Journal of New Results in Science
dergipark.org.tr/en/pub/jnrs
Open Access

ISSN: 1304-7981 14 (1) (2025) 48-61 doi.org/10.54187/jnrs.1654821

Glandular Trichomes on the Vegetative and Generative Organs of Endemic Two *Sempervivum* Taxa

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Article Info
Received: 10 Mar 2025
Accepted: 29 Apr 2025
Published: 30 Apr 2025
Research Article

Abstract − In this study, the morphological characteristics and distribution of glandular trichomes on the vegetative and generative organs of endemic two *Sempervivum* taxa (*Sempervivum brevipilum* and *Sempervivum gillianiae*) were comparatively investigated. *S. brevipilum* is the Irano-Turanian element and *S. gillianiae* is the Euxine element. In the trichome examinations, cross and surface sections were taken from the stems, rosette leaves, sepals and petals of the taxa. The trichomes were grouped under three groups as capitate, multicellular biseriate and uniseriate glandular trichomes. The multicellular biseriate and uniseriate glandular trichomes were observed on both vegetative and generative organs of the two taxa. In addition, capitate glandular trichomes one or two stalk and head celled were found on the organs of these taxa. Similar and different trichome features were given in tables. Mann Whitney U test was applied to the measurement results of trichomes features. No significant differences were found in the density and sparseness of long and short multicellular biseriate and uniseriate, capitate glandular trichomes. However, differences in the lengths of multicellular biseriate, uniseriate glandular and capitate glandular trichomes on the vegetative and generative organs of these two taxa were seen ($p < 0.05$). It was emphasized that different trichome characteristics (especially trichome length) are valuable taxonomic characteristics that can be used to distinguish these two *Sempervivum* taxa.

Keywords **–** *Sempervivum taxa, endemic, glandular trichomes, Crassulaceae*

1. Introduction

Members of the Crassulaceae family are xeromorphic structures, generally annual or perennial, herbaceous or shrubby plants. Taxa of the family is notable for the presence of water storage tissue in leaves and stems and the Crassulacean Acid Metabolism (CAM) feature [1-3]. Unlike C_3 and C_4 plants, CAM plants convert atmospheric CO_2 to C_4 acids at night and produce carbohydrates from this CO_2 the next day [4]. Although the family species are distributed worldwide, they are mostly distributed in the Northern Hemisphere [5]. Crassulaceae is represented by 8 genera, 79 species, and subspecies taxa (93 taxa in total) in Türkiye [6].

The *Sempervivum* L. genus, which belongs to the Crassulaceae family, includes herbaceous and perennial succulent plants with monocarpic rosettes that give them an advantage in vegetative reproduction. The genus grows in the mountainous regions of the Mediterranean, Southwestern Asia, the Caucasus, and Central and Southern Europe [7, 8]. Members of the genus show obvious phenotypic plasticity and hybridization property. This situation creates great difficulties in the identification and delimitation of taxa [9]. *Sempervivum* taxa are

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widely used in rock gardens, green roofs and succulent plant enthusiasts [2]. Recent studies have revealed that some *Sempervivum* species have high antimicrobial and antioxidant activity [10, 11]. *S. brevipilum* Muirhead is an Irano-Turanian element and is known among the people as the "life flower or density flower". Local people believe that this plant protects them from various spells. *S. gillianiae* Muirhead is a Euxine element and is called "desire grass" by the local people. In the areas where this species is distributed, people uproot it with its roots, hang it at doorways and make wishes. If the plant blooms, they believe that their wishes or desires will come true, and if they do not bloom, their wishes will not come true.

Trichomes, protect plants against abiotic and biotic stress factors such as herbivores, insect attacks, seed dispersal, seed protection, ultraviolet (UV) radiation, excessive transpiration, drought, salinity, and heavy metals [12,13]. On the other hand, trichomes are epidermal structures that are important in species identification, comparative systematic studies, and identification of powdered drugs. When plant samples are powdered, species identification and detection of forgery or substitution are extremely difficult. However, the presence and micromorphology of trichomes can be used as anatomical markers [14]. Even trichomes are of great importance as taxonomic evidence at the family, genus and species level [15-19]. Six types of trichomes have been identified in members of Crassulaceae. These are unicellular, simple and thick walled (1. type), unicellular swollen bladder-celled (2. type), multicellular simple (the most common type, this type may be biseriate-stalked eglandular or glandular, the head is spiral-shaped and has 2-12 cells (3. type), multicellular stelate type and 3(-6) apical arms (4. type), multicellular sessile, basal celled and small headed (5. type) and multicellular uniseriate simple or capitate (6. type) [2]. The presence, type and length of trichomes covering rosette leaves, stems and all parts of the inflorescence of many *Sempervivum* taxa have been reported to be of taxonomic importance in the identification of species [20-23]. This study aims to detect the types of glandular trichomes on the vegetative and generative organs of these two taxa and to distinguish them from each other according to their trichome morphology.

The rest of the paper is organized as follows: Section 2, describes the identification of plant specimens used in this study and the methods. In section 3, we provide information about glandular trichome types in the vegetative and generative organs of the examined taxa. In addition, studies on trichomes conducted with other members of the Crassulaceae family in the literature were mentioned. The results obtained from this study and the results in the literature were discussed. Section 4 includes the results of the study.

2. Materials and Methods

Plant materials were taken from areas where taxa naturally spread during flowering periods. Collection data related to plant materials are presented in Table 1. The description of the taxa studied was made according to Muirhead [24] and Eggli [25]. In examinations, cross and surface sections from stems, rosette leaves, sepals and petals were taken and photographed. The cross and surface sections were taken with a razor blade. 10 plant samples were used for each taxon in trichomes studies. Length measurements of trichomes on the vegetative and generative organs of each taxon were made using an ocular-micrometer. The minimum and maximum values, means and standard deviations were determined according to the IBM SPSS Statistics 27.0 program. Similarities and differences in trichomes feature of the examined taxa are given in Table 2 and mean and standard deviation values are given in Table 3. Also, Mann Whitney U test was applied to trichomes measurement results and test results are shown in Table 4. In determining the morphology of the trichomes on the vegetative and generative organs of the taxa, 10X and 40X magnification objectives of the Leica ICC50 HD microscope and stereo microscope were used. The trichomes were classified according to Payne [26].

Table 1. Locality information of *S. brevipilum* and *S. gillianiae* taxa

Taxa	Locality	Coordinates	Altitude	Collectors
S. brevipilum	Akdağ (Derebaşalan-Amasya) 07.08.2023	40°52'34.4"N 35°51'34.3"E	1500 m.	Tuğba Şahin
S. gillianiae	Sakarat Mountain (Yuva Village-Amasya) 02.07.2023	40°38'47.2"N 36°10'49.1"E	1100 m.	Tuğba Şahin

3. Results and Discussion

The morphological characters and distributions of the glandular trichomes on the vegetative and generative organs of two *Sempervivum* taxa (*S. brevipilum* and *S. gillianiae*) endemic to Türkiye were investigated in detail.

In the literature, the presence and types of trichomes in the Crassulaceae family have been reported to be of taxonomic importance [21, 23]. In particular, members of this family are characterized by multicellular biseriate glandular trichomes [2, 27, 28]. This situation was also observed in *Kalanchoe* Adans. taxa [29, 30], *Prometheum pilosum* (M.Bieb.) H. Ohba and *Prometheum sempervivoides* (Fisch. ex M.Bieb.) H. Ohba [31] and *Sempervivum globiferum* L. [32], the members of *Sempervivum ciliosum* Craib. and *Sempervivum ruthenicum* Schnittsp. ex C. B. Lehm. complexes [23].

In the examined two taxa, dense multicellular biseriate glandular trichomes were observed on the stems (Figure 1 A, B, D and Figure 2 A, B, D). In *S. brevipilum*, the margins of these trichomes were micropapillated. Among these trichomes, rare 1-2 cells stalked and large-headed capitate and multicellular uniseriate glandular trichomes were seen (Figure 1 C, D, E and Figure 2 C, D). In the leaf surface sections of *S. brevipilum* and *S. gillianiae*, short-stalked multicellular biseriate glandular trichomes were densely found on the lower and upper epiderma (Figure 1 K). Among short stalked multicellular biseriate glandular trichomes on leaves, long-stalked, multicellular uniseriate and capitate glandular trichomes (stalk and head 1-2 celled) were rarely also seen (Figure 1 F, G, H and Figure 2 E, F, G). In both taxa, the margins of the stalks of the multicellular biseriate trichomes were micropapillated. On the other hand, usually single long multicellular biseriate glandular trichome was seen on the leaf apex of *S. brevipilum* and *S. gillianiaea*. On the sepals and petals of both *S. brevipilum* and *S. gillianiae*, long and short multicellular biseriate glandular trichomes are quite dense (Figure 1 L, M, N, P, R and Figure 2 H, L, M, N, R). The margins of the stalks of these trichomes are smooth or no micropapillae. The capitate and multicellular uniseriate glandular trichomes are rare on petals and sepals (Figure 1 L, N, P, R and Figure 2 K, L, M, N, P).

The differences in the length of multicellular biseriate and uniseriate, capitate glandular trichomes on the vegetative and generative organs of these two taxa were determined to be significant by statistical analysis ($p<0.05$) (Table 4). These differences are as follows; in the lengths of short multicellular biseriate glandular trichomes on the stem, long multicellular uniseriate and biseriate, long capitate trichomes on the margins of rosette leaves, short multicellular uniseriate and capitate glandular trichomes on the upper surface of the rosette leaf, short multicellular biseriate glandular trichomes on the apex, long multicellular biseriate glandular trichomes on the sepals (blade), long capitate and short multicellular biseriate glandular trichomes on the petals (blade). No statistical differences were found in other trichome values ($p>0.05$). The margin structure of multicellular biseriate glandular trichomes on the stem of *S. gillianiae* is smooth, while the margin structure of multicellular biseriate glandular trichomes on the stem of *S. brevipilum* is micropapillated (Table 2). On the other hand, single multicellular biseriate glandular trichomes were found on the apex of the rosette leaves of both taxa. The micropapillae were detected on the stalk parts of the multicellular biseriate and capitate glandular trichomes on the rosette leaves. In addition, it was determined that there were no seen significant differences in the density and sparseness of long and short multicellular biseriate, uniseriate, and capitate glandular trichomes on the vegetative and generative organs of these two *Sempervivum* taxa (Table 2). In the Table 3, Means and standard values of trichome measurements were given of the studied two taxa.

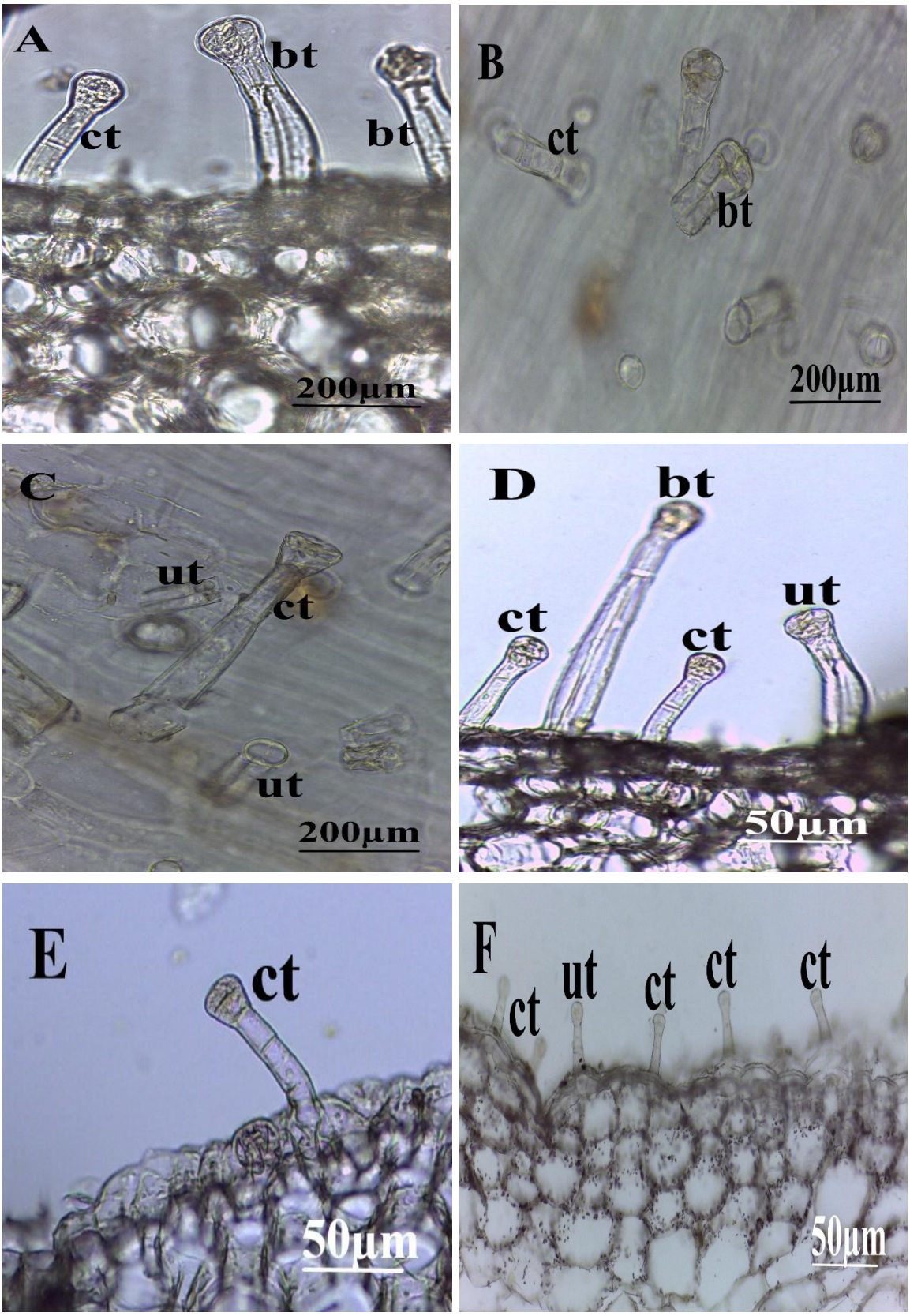

Figure 1. Glandular trichomes on the vegetative and generative of *Sempervivum brevipilum*. A and B. Multicellular biseriate and capitate glandular trichomes on the stem. C. Multicellular uniseriate and capitate glandular trichomes on the stem. D. Multicellular biseriate, uniseriate and capitate glandular trichomes on the stem. E. Capitate glandular trichome on the stem. F. Capitate and uniseriate glandular trichomes on the rosette leaves.

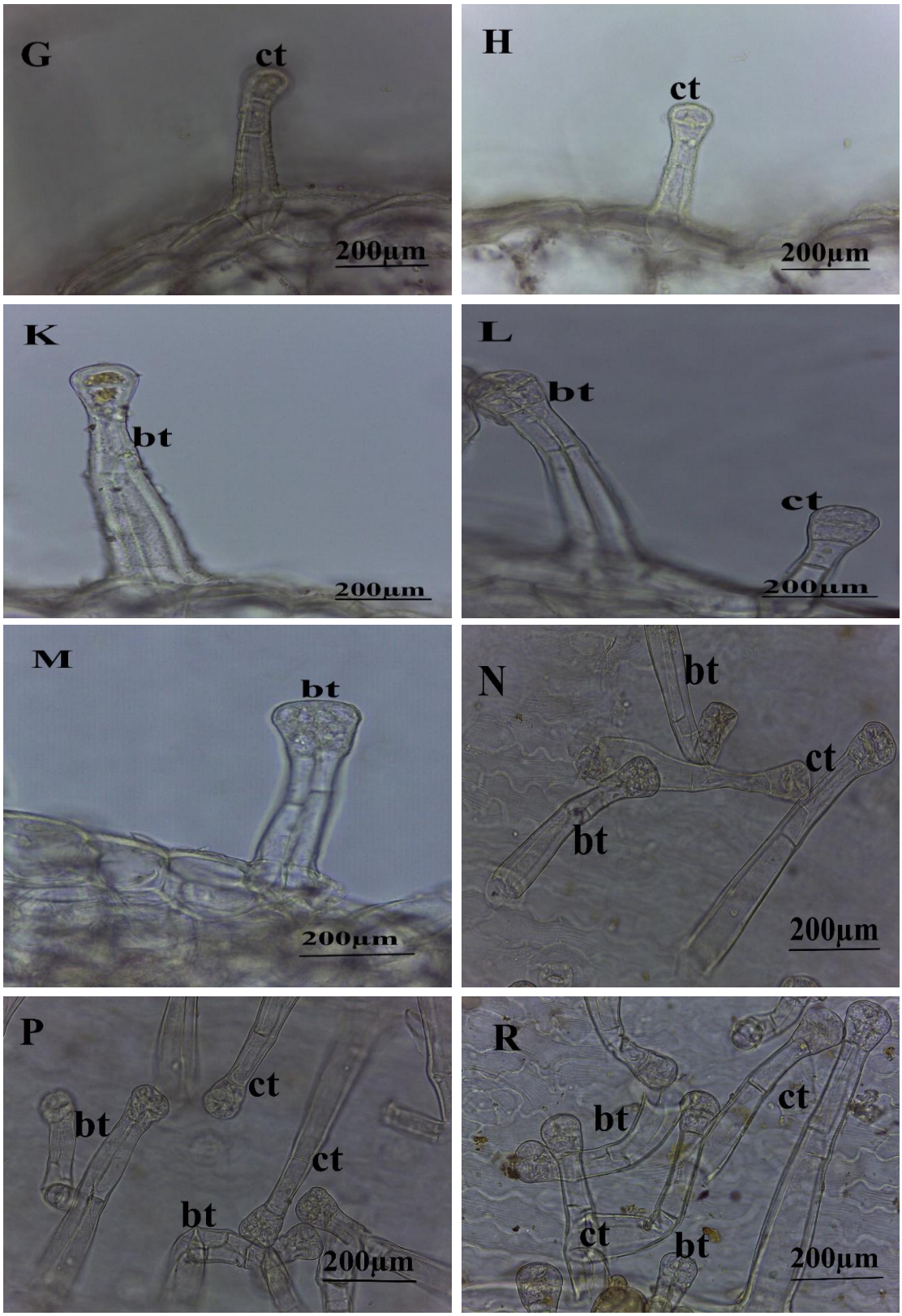

Figure 1. (Continued) Glandular trichomes on the vegetative and generative of *Sempervivum brevipilum*. G and H. Capitate glandular trichomes on the rosette leaves. K. Multicellular biseriate glandular trichome on the rosette leaves. L. Multicellular biseriate and capitate glandular trichomes on the sepal. M. Multicellular biseriate glandular trichomes on the petal. N-R. Multicellular biseriate and capitate glandular trichomes on the petal. bt: multicellular biseriate glandular trichome; ut: multicellular uniseriate glandular trichome; ct: capitate glandular trichome

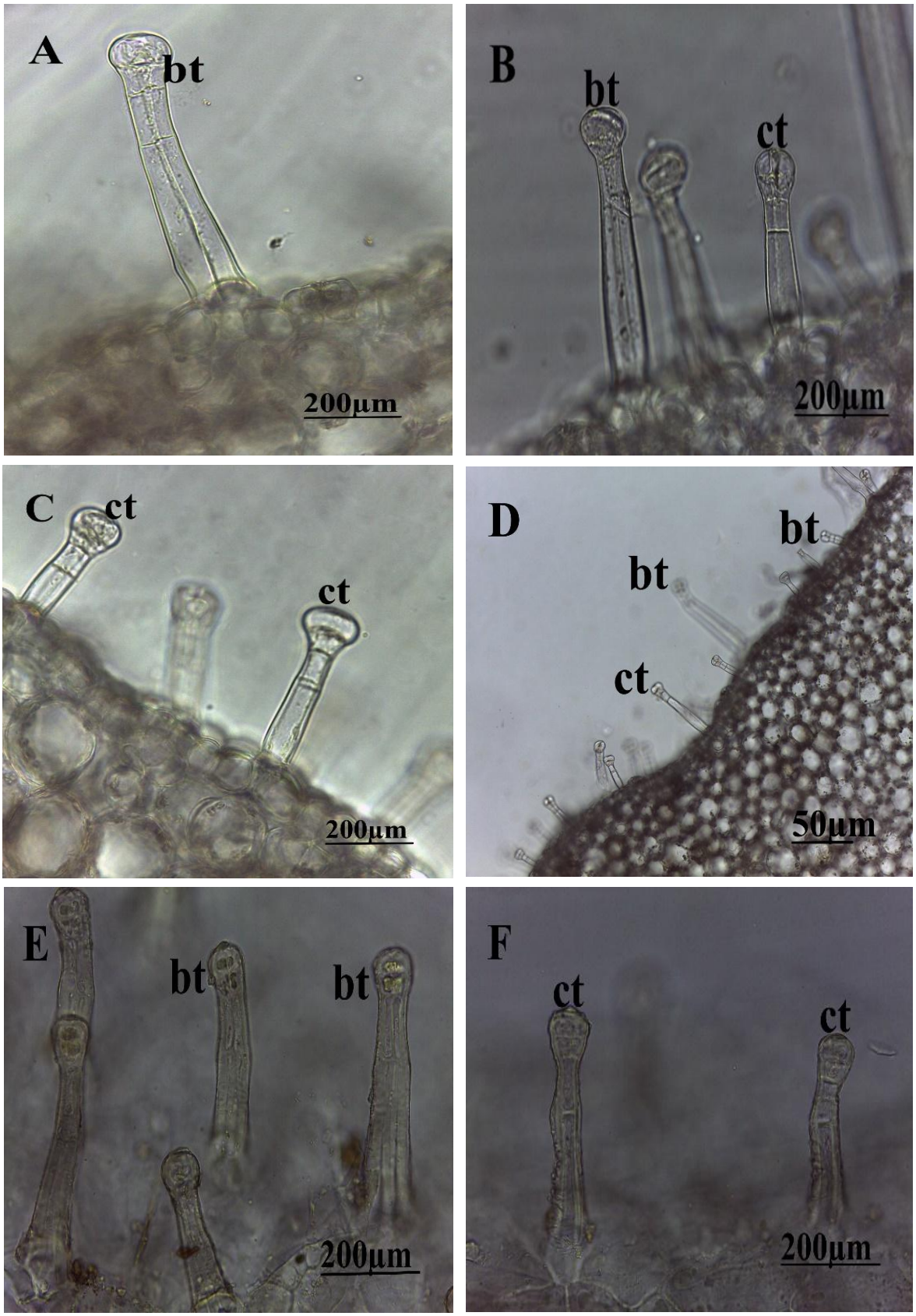

Figure 2. Glandular trichomes on the vegetative and generative of *Sempervivum gillianiae*. A. Multicellular biseriate glandular trichome on the stem. B. Multicellular biseriate and capitate glandular trichomes on the stem. C. Capitate glandular trichomes on the stem. D. Multicellular biseriate and capitate glandular trichomes on the stem. E. Multicellular biseriate glandular trichomes on the rosette leaves. F. Capitate glandular trichomes on the rosette leaves.

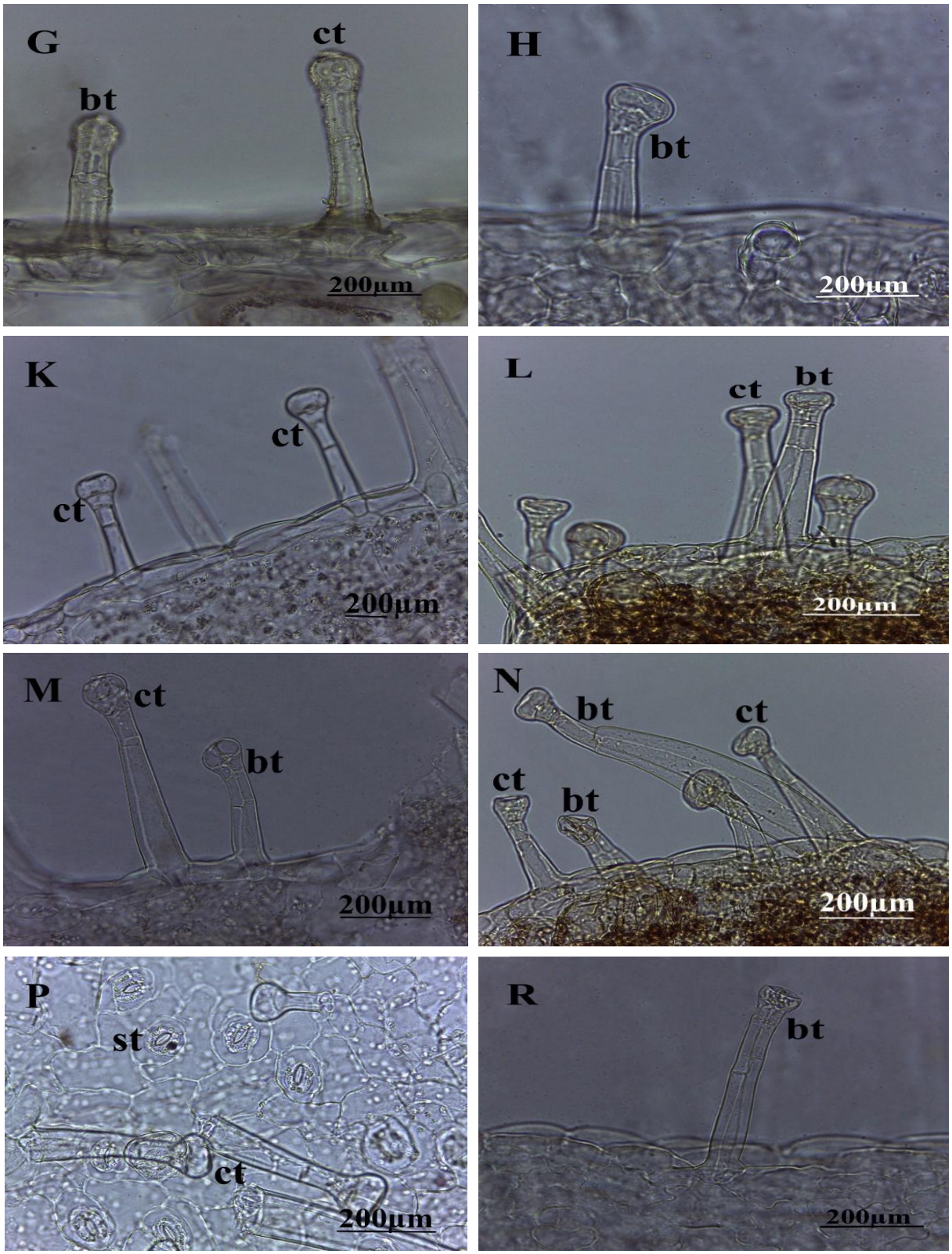

Figure 2. **(Continued)** Glandular trichomes on the vegetative and generative of *Sempervivum gillianiae*. G. Multicellular biseriate and capitate glandular trichomes on the rosette leaves. H. Multicellular biseriate glandular trichomes on the sepal. K. Capitate glandular trichomes on the sepal. L-N. Multicellular biseriate and capitate glandular trichomes on the sepal. P. Capitate glandular trichomes on the sepal. R. Multicellular biseriate glandular trichomes on the petal. bt: multicellular biseriate glandular trichome; ut: multicellular uniseriate glandular trichome; ct: capitate glandular trichome; st. stomata

Table 2. Comparison of trichomes on vegetative and generative organs of *S. brevipilum* and *S. gillianiae*

	Glandular trichomes	***S. brevipilum***	***S. gillianiae***
STEM	Biseriate glandular trichomes*	Dense, trichome stalk micropapillaed	Dense, trichome stalk straight
	Uniseriate glandular trichomes	Sparse	Sparse
	Capitate glandular trichomes	Sparse	Sparse
ROSETTE LEAF	Biseriate glandular trichomes	Dense, trichome stalk micropapillaed	Dense, trichome stalk micropapillaed
	Uniseriate glandular trichomes	Sparse	Sparse
	Capitate glandular trichomes*	Sparse, trichome stalk micropapillaed	Sparse, trichome stalk straight
SEPAL	Biseriate glandular trichomes	Dense, trichome stalk straight	Dense, trichome stalk straight
	Uniseriate glandular trichomes	Sparse	Sparse
	Capitate glandular trichomes	Sparse	Sparse
PETAL	Biseriate glandular trichomes	Dense, trichome stalk straight	Dense, trichome stalk straight
	Uniseriate glandular trichomes	Sparse	Sparse
	Capitate glandular trichomes	Sparse	Sparse

*:different trichome features between taxa

Table 3. Mean and standard deviations of the trichome measurements (mm) on the organs of *S. brevipilum* and *S. gillianiae*

	Glandular trichomes	**Number of samples**	**Mean ± Standard deviations**	
			S.brevipilum	***S. gillaniae***
STEM	Biseriate short trichome length	10+10	91.0±12.86	71.0±9.94
	Biseriat long trichome length	10+10	229.0±51.52	238.0±46.38
	Uniseriate short trichome length	10+10	77.0±14.94	84.00±13.49
	Uniseriate long trichome length	10+10	223.0±50.34	239.0±39.84
	Capitate short trichome length	10+10	90.0±15.63	77.0±16.34
	Capitate long trichome length	10+10	199.0±55.06	199.0±27.66
ROSETTE LEAF UPPER SURFACE	Biseriate short trichome length (Margin)	10+10	85.0±14.33	84.0±11.73
	Biseriate long trichome length (Magjin)	10+10	444.0±67.85	255.0±44.53
	Uniseriate short trichome length (Margin)	10+10	80.0±18.85	79.0±16.63
	Uniseriate long trichome length (Margin)	10+10	236.0±55.81	299.0±34.46
	Capitate short trichome length (Margin)	10+10	71.0±28.84	81.0±17.92
	Capitate long trichome length (Margin)	10+10	216.0±48.80	294.0±24.12
	Biseriate short trichome length (Apex)	10+10	65.0±8.49	83.0±9,.48
	Biseriate long trichome length (Apex)	10+10	-	210.0±31.97
	Biseriate short trichome length (Leaf blade)	10+10	65.0±15.09	70.0±14.14
	Biseriate long trichome length (Leaf blade)	10+10	-	236.0±45.99
	Uniseriate short trichome length (Leaf blade)	10+10	78.0±16.19	62.0±13.98
	Capitate short trichome length (Leaf blade)	10+10	62.0±9.18	82.0±16.86
ROSETTE LEAF LOWER SURFACE	Biseriate short trichome length (Margin)	10+10	85.0±14.33	84.0±11.73
	Biseriate long trichome length (Margin)	10+10	444.0±67.85	255.0±44.53
	Uniseriate short trichome length (Margin)	10+10	83.0±18.88	85.0±14.33
	Uniseriate long trichome length (Margin)	10+10	233.0±59.82	273.0±50.34
	Capitate short trichome length (Margin)	10+10	78.0±13.16	74.0±20.65
	Capitate long trichome length (Margin)	10+10	218.0±56.13	241.0±72.48
	Biseriate short trichome length (Apex)	10+10	65.0±8.49	83.0±9.48
	Biseriate long trichome length (Apex)	10+10	-	210.0±3197
	Biseriate short trichome length (Leaf blade)	10+10	76.0±11.73	72.0±13.98
	Biseriate long trichome length (Leaf blade)	10+10	-	216.0±18.97
	Uniseriate short trichome length (Leaf blade)	10+10	79.0±13.70	73.0±16.36
	Capitate short trichome length (Leaf blade)	10+10	64.0±13.70	70.0±13.33
SEPAL UPPER SURFACE	Biseriate short trichome length	10+10	83.0±9.48	78.0±10.32
	Biseriate long trichome length	10+10	236.0±55.21	189.0±13.70
	Uniseriate short trichome length	10+10	64.0±10.75	76.0±17.76
	Uniseriate long trichome length	10+10	173.0±31.99	203.0±42.96
	Capitate short trichome length	10+10	84.0±16.45	78.0±15.49
	Capitate long trichome length	10+10	176.0±20.65	164.0±24.129
PETAL UPPER SURFACE	Biseriate short trichome length	10+10	100.0±18.85	62.0±7.88
	Biseriate long trichome length	10+10	240.0±41.09	207.0±26.68
	Uniseriate short trichome length	10+10	81.0±17.92	84.0±15.77
	Uniseriate long trichome length	10+10	208.0±35.21	229.0±49.09
	Capitate short trichome length	10+10	94.0±10.75	88.0±19.88
	Capitate long trichome length	10+10	184.0±21.18	210.0±36.51

Table 4. Mann-Whitney U results of trichome measurements of *S. brevipilum* and *S. gillianiae*

Glandular trichomes		Number of samples	Mann-Whitney U test	
			U	p
STEM	Uniseriate long trichome	20	44.000	0.649
	Uniseriate short trichome	20	37.000	0.312
	Capitate long trichome	20	39.000	0.404
	Capitate short trichome	20	29.000	0.106
	Biseriate long trichome	20	41.000	0.492
	Biseriate short trichome	20	11.000	0.003*
ROSETTE LEAF	Lower surface uniseriate long trichome (margin)	20	25.000	0.050*
	Lower surface uniseriate short trichome (margin)	20	49.000	0.939
	Lower surface capitate long trichome (margin)	20	38.500	0.383
	Lower surface capitate short trichome (margin)	20	41.000	0.490
	Upper surface uniseriate long trichome (margin)	20	13.000	0.005*
	Upper surface uniseriate short trichome (margin)	20	48.000	0.877
	Upper surface capitate long trichome (margin)	20	4.500	0.001*
	Upper surface capitate short trichome (margin)	20	40.000	0.444
	Upper surface biseriate long trichome	20	0.000	0.001*
	Upper surface biseriate short trichome	20	48.000	0.877
	Lower surface uniseriate short trichome (leaf blade)	20	41.000	0.483
	Lower surface capitate short trichome (leaf blade)	20	36.000	0.280
	Lower surface biseriate short trichome (leaf blade)	20	38.000	0.555
	Upper surface uniseriate short trichome (leaf blade)	20	22.500	0.034*
	Upper surface capitate short trichome (leaf blade)	20	17.000	0.011*
	Upper surface biseriate short trichome (leaf blade)	20	41.000	0.483
	Apex biseriate short trichome	20	8.000	0.001*
	Apex biseriate long trichome	20	0.000	0.001*
SEPAL UPPER SURFACE	Uniseriate long trichome (leaf blade)	20	26.500	0.072
	Uniseriate short trichome (leaf blade)	20	24.000	0.079
	Capitate long trichome (leaf blade)	20	34.000	0.221
	Capitate short trichome (leaf blade)	20	41.500	0.511
	Biseriate long trichome (leaf blade)	20	23.000	0.039*
	Biseriate short trichome (leaf blade)	20	37.500	0.324
PETAL UPPER SURFACE	Uniseriate long trichome (leaf blade)	20	37.500	0.343
	Uniseriate short trichome (leaf blade)	20	43.500	0.612
	Capitate long trichome (leaf blade)	20	24.500	0.050*
	Capitate short trichome (leaf blade)	20	44.000	0.643
	Biseriate long trichome (leaf blade)	20	25.000	0.057
	Biseriate short trichome (leaf blade)	20	2.000	0.001*

*: $p<0.05$

The morphological characteristics of the trichomes on the rosette leaves of taxa within the *S. ciliosum* and *S. ruthenicum* complexes were investigated [23]. Yellow-flowered *Sempervivum* species were grouped under two complexes: *S. ciliosum* (*S. jakucsii* Penzes, *S. galicicum* (A.C.Sm.) Micevski), *S. ciliosum* Craib, *S. octopodes* Turrill and *S. klepae* Micevski) and *S. ruthenicum* (*S. kindingeri* Adamovic, *S. zeleborii* Schott., *S. ruthenicum* Pancis and *S. leucanthum* Pancis). Multicellular biseriate glandular trichomes were found on the adaxial, abaxial surfaces and the margins of the rosette leaves in all taxa of two complexes. The stalks of these trichomes usually were two or three pairs of long celled. The head parts were spherical or cuneiform shaped and consist of at least four secretory cells. The greatest difference between the members of the two complexes was found in the length of marginal, apical and abaxial trichomes on the rosette leaves. Species of the *S. ciliosum* complex have longer apical and marginal trichomes than species of the *S. ruthenicum* complex. For example; *S. klepae* is characterized by the largest marginal trichomes (3.10±0.47) and apical trichomes (2.08±0.49). On the contrary, *S. kindingeri* was seen to have the shortest marginal and apical trichomes (0.37±0.07; 0.34±0.08), respectively. It was stated that the length of the apical, marginal and abaxial trichomes on the rosette leaves could also be characters of taxonomic importance. However, it was observed that indumentum density was less important in taxonomic terms [24]. Similar trichome features were also found in the trichomes of rosette leaves of *S. brevipilum* and *S. gillianiae*. It was emphasized that these trichome features may be important

taxonomic characters in distinguishing taxa. Jovanovic et al. [23] findings on trichome characteristics are consistent with our findings in this study.

The anatomical features of the leaves *of Sempervivum tectorum* L. from the Crassulaceae family, which is widespread in extreme habitats, were examined [33]. Glandular trichomes were obtained in the leaves. Multicellular biseriate and capitate glandular trichomes were seen on the leaves and stem of *S. globiferum* [32]. Our trichome findings are consistent with the findings of Kirilenko [33] and Vorobei et al. [32].

Shahrestani et al. [31] investigated the leaf anatomical features of 22 taxa of *Sedum* Sensu lato distributed in Iranian. The multicellular glandular trichomes were observed on the epiderma of the leaves of *Prometheum sempervivoides* and *P. pilosum*. These glandular trichomes were densely found in both the lower and upper epiderma of *P. sempervivoides,* while these trichomes were densely found on the lower epiderma of *P. pilosum*. The presence multicellular biseriate and uniseriate glandular trichomes was detected on the vegetative and generative organs of *S. brevipilum* and *S. gillianiae*. Our findings are parallel to the findings of Shahrestani et al. [31].

Abdel-Raouf [30] investigated the anatomical features of 15 *Kalanchoe* (Crassulaceae) species, their taxonomic significance and identified characters important for distinguishing species. The multicellular branched trichomes were recorded on the leaves of *K. beharensis* Drake et Castillo and *K. tomentosa* Baker. On the stem, glandular trichomes were detected in *K. beharensis*, multicellular branched trichomes in *K. tomentosa* and papilla trichomes in *K. caniflora* Adans. [30].

In another study, leaf anatomical and morphological features of 35 *Kalanchoe* taxa were examined and the presence of glandular and eglandular trichomes on the leaf surfaces of some taxa was reported [34]. Also, anatomical features of four *Crassula* species were investigated by Jones [35]. The trichomes were observed only on the leaf of *C. socialis*.

Weryszko-Chmielewska and Chernetskyy [21] studied the structures of glandular and eglandular trichomes on the leaf surfaces of 8 species of the *Kalanchoe* genus and the trichomes were divided into 8 types. Four of these are eglandular trichomes. Except *K. gastonis-bonnieri* R. Hamet et H. Perr., eglandular trichomes were densely found on both surfaces of the leaves of all examined species. The first of the eglandular trichomes is the bushy three-branched type (*K. millotii* R. Hamet H. Perr., *K. tomentosa* and *K. beharensis*), the second is the peltate-stellate type (*K. hildebrandtii* Baill.), the third is the peltate sagittal-hastate type (*K. orgyalis* Bak. and *K. hildebrandtii*) and the fourth is the peltate rhombic type (*K. rhombopilosa* Mann and Boit.). The other four types are glandular trichomes. The first of the glandular trichomes is clavate type (knobbed) (*K. gastonis-bonnieri*), the second is capitate type (*K. manginii* R. Hamet et H. Perr., *K. beharensis* and *K. millotii*), the third is peltate type (*K. millotii*) and the fourth is truncate type (cut or split-tipped) (*K. orgyalis*). Glandular trichomes have rarely been observed on both surfaces of *K. gastonis-bonnieri* leaves. The heads of the glandular trichomes of *K. hildebrandtii* and *K. orgyalis* are arrow shaped.

Cuticular ornamentations in the form of lines extending along the stalks of the eglandular ones were seen in *K. tomentosa, K. beharensis, K. orgyalis, K. millotii,* while irregular ornamentations were seen in *K. hildebrandtii, K. rhombopilosa, K. orgyalis*. Cell wall protrusions were found on the surface of the branched trichomes of *K. millotii*. The head of glandular ones is 2-celled (*K. millotii, K. gastonis-bonnieri, K. orgyalis, K. beharensis*) or 4-celled (*K. manginii, K. gastonis-bonnieri, K. millotii*). The stalks are 2-4 celled. Unlike the eglandular trichomes, the surface of glandular ones is smooth or wavy, and the cuticle is sometimes covered with wax globules. It has been determined that the localization of glandular ones on the leaf surfaces of *Kalanchoe* taxa varies greatly among species. In *K. millotii* and *K. beharensis*, glandular trichomes were found in higher density on the petioles than on the leaf blade. In *K. beharensis*, these types of trichomes are more on the upper surface than the lower surface. The highest number of glandular ones was seen on the epidermis of *K. manginii* and the least in *K. beharensis*. The shortest glandular trichomes were found in *K. orgyalis*, while the longest ones were found in *K. manginii*. In short, Weryszko-Chmielewska and Chernetskyy [21]

emphasized that the characteristics of the glandular and eglandular trichomes on the leaf surface of the *Kalanchoe* species are of great importance in the taxonomy of these species. In this study, it has been revealed that some features of multicellular biseriate and uniseriate capitate glandular ones found on the vegetative and generative organs of the examined two *Sempervivum* taxa can be used as valuable taxonomic characters in distinguishing the two taxa. It has also been reported by some researchers that the trichomes on the organs of plants (especially glandular and branched or stellate eglandular ones) can be used as important taxonomic characters in distinguishing species [15-19, 36, 37].

Since *Sempervivum marmoreum* Griseb. is very variable, especially in leaf colour and indumentum, it is divided into the following subspecies: subsp. *reginae-amaliae* (Heldr. et Sartori ex Boiss.) B.J.M. Zonneveld, subsp. *marmoreum*, subsp. *blandum* (Schott) Soo, subsp. *eritreum* (Velen.) B.J.M. Zonneveld, subsp. *rubrifolium* (Schott) G.G. Bellia et A. Andrade and subsp. *ballsii* (Gal) B.J.M. Zonneveld. Capitate glandular trichomes were reported on the organs of *S. marmoreum*. These trichomes were detected to be short at the base of leaves and flowering stems and quite long on the inflorescence and its upper parts [38].

4. Conclusion

Some differences in the lengths of multicellular biseriate, uniseriate and capitate glandular trichomes seen on the vegetative and generative organs of these two taxa (in the lengths of short multicellular biseriate trichomes on the stem, long multicellular uniseriate, biseriate and capitate ones on the margins of rosette leaves, short multicellular uniseriate and capitate glandular trichomes on the upper surface of the rosette leaves, short multicellular biseriate glandular ones on the apex, long multicellular biseriate glandular trichomes on the sepals (blade) and short multicellular biseriate glandular trichomes on the petals (blade)) were determined by statistical analyses ($p<0.05$). In addition, it was found that there were no significant differences in the density and sparseness of long and short multicellular biseriate, uniseriate and capitate ones observed in the vegetative and generative organs of the taxa. On the other hand, sparse (usually single) long multicellular biseriate ones were detected at the apex of the rosette leaves in both taxa. The data regarding the trichome characteristics of the taxa are consistent with the trichome data of other members of the genus *Sempervivum.* There are not many anatomical, trichome morphology, antioxidant and antimicrobial studies on *Sempervivum* taxa (including the examined species). The examined taxa densely contain tannin (polyphenol type) in both vegetative and generative organs. Therefore, it is thought that they have antioxidant properties. In addition, the examined taxa have the potential to be used in ornamental plants (rock gardens and wall landscaping) due to the rosette structure and different colors of the rosette leaves.

Author Contributions

All the authors equally contributed to this work. This paper is derived from the first author’s master’s thesis supervised by the second author. All the authors read and approved the final version of the paper.

Conflict of Interest

The authors declare no conflict of interest.

Ethical Review and Approval

No approval from the Board of Ethics is required.

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