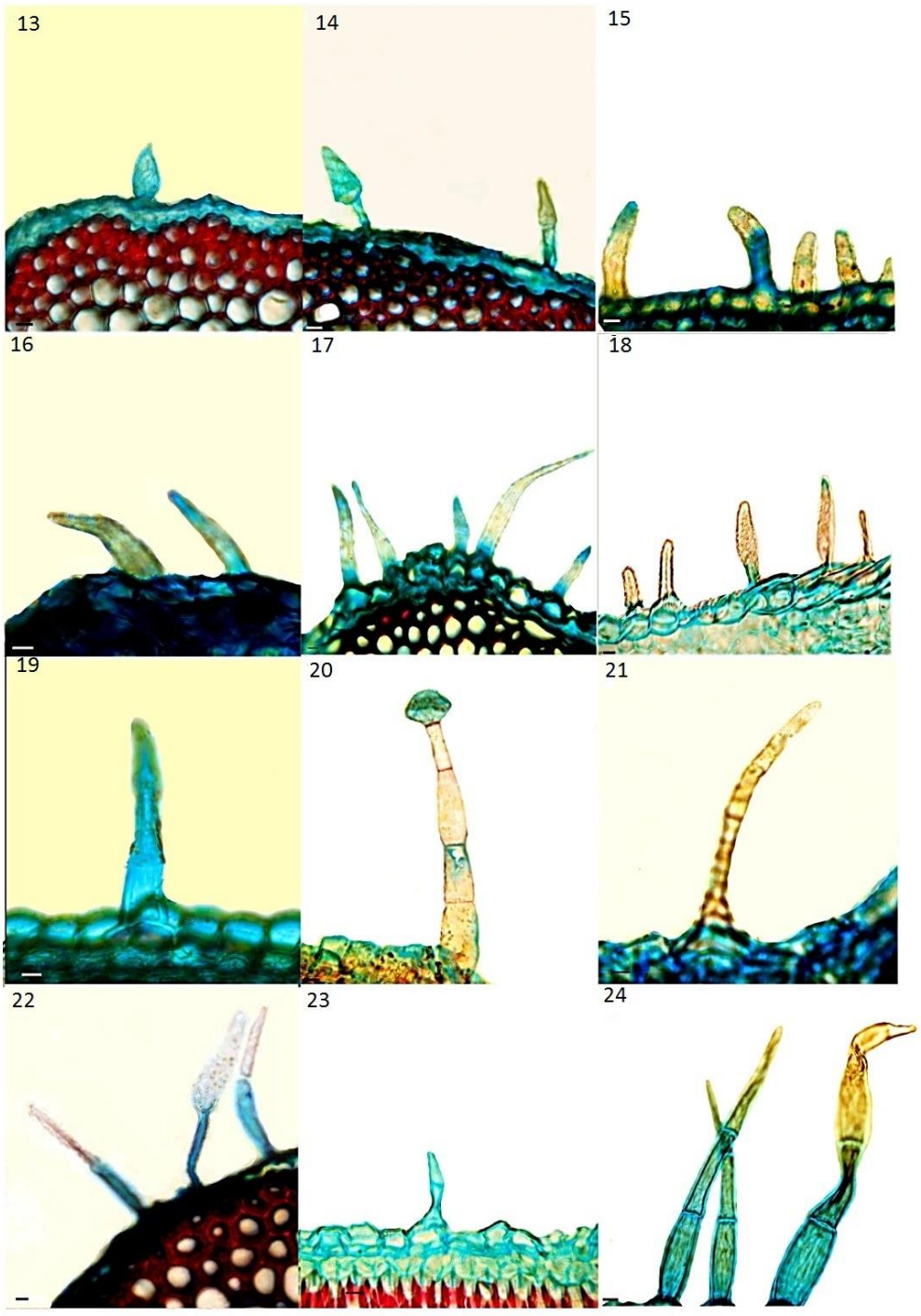

Fig. 2. Continued. 13-14, *S. indeprensa*; 15, *S. marschalii* subsp. *marschalii*; 16, *S. meyeri*; 17, *S. microphylla*; 18, *S. nizvana*; 19, S. *palinotricha*; 20, S. *persepolitana*; 21, *S. persica*; 22, *S. pungens*; 23, *S. schafta*; 24, *S. sojakii* (scale bar=10µm).

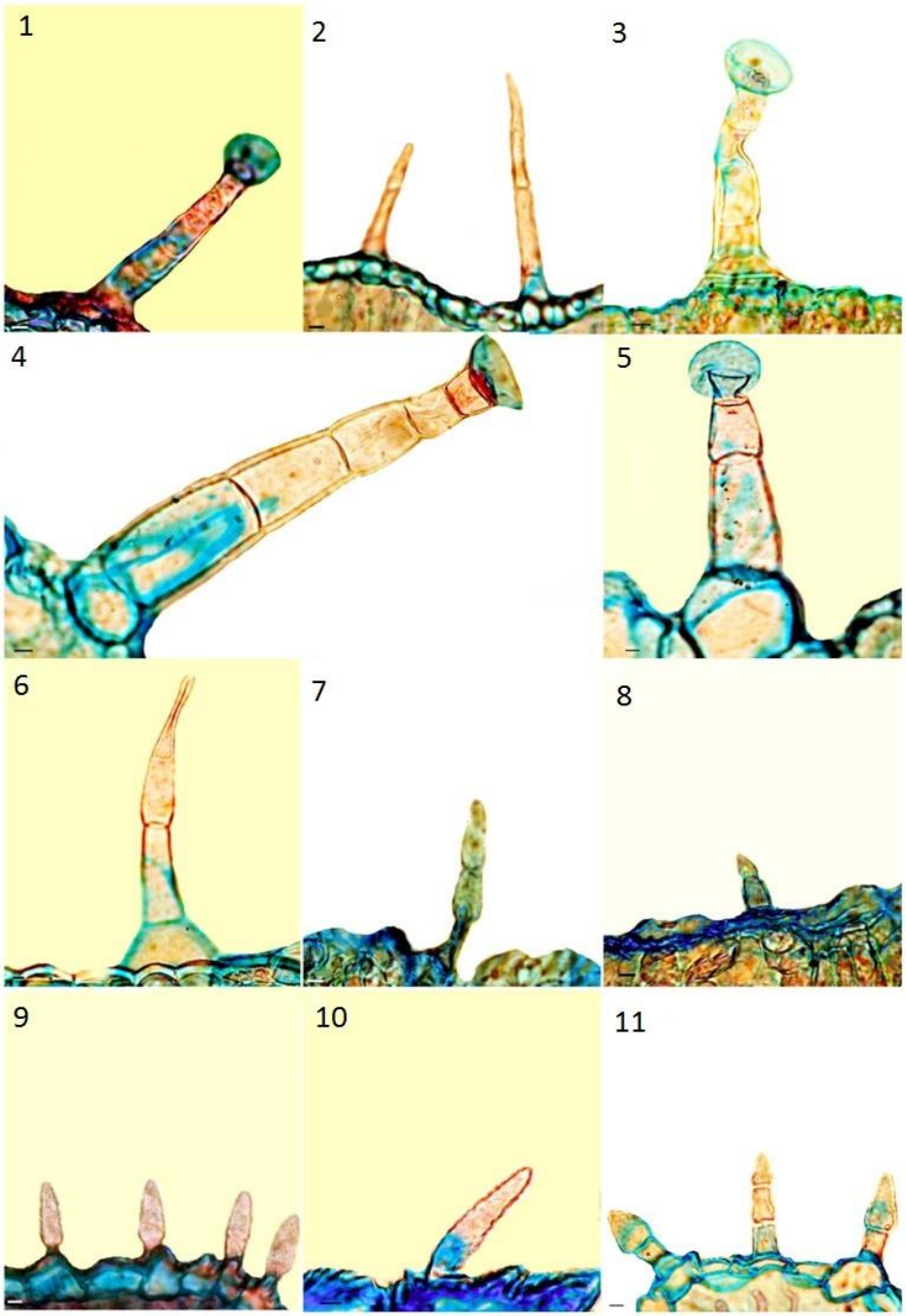

Fig. 3. LM micrographs of trichomes on leaf surface in *Silene* species; 1, *S. amullata*; 2, *S. aucheriana*; 3, *S. commelinifolia* subsp. *commelinifolia*; 4-6, *S. elymaitica*; 7-8, *S. guntensis*; 9-10, *S. gynodioica*; 11, *S. indeprensa* (scale bar=10µm).

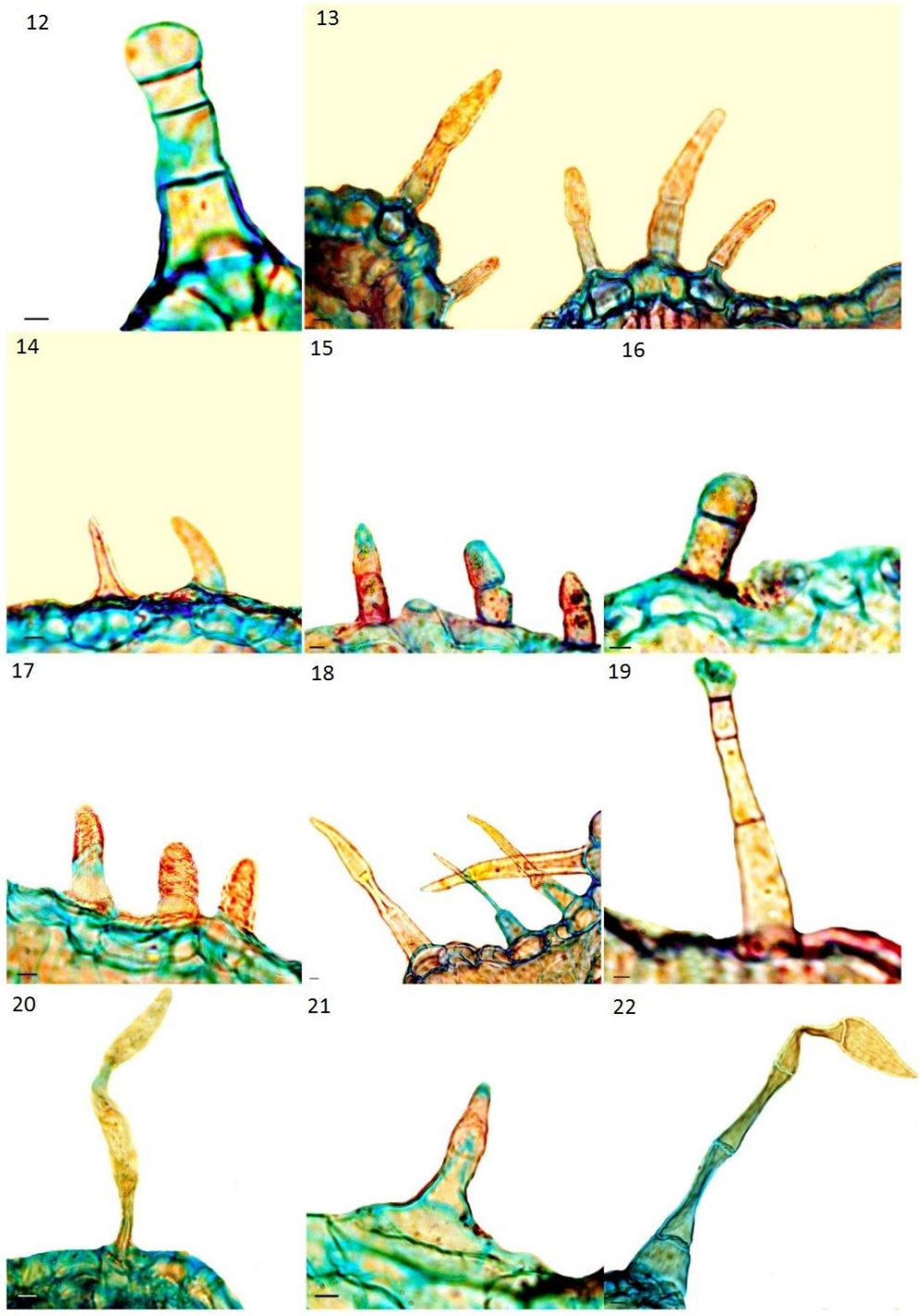

Fig. 3. Continued. 12, *S. indeprensa*; 13, *S. marschalii*; 14, *S. meyeri*; 15-16, *S. microphylla*; 17, *S. nizvana*; 18, *S. palinotricha*; 19, *S. persepolitana*; 20, *S. pungens*; 21, *S. schafta*; 22, *S. sojakii* (scale bar=10µm).

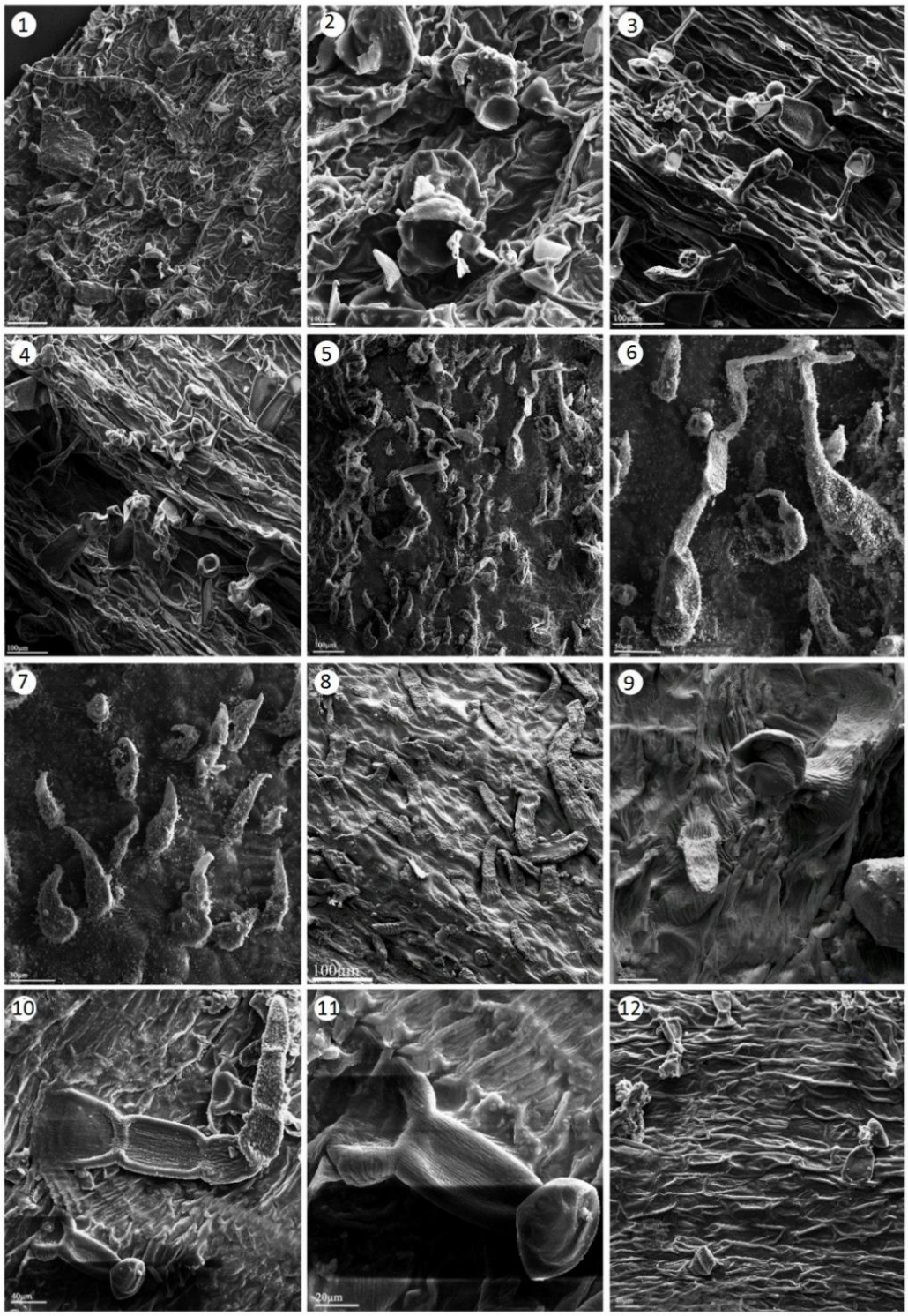

Fig. 4. SEM micrographs of trichomes on calyx surface in *Silene* species; 1-2, *S. aucheriana*; 3-4, *S. elymaitica*; 5-7, *S. eriocalycina*; 8, *S. gynodioica*; 9, *S. guntensis*; 10-11, *S. meyeri*; 12, *S. microphylla*.

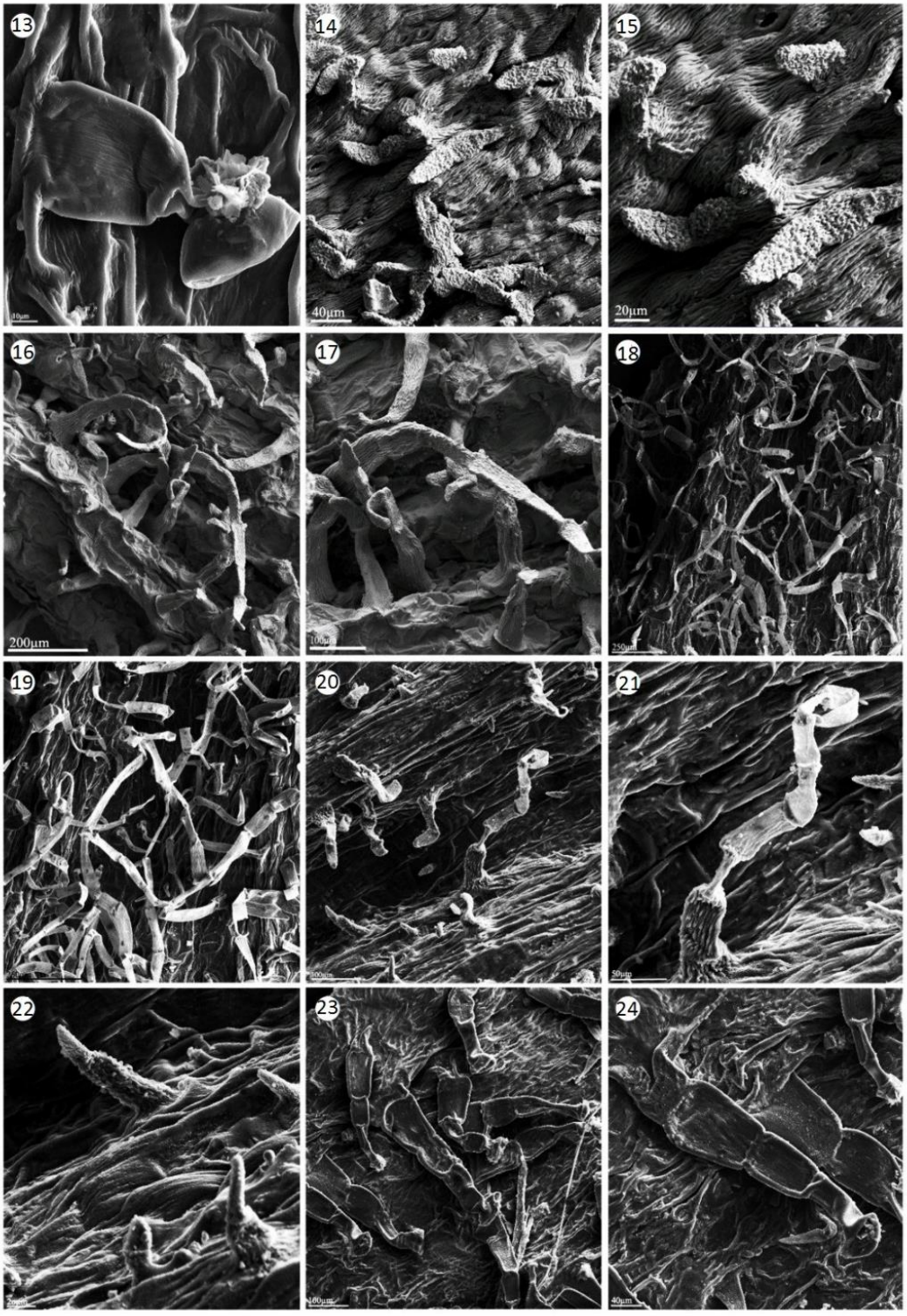

Fig. 4. Continued. 13, *S. microphylla*; 14-15, *S. nizvana*; 16-17, *S. oligophylla*; 18-19, *S. palinotricha*; 20-22, *S. persica*; 23-24, *S. sojakii*.

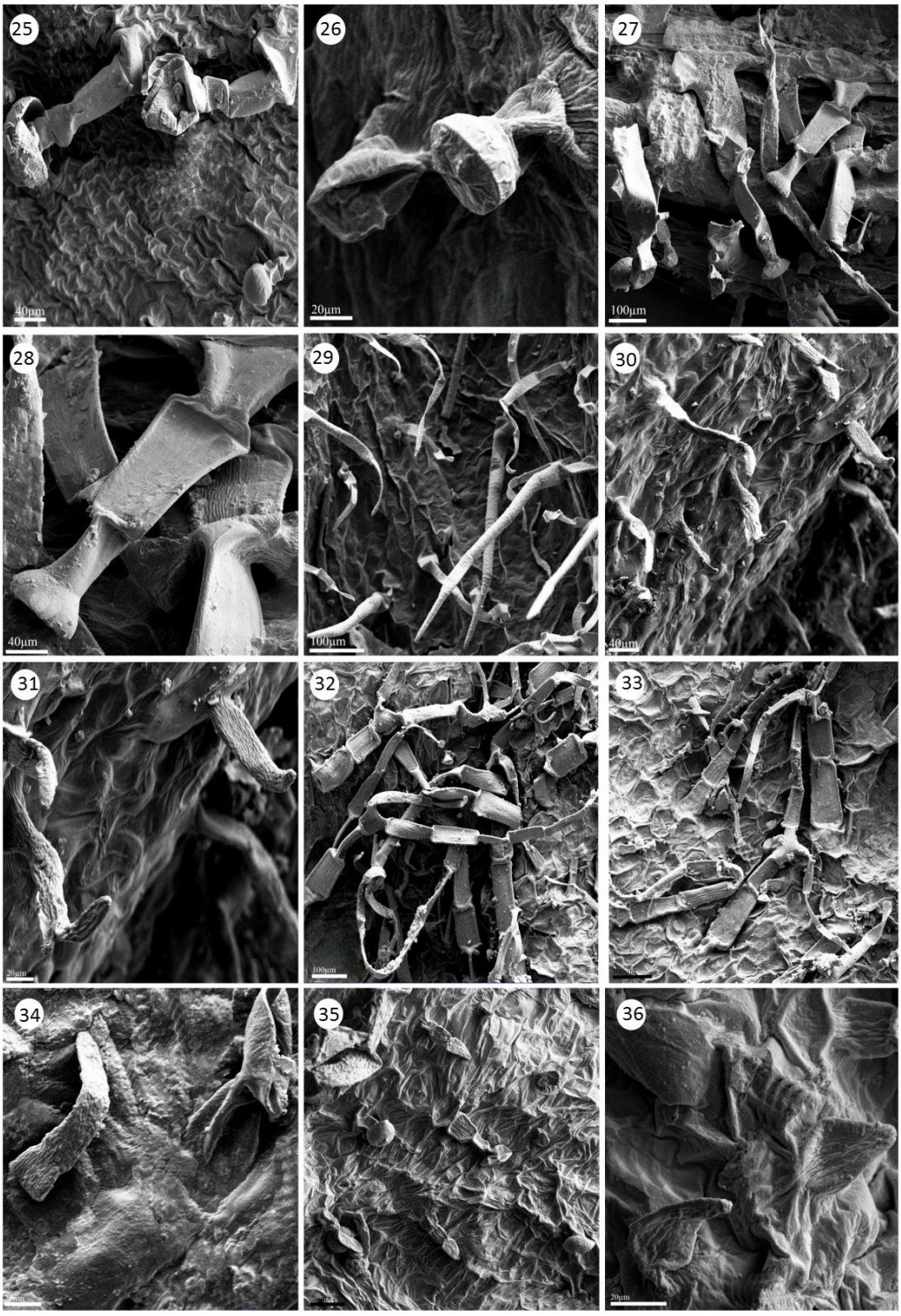

Fig. 4. Continued. 25, *S. commelinifolia* subsp. *commelinifolia*; 26, *S. indeprensa*; 27-28, *S. persepolitana*; 29, *S. multifida*; 30-31, *S. ampullata*; 32-33, *S. odontopetala*; 34, *S. pungens*; 35-36, *cephalantha*.

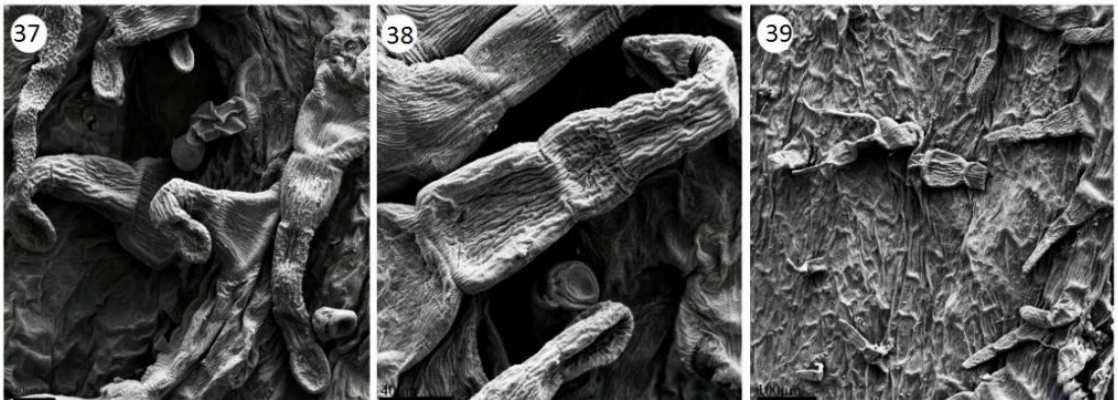

Fig. 4. Continued. 37-38, *S. spergulifolia*; 39, *S. schafta*.

The present study indicated that although trichome micromorphology is helpful for characterizing some species of *Silene*, it is of low phylogenetic value and suitable for separation of closely related species within the same section rather than characterizing larger natural groups such as sections.

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