

Full Length Research Paper

Comparative morphological and ecological studies of two *Stachys* species (sect. *Eriostomum*, subsect. *Germanicae*) grown in Turkey

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In this study, comparative morphological and ecological studies of *Stachys balansae* and *S. carduchorum* were investigated. Morphologically, general views of taxa and micromorphological features of the trichomes were studied. *S. balansae* differs from *S. carduchorum* in its leaves sericeous-pilose on the upper surface and narrow oblong-lanceolate cauline leaves. It was observed that there are some differences in calyx and leaves indumentum in two species. In ecological studies, *Stachys* species grow on loamy and clayey-loamy soils, with pH of 7.29 to 7.60, with 2.32–6.06% of organic matter, 110-172% of total salt content, 8.02 -24.51% phosphorus and 204-254% potassium.

Key words: Morphology, Micromorphology, Ecology, Lamiaceae, *Stachys*, Turkey.

INTRODUCTION

Stachys L., one of the largest genera of the Lamiaceae, contains about 300 species. It is a cosmopolitan genus centred in the warm temperate regions of the Mediterranean and South West Asia, with secondary centres in North and South America and Southern Africa; it is not present in Australia and New Zealand (Bhattacharjee, 1980). *Stachys* has 90 species (115 taxa) belonging to 13 subsections, 15 sections and 2 subgenera in Turkey. Of the 115 taxa, 54 (47%) are endemic to Turkey (Bhattacharjee, 1974, 1982; Davis et al., 1988; Sümbül, 1990; Falciani, 1997; Duman, 2000; Dinç and Doğan, 2006; İlçim et al., 2008; Daşkin et al., 2009; Akçiçek, 2010; Yılmaz et al., 2010; Martin et al., 2011; Erdoğan, 2011).

Stachys species are known in Anatolia as Adaçayı and Dağ çayı, and used as sage and in popular medicines to treat genital tumours, sclerosis of the spleen, inflammatory tumours, coughs and ulcers (Potoğlu-Erkaya and Koyuncu, 2007). Teas prepared from the whole plant or leaves are used in phytotherapy, possessing sedative,

as antispasmodic, diuretic and emmenagogue activities (Jovanovic et al., 2008). In addition, its aerial parts are orally used as herbal tea in the treatment of various infections, asthmatic, antibacterial, antioxidant rheumatic and other inflammatory disorders (Couladis et al., 2003; Grujic-Jovanovic et al., 2004; Matkowski and Piotrowska, 2006; Jovanovic et al., 2008; Ebrahimabadi, 2010). Recently, some studies have been conducted on the morphological and ecological of *Stachys* species (Demissew and Harley, 1992; Falciani et al., 1995; Šilić and Šolić, 2002; Uysal, 2002, 2003; Potoğlu-Erkaya 2007, Dinç and Öztürk 2008; Salmaki et al. 2008a, b, 2009; Dirmenci et al., 2010; Erdoğan, 2011). The aim of this study was to present the morphological and ecological features of two *Stachys* taxa close to each other and to discuss their taxonomic values.

MATERIALS AND METHODS

Plant specimens of the 2 species were collected from their typelocalities. Information about the plant material is given in Table 1. Species collected were examined in the herbaria and were determined using the relevant literature (Bhattacharjee, 1982; Duman, 2000). The specimens were dried according to standard

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Table 1. Specimens of *S. balansae* and *S. carduchorum* examined in Turkey.

Species	Collection data
<i>S. balansae</i>	<p>Turkey. A4 Kastamonu: between Cide and Doğanyurt, 50 m, Yıldız 16556. A6 Sivas: Şerefiye, 1800–2000 m, Yıldız 4922; Çamlıkale, 1600–1800 m, Yıldız 6868; Suşehri, 1300 to 1500 m, Yıldız 5740. A7 Giresun: Balaban dağları, 2700 m, P.H.Davis 20579, Dodds & Çetik (BM,K). A8 Artvin: Yusufeli, 1500 m, Yıldız 16704; Şavşat, 1400 m, Akçiçek 5227 & Dirmenci; Murgul, 2470 m, A.Düzenli 758 (ANK,E); Murgul, 2600 m, A.Duran 6846. Erzurum: Kop dağı, 2450 m, Akçiçek 5154 & Dirmenci; between Erzurum and İspir, 2000–2200 m, Z.Aytaç 3187 (GAZI); Kop dağı, 2450 m, Yıldız 16851; Kop dağı, 2300 m, Nydegger 12886 (G); between Erzurum and Tortum 1900 m, Nydegger 19293 (G); 23 km N from Aşkale to Trabzon, 2390 m, Uotila 19636 (G). Rize: Çamlıhemşin, 1980 m, Akçiçek 5238 & Dirmenci; İkizdere, 2450 m, Akçiçek 5233 & Dirmenci; Çamlıhemşin, 2900 m, Güner 3001 (ANK); İkizdere, 2400–2500 m, Güner 6594 & Vural (GAZI); Çamlıhemşin, 3000 m, Güner 4499 (ISTE 50227); İkizdere, Başköy, 2200 m, Güner 6075 (GAZI). Bayburt: Kop dağı, 2490 m, Hamzaoğlu 3543 (GAZI); Bayburt, 1500 m, Nydegger 19163 (G). A9 Erzurum: Olur, 2350 m, 05.08.2008, Yıldız 16861. Ardahan: Ulgar pass, 2540 m, 07.08.2008, Yıldız 16883. Kars: Sarikamiş, 2050 m, 15.07.1966, P.H.Davis 46552 (K). Artvin: Yalnızçam pass 2300 m, 11.07.1959, Hub-Mor. 15273 (G); Ardanuç, 1700 m, 27.06.1957, P.H.Davis 30103 & Hedge (ANK,K). B5 Kayseri: Bakir Da., 2000 m, 29.06.1952, P.H.Davis 19437 Dodds & Çetik (ANK,K). B6 Kahramanmaraş: Göksun, Doğankonak, Binboğa dağı, 1800–2150 m, 02.07.1992, Z.Aytaç, H.Duman, No: 5228, (GAZI); Çardak, Berit Dag, 2800 m, 26.07.1952, P.H.Davis 20349, Dodds & Çetik, (ANK,BM,G,K,W). Sivas: Kunduz Dağ, 1800 m, 13.07.1969, Sorger 69-52-18 (W). B7 Tunceli: Pülümür to Mutu, 1780 m, 07.07.1959, Hub-Mor. 15272 (G).Munzur dağı, Ovacık, 2400 m, 18.07.1957, P.H.Davis 31371 & Hedge (ANK). Erzincan: Keşiş Dağı, 2500–2600 m, 26.07.1957, P.H.Davis 31668 & Hedge (ANK,G,ISTE,K,W); between Erzincan and Kelkit, 2300 m, 02.07.2006, Hamzaoğlu 4122(BOZOK). B8 Erzurum: 20 km from Hınıs to Pasinler, 1900 m, 12.07.1966, P.H.Davis 46343 (ISTE 52337, K); Erzurum, Eğerti village, 13.07.1976, 2200 m, A.Tatlı 4644 (E). Muş: Bulanık-Muş, 2000 m, 14.07.1951, Hub-Mor. 11388 (G). B9 Ağrı: Tahir village, 2450 m, 12.08.2007, Dirmenci 3547. Bitlis: Reşadiye, Pelli, 1900 m, 06.07.1954, P.H.Davis 22366, O.Polunin, (ANK,K); Kars: Susuz, 2500 m, 06.09.1993, Y.Altan 5652 (GAZI); Ziyaret Da., 2250 m, 29.06.1957, P.H.Davis 30302 & Hedge (ANK,BM,G). C5 Adana: Bakir Da., 2000 m, 29.06.1952, P.H.Davis 19437 (ANK). C6 Kahramanmaraş: Engizek Dağı, 2000 m, 22.07.1987, H.Duman 3640 (GAZI); Ahır Dağ, 1830–2135 m, 07.1907, Haradjian 1663 (G,W); Çardak, Berit Dağ, 2800 m, 26.07.1952, P.H.Davis 20349, Dodds & Çetik (G, ISTE, W).</p>
<i>S. carduchorum</i>	<p>Turkey. B9 Bitlis: Karz Dağ, above Kotum, 6500 ft., 28.06.1954, P.H.Davis 22230 & Q.Polunin (K); ibid., 2200 m, 24.08.1954, P.H.Davis 24593 & Q.Polunin (ANK,BM,G,K); Van: Çatak, Kavuşşahap mountain, Karapet pass, 2750 m, 24.07.2009, Akçiçek 5335 & Dirmenci (ISTE); ibid., 3100 m, 23.07.1954, P.H.Davis 23214 & Q.Polunin (ANK,BM,K); ibid., 22.07.1954, P.H.Davis 23032 & Q.Polunin (BM,K); Artos Da., 3000 m, 02.09.1956, McNeill 751 (K); Bitlis / Van: 10 km S.E. of Belli, 9000 ft., 08.07.1954, P.H.Davis 22571 & Q.Polunin (K). C9 Hakkari: Cilo Da, 2438 m, 10.08.1954, P.H.Davis 24265 & Q.Polunin (Isotypes: ANK, BM, K); Cilo Tepe, ca. 3100 m, 08.08.1954, P.H.Davis 24076 & Q.Polunin (ANK,BM,K). C10 Hakkari: Sat Dağı, 1750–1900 m, 30.06.1966, P.H.Davis 45733 (K).</p>

herbarium techniques and stored in the Herbarium of Necatibey Education Faculty, Balıkesir University, Turkey.

General view of species were demonstrated by illustrations and biometrical measures of whole plant were taken. An Olympus SZX12 stereomicroscope with drawing tube was performed for morphological examinations and illustrations. The dried plant samples were mounted on standard SEM pin mount stubs using a double-sided conductive carbon tape. The samples were then coated with a thin layer of gold-palladium using a Cressington 108 Auto sputter coater to reduce charging. The coated samples were imaged using a Hitachi S-4800 Scanning Electron Microscope (SEM) at an accelerating voltage of 5–15 KV and working distances ranging from 20–22 mm at University of Toledo, Ohio, USA. The SEM micrographs were then analyzed.

For ecological studies, soil samples were taken from type

localities. The chemical analysis of soil samples were made in the laboratory of Basic Sciences Research and Applied Center, Balıkesir University. Soil texture, EC, pH, CaCO₃, P₂O₅, K₂O, various elements (Zn, Fe, Cu and Mn) and organic matter were analyzed and the results have been evaluated (Anonymus, 1990 a,b,c,d, 1995; Tüzüner, 1990; Dönmez, 2004).

RESULTS

Morphological characteristics

Stachys balansae Boiss. & Kotschy (Figure 1)

It is a perennial mesophytic herb, usually with basal

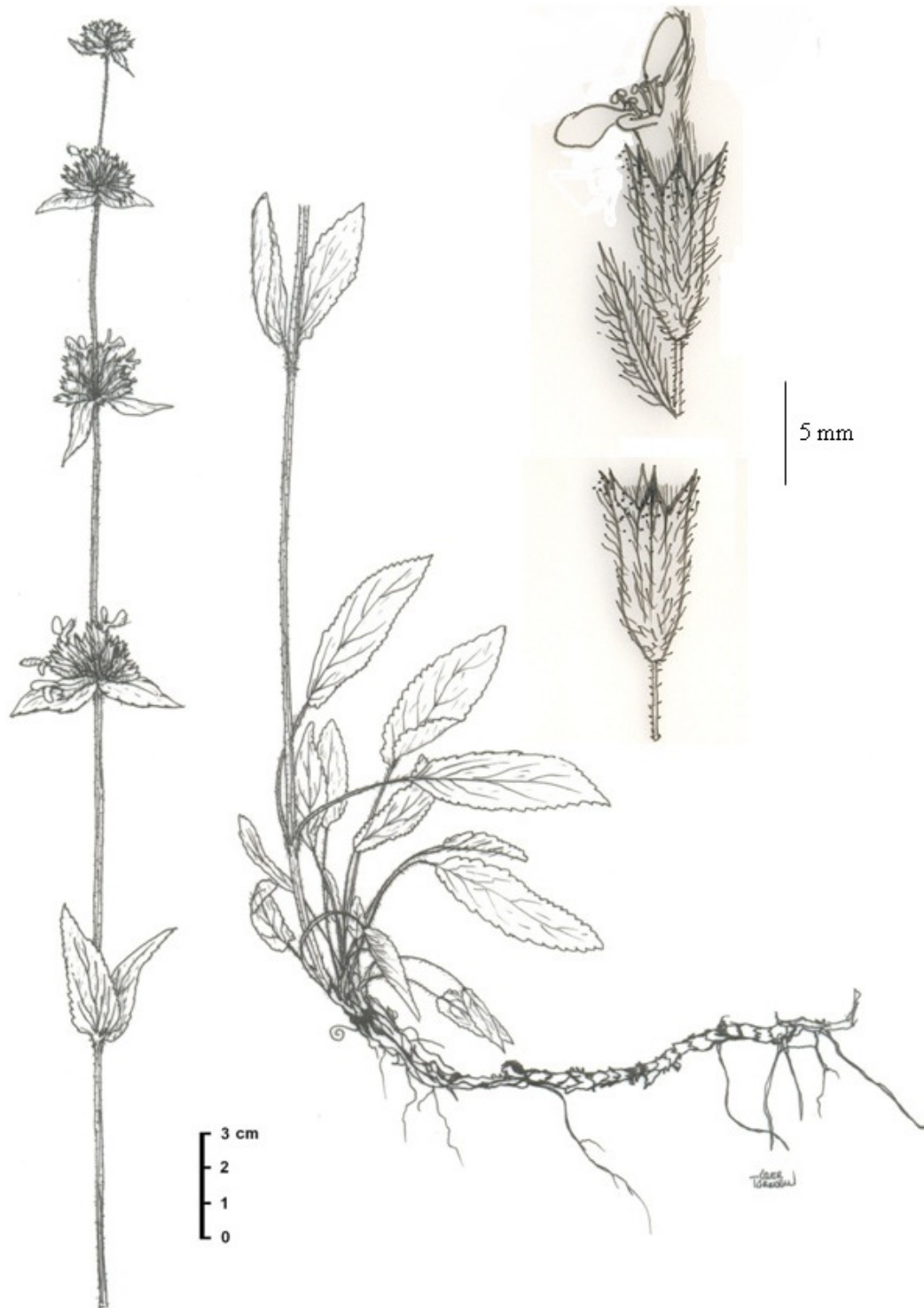


Figure 1. General view of *S. balansae* (EA 5227).

sterile rosettes. Flowering stems are 25 to 100 cm in length, simple or rarely branched, erect, tomentose-villous to villous or pilose with eglandular and glandular hairs. Basal leaves are oblong to ovate-oblong, 2.5 to 11 x 1 to 3.5 cm, margin crenate-serrate, apex obtuse to

acute, cordate to subcordate at base, petiole 3 to 11 cm. Cauline leaves are usually narrowly oblong to oblong-lanceolate, rarely broadly ovate to ovate-lanceolate, 2 to 10 x 1 to 3(-5) cm, gradually becoming smaller above, margin crenate-serrate, rarely serrate, apex acute, rarely

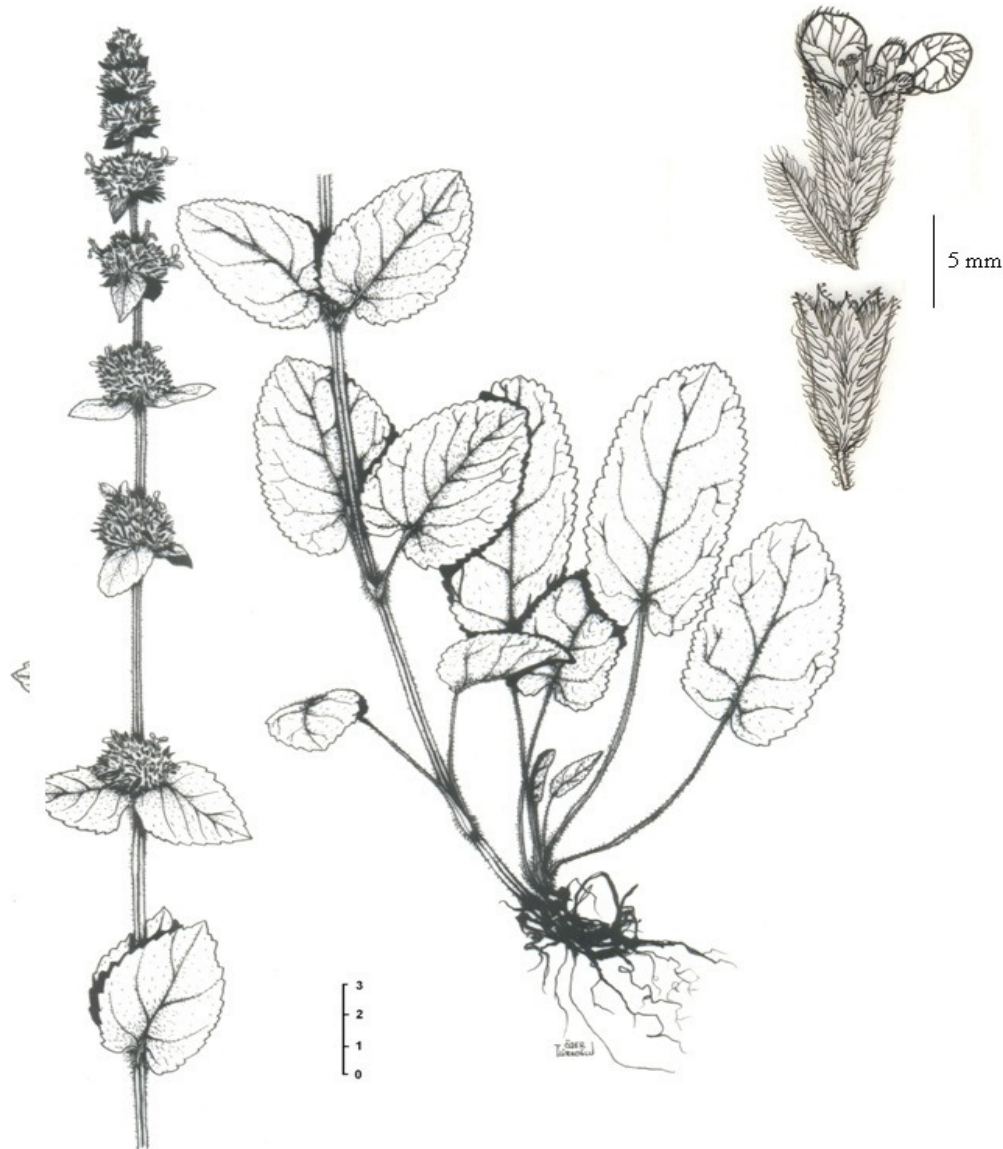


Figure 2. General view of *S. carduchorum*. (EA 5335).

obtuse, cordate to subcordate at base, subsessile or petiolate to 7 cm. All leaves are usually sericeous-pilose on upper surface, softly villous beneath. Floral leaves are ovate-lanceolate to lanceolate, rarely ovate, sessile, as long as or longer than verticillasters. Verticillasters are 2 to 10, remote throughout or the lower (2 to 8) is remote, distant to 8 cm, the upper is (2 to 6) approximate, 17 to 25 flowered.

Bracteoles lanceolate to linear, 4 to 18 mm, herbaceous, tip not spinescent. Pedicels are 1.5 to 7.5 mm. Calyx is sub-bilabiate, subcampanulate, 8 to 12 mm, sparsely sericeous, mouth with hair ring; teeth subequal, ovate to ovate-lanceolate, $\frac{1}{2}$ to $\frac{1}{3}$ x tube, erect to slightly recurved in fruit, glandular hairy, tip spinescent, mucro 0.5 to 1 mm. Corolla rose-pink, 14 to 18 mm, tube subincluded, bilabiate, upper lip entire, lower lip 3-lobed,

middle lobe much larger than 2-lateral lobes, upper lip densely sericeous-tomentose on outside, hairs usually exceeding the lip. Style does not exceed the upper lip, 2 branched, branches are equal. Stamens are 4, including thecae divaricate, filaments with hairs from base to middle. Nutlets \pm rounded, faintly trigonous, 1.8 to 2.2 x 1.5 to 2 mm, slightly winged near base, blackish-brown at maturity.

***Stachys carduchorum* (R. Bhattacharjee) Rech.f. (Figure 2)**

It is perennial mesophytic herb with basal sterile rosettes. Flowering stems are 40 to 65 cm in length, simple, rarely branched, erect, patent white-villous with sessile

Table 2. Soil characteristics of *S. balansae* and *S. carduchorum* growing regions.

Species	Texture	Total salt (%)	pH	CaCO ₃ (%)	P ₂ O ₅ (%)	K ₂ O (%)	Organic matter (%)	N	Zn	Fe	Cu	Mn
<i>S. balansae</i>	Loamy	110	7.60	4.91	24.51± 0.52	254.33 ± 21.95	2.32	0.04	0.59± 0.19	7.88 ± 0.96	1.91 ± 0.18	15.27 ± 0.37
<i>S. carduchorum</i>	Clayey-loamy	172	7.29	11.62	8.02 ± 0.52	204.24 ± 21.90	06.06	0.3	0.91 ± 0.19	15.9 ± 0.94	1.42 ± 0.18	9.85 ± 0.37

glands. Basal leaves are ovate-oblong, margin are distinctly crenate-dentate, apex is obtuse to acute, cordate at base, petiole is 3 to 8 cm. Cauline leaves are ovate to broadly elliptic, 3 to 10 x 1 to 5 cm, gradually becoming smaller above, margin is distinctly crenate to serrate, apex rotund or obtuse to acute, cordate to subcordate at base, membranous when dry, green on both surfaces, distinctly reticulate-veined, subsessile or petiolate to 7 cm. All leaves are glabrescent or sparsely (rarely densely) pilose on both surfaces. Floral leaves are ovate to ovate-lanceolate, rarely lanceolate, apex acute, margin sharply serrate to entire, sessile, as long as or longer than verticillasters. Verticillasters are 2 to 8, usually the lower (1 to 5) remote, 1.5 to 9 cm distant, the upper (2 to 4) is congested, rarely remote throughout, 10 to 20 flowered. Bracteoles are numerous, lanceolate to linear or filiform, 5 to 13 mm, herbaceous, tip not spinescent, with shortly glandular hairs. Pedicels is 1 to 4 mm. Calyx is subbilabiate, subcampanulate, 8 to 11 mm, densely sericeous, mouth with hair ring; teeth subequal, ovate-lanceolate, c. 1/3 x tube, erect to slightly recurved in fruit, with shortly glandular hairs, tip spinescent, mucro 0.2 to 0.5 mm. Corolla is purplish-pink, 13 to 15 mm, tube subincluded, bilabiatae, upper lip emarginate, lower lip is 3-

lobed, middle lobe is much larger than 2-lateral lobes, upper lip is densely sericeous tomentose on outside, hairs are usually exceeding the lip. Style does not exceed the upper lip, 2 branched, branches are equal. Stamens are 4, including thecae divaricate, filaments are with hairs from base to middle. Nutlets are obovoid, faintly trigonous, 2.5 to 3 x 1.8 to 2 mm, distinctly winged near base, glabrous, blackish-brown at maturity.

Ecological characteristics

S. balansae and *S. carduchorum* have been determined to grow on loamy and clayey-loamy soils, with pH 7.29-7.60, with 2.32–6.06% of organic matter, 110-172% of total salt content, 8.02 - 24.51% phosphorus and 204-254 % potassium. The results obtained from ecological studies are shown in Table 2.

DISCUSSION

In this study, morphological and ecological features on the two *Stachys* species from subsect. Germanicae of sect. Eriostomum were investigated. Also, micromorphological characters (trichomes)

were examined.

S. balansae differs from *S. carduchorum* in its leaves sericeous-pilose on upper surface and narrowly oblong-lanceolate cauline leaves. It was observed that there are some differences in calyx and leaves indumentum in the two species.

In micromorphological studies, selected SEM and LM micrographs of common indumentum types of stem, leaf and petiole of *S. balansae* and *S. carduchorum*, are presented in Figure 3.

Two basic types of trichomes can be distinguished: Glandular and non-glandular trichomes. Nonglandular trichomes are unbranched and unicellular or multicellular. Glandular trichomes are two types: Capitate and peltate. Capitate trichomes consist of short stalked (single cell base, short single cell neck and oval two cell head) and long stalked trichom (extended two cell base, single cell neck and oval two cell head) (Figure 3). Peltate trichomes consist of single cell base, single cell neck and eight cell head (Figure 3).

When analyzed soil structures of *Stachys* taxa; *S. balansae* prefers loamy, slight alkaline, non-saline, moderate calcareous, mild humic and fine total nitrogen whereas; *S. carduchorum* generally prefers clayey and loamy, notr, non-saline, many calcareous, many humic and great total nitrogen soils.

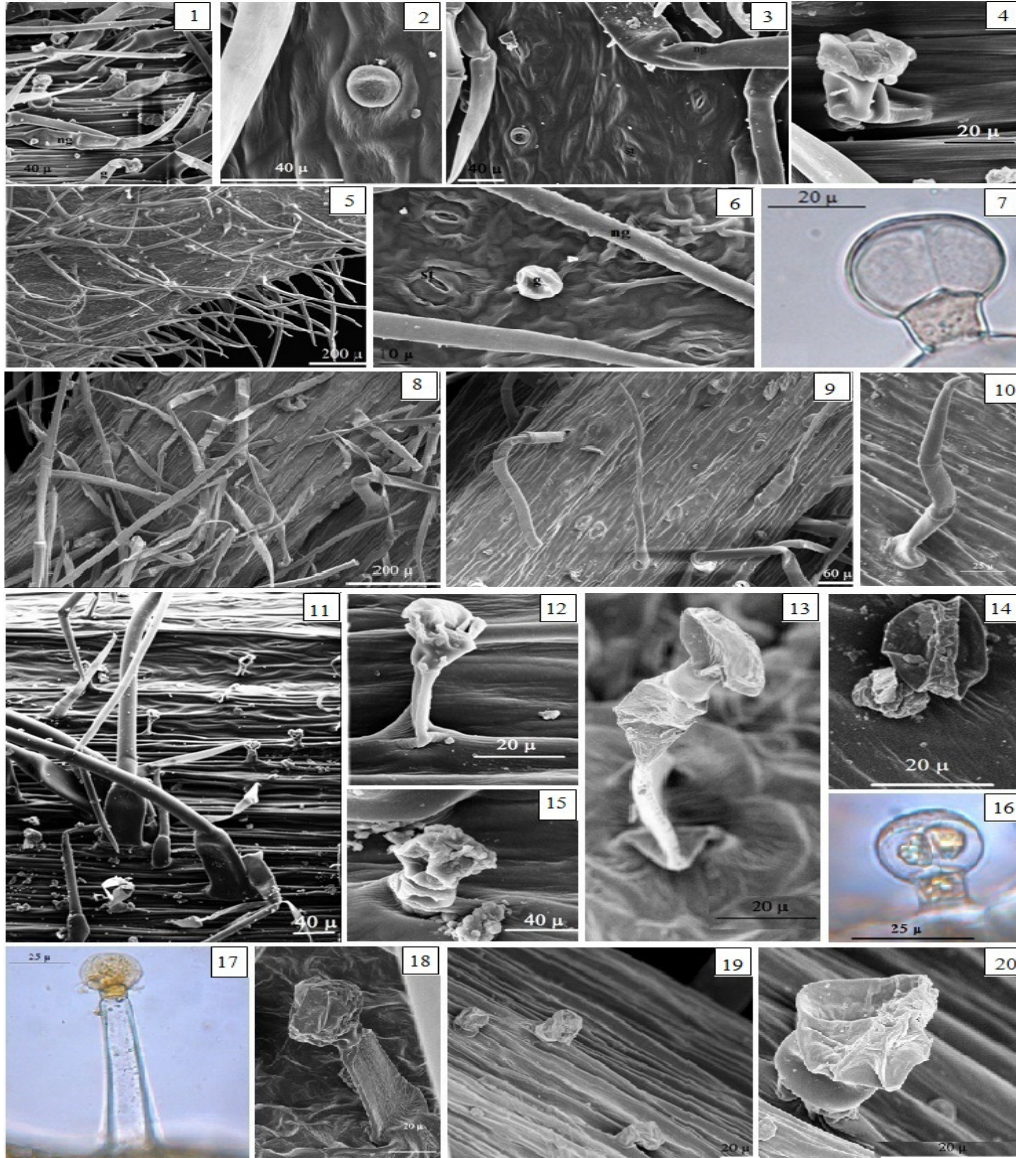


Figure 3. Trichome micromorphologies of stem, leaf and petiole of *S. balansae* (1 to 10) and *S. carduchorum* (11 to 20). Stem (1 to 4; 11 to 12), Leaf (5 to 7; 13 to 18), petiole (8 to 10; 19 to 20). G: glandular hair, ng: nonglandular hair.

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