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ORIGINAL ARTICLE

COMPARATIVE STUDY ON TRICHOMES TYPES OF WILD SPECIES OF *SOLANUM* L., 1753 (SOLANALES, SOLANACEAE) IN EGYPT AND ITS TAXONOMIC SIGNIFICANCE

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ABSTRACT

Trichomes are extensions of the epidermis, frequently used as diagnostic traits for determining plant species. *Solanum* L., 1753 is a widespread and taxonomically complex genus. Although the genus S*olanum* has been the subject of numerous types of research, little attention has been given to the trichomes of the wild species found in Egypt. Therefore, the objective of the current study was to examine trichome types in ten wild *Solanum* species and assess their taxonomic importance. Using light, scanning electron microscopy and line drawings, indumentum characteristics on the abaxial leaf surface are investigated. The results showed a wide range of variation in trichome density on a 1mm^2 area of leaf blade (sparse, moderate, and dense), nature (glandular or non-glandular, simple or stellate), and structure (number of composing cells in simple non-glandular and glandular stalk and head; the number of radiating rays in stellate hairs). SEM revealed the existence of unique wax structures, including warty granules in addition to flakes. Our observations are consistent with the general characteristics of the subgenus *Leptostemonum* and the subgenus *Solanum*. This work provides strong evidence for the separation and interspecific delimitation of the investigated *Solanum* species using trichome morphology as a significant taxonomic trait.

Keywords: Glandular, Non-glandular, Scanning Electron Microscopy, Solanum, Trichomes

INTRODUCTION

Almost all plant species possess some kind of hair-like epidermal structures; these structures are commonly referred to as trichomes when found on a plant's aerial parts. Trichomes are extensions of the epidermis and are not a part of the plant's vascular system. (Wagner *et al*., 2004). They have a remarkably wide range of shapes, sizes, and densities within each species. As a result, they are frequently used as diagnostic traits to identify different plant species (Seithe and Sullivan, 1990; van Dam *et al*., 1999; Reis *et al*., 2002; Adedeji *et al*., 2007; Kang *et al*., 2010; Nurit-Silva and Fatima Agra, 2011; Glas *et al*., 2012; Munien *et al*., 2015; Talebi *et al*., 2018).

Trichomes and epidermal features are the main foliar adaptations in response to specific environments (Li *et al*., 2011). Generally, trichomes are classified into glandular and non-glandular (Werker, 2000). Both types have been well-documented to protect plants from abiotic pressures like UV radiation, dehydration, extreme temperatures, and herbivore damage (Li *et al*., 2018; Oksanen, 2018; Kaur and Kariyat, 2020 a, b; Watts and Kariyat, 2021), either by the chemical products in their glandular heads or by their sturdy structure (Karabourniotis *et al*., 2019; Tang *et al*., 2020). Trichomes can also decrease leaf wettability and keep the epidermis dry for better gas exchange (Hess and Falk, 1990; Brewer and Smith, 1997; Brewer and Nuñez, 2007; Huangfu *et al*., 2009). Hayat *et al.* (2009) and Dipa and Daniel (2011) revealed how foliar trichomes in Acanthaceae and Asteraceae have taxonomic importance. Celep *et al.* (2011) revealed the importance of *Lamium* (L., 1753) species' trichome micromorphology.

The Family Solanaceae (Juss., 1789) includes 90 genera with about 3000-4000 species distributed in warm and temperate parts of the globe (Knapp *et al*., 2004). It contains a variety of economically significant vegetable species that are also employed as biological model systems. *Solanum* (L., 1753) is the largest and most complex genus in the family, with around 1235 species according to POWO (2020), found in tropical and subtropical parts of the Americas, Africa, and Australia (Bohs, 2005; Eskandari *et al*., 2019).

Among the angiosperms, the diversity of *Solanum* is highly displayed by the morphological plasticity of its vegetative organs (Roe, 1972; Frodin, 2004). This morphological plasticity with the high species number has resulted in a very complex taxonomy of the genus, being a challenge for many taxonomists (Weese and Bohs, 2007). D'Arcy (1972, 1991) divided genus *Solanum* into seven subgenera: *Archaesolanum*, *Bassovia*, *Brevantherum*, *Leptostemonum*, *Lyciosolanum*, *Solanum* and *Petota*, with numerous sections and series. Lester *et al.* (2011) modified D'Arcy's system of classifying species growing in Africa and divided *Solanum* into five subgenera: *Lyciosolanum*, *Solanum*, *Petota*, *Brevantherum* and *Leptostemonum*. The previous divisions were mainly based on the morphological characters.

The trichomes morphology of *Solanum* species was originally described by Luckwill (1943) and revised later by Channarayappa *et al.* (1992) then Simmons and Gurr (2005). Eight different types of trichomes were distinguished based on their length, number of stalk cells and basal cells, and the absence or presence of glands. Many studies have used the great diversity of trichomes in *Solanum* as diagnostic characters for the systematics of the genus, and for specific and infrageneric delimitation (Peiffer *et al*., 2009; Weinhold and Baldwin, 2011; Burrows *et al*., 2013; Sampaio *et al*., 2014; Kariyat *et al.*, 2018). According to Boulos (2002) *Solanum* species are herbs, shrubs, climbers without tendrils, or small trees. Leaves are alternate, often paired, entire or irregularly toothed or divided. Calyx is campanulate or rotate, with five segments. Corolla is usually rotate, with five lobes. Filaments are very short. Stamens are five in number. Anthers are with apical pore. Ovary 2-loculled, with numerous ovules. Fruit is spherical variously-colored berry, with numerous compressed seeds.

In Egypt, nine wild *Solanum* species are present (Boulos, 2009), belong to two subgenera. Subgenus *Leptostemonum* with six species, namely: *S. coagulans* (Forssk., 1775), *S. elaeagnifolium* (Cav., 1795), *S. forskalii* (Dunal, 1813), *S. incanum* (L.,1753), *S. schimperianum* (Hochst., 1841), and *S. virginianum* (L., 1753). Subgenus Solanum with three species, namely: *S. nigrum* (L., 1753), *S. sinaicum* (Boiss., 1849), *S. villosum* (Mill., 1768). Shaheen *et al.* (2004) has recorded *Solanum diphyllum* (L., 1753) as a new species for the Egyptian flora. The later species also belongs to subgenus Solanum. Despite the many studies interested in the micromorphological features of the genus *Solanum*, little attention was paid to the trichomes of wild species in Egypt. Therefore, the present study aimed to evaluate different trichome types in wild *Solanum* species and their taxonomic significance.

MATERIALS AND METHODS

Collection of plant material: Leaf samples for ten studied taxa were chosen from revised authenticated voucher specimens collected from their natural habitats of different localities, or from fresh samples newly collected, preserved and kept in Cairo University Herbarium (CAI). The examined representative species are recorded in Table (1), with the collector, date of collection and their distribution according to the phytogeographical territories of Egypt proposed by El Hadidi (2000). The nomenclature and identification were made according to Linnaeus (1753), Miller (1768), Forsskål (1775), Cavanilles (1795), Dunal (1813), Hochstetter (1841) and Boissier (1849).

Preparation of leaves for Light Microscopy (LM): The leaf samples were examined with a Light microscope model number AmScope M150C-I at magnification 40X-1000X.

Preparation of leaves for Scanning Electron Microscope (SEM): The samples were examined with a dissecting microscope under diffuse light and then prepared for Scanning Electron Microscope (SEM) studies. The adaxial surfaces of the leaf were fixed using double-sided adhesive tape and then attached to the labelled stubs. Each sample was coated with gold/ palladium in a vacuum evaporator and examined by JEOL-JSM 5500 LV scanning electron microscopy accelerated by a voltage of 20 kV in the SEM Unit at the Regional Center of Mycology, and Biotechnology, Al Azhar University, Cairo, and JEOL JSM 5400 LV scanning electron microscopy accelerated by a voltage of 15 kV at the Electron Microscopy Unit (EMU) in Assiut University, Egypt.

Morphological examination: The general characteristics of trichomes were investigated and summarized in Table (2). The trichome density on a 1 mm2 area of leaf blade was determined as sparse (< 300), moderate (300-600), or dense (> 600). Nature (glandular or non-glandular, simple or stellate) and structure (the number of composing cells in simple non-glandular trichomes and glandular stalk and head; the number of radiating rays in stellate hairs) were determined. Length of various trichome types was measured depending on the length of spikes from base to apex in non-glandular trichomes; length of trichome from base to head apex in glandular trichomes; length of lateral rays till the center of central ray in stellate trichomes. Standard deviation was calculated for all measurements. Line drawings were made by the author to clear fine details that are not visible in SEM photos.

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Terminology: In this work, the terminology of Knapp *et al*. (2017), and Watts and Kariyat (2021) for trichomes were adopted.

Table (1): List of the studied *Solanum* species examined in the present study along with voucher specimens and fresh collecting materials.

No.	Species	Voucher specimens
1	*S. coagulans* Forsk.	R: Mersa Halaib, 21.1.1929; Gunnar Täckholm s.n. (CAI).
2	*S. diphyllum* L.	Nv: Giza, Research institute of vegetables and aromatic plants, Dokki, 20.4.2017; M. Mahdy s.n. (CAI).
3	*S. elaeagnifolium* Cav.	M: El-Arish, near Garada railway station, 11 km north, 29.41955, L. Boulos s.n. (CAI).
4	*S. forskalii* Dunal	Ge: 23-27.1.1929, collected during the excursion of the Botanical Department of the Egyptian University, M. T. Hefnawy & G. Täckholm s.n. (CAI); Wadi Aak. 27.1.1962, V. Täckholm, M. Kassas, H. Fawzy, F. Shalaby, M. Samy, M.A. Zahran (CAI).
5	*S. incanum* L.	Nn: Kom Ombo, near the temple, 21.1.1927, G. Täckholm s.n. (CAI); Ge: 1932, M. Drar s.n. (CAI).
6	*S. nigrum* L.	Nv: Tal El- Ruba, 18 Km north of Senbellawin, 21-24.7.1977; A. El-Gazzar s.n. (CAI); Cairo University garden, 14.8.2022; R. Hamdy s.n. (CAI).
7	*S. schimperianum* Hochst.	Sudan: Ekwit, Red Sea hills, Gebl Sila, 6.2.1938, M. Drar 371 (CAI).
8	*S. sinaicum* Boiss.	S: Gebel El Deir near the Monastery of St Catherine, 11.5.1956, V. Täckholm s.n. (CAI).
9	*S. villosum* Mill.	Nn: Silwa Bahri, between Kom Ombo and Edfu, 29.6.1967, M.N.El Hadidi & S.I.Ghabbour s.n. (CAI); Nv: Giza: Faculty of Pharmacy Farm, 4. 2014, M. Mahdy s.n. (CAI); Cairo University garden, 24.10.2022; R. Hamdy s.n. (CAI).
10	*S. virginianum* L.	Sudan: Kordofan, Melbeis, 1875; J.-H. Zarb 404 (CAI).

RESULTS AND DISCUSSION

Trichomes play an important role in plant defense against various biotic and abiotic stresses (Radcliffe, 1982; Radcliffe and Ragsdale, 2002; Pompon *et al*., 2010). Many studies have represented the trichomes features on epidermal surfaces as being important classification criteria (Rollins and Shaw, 1973; Adedeji *et al*., 2007), and have long been used in delimiting species, genera, or families (Cantino, 1990; Benitez and Ferrartto, 2009; Hayat *et al*., 2009; Shaheen *et al*., 2009; Ajmal and Al Hemaid, 2011; Saheed and Illoh, 2010; Kemka and Nwachukwu, 2011; Adedeji, 2012; Al Sheef *et al*., 2013; Khosroshahi and Salmaki, 2019). The trichomes were employed by Rao and Ramayya (1977) to distinguish the two *Malvastrum* (A. Gray, 1849) species in India. Similarly, the structure, ontogeny, and taxonomic importance of trichomes in the family Cucurbitaceae were described by Inamdar *et al*. (1990). Moreover, the species of *Leucas* (R. Br., 1810) from Asia and Africa were divided by Mannethody and Purayidathkandy (2018) by using the differences in capitate trichomes.

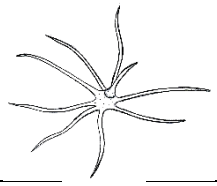
The morphology of the trichomes in *Solanum* has taxonomic significance at both the generic and specific levels (Seithe, 1962, 1979; Roe, 1972; Mosaferi *et al.*, 2021; Kumar *et al*., 2017; Watts and Kariyat, 2021). The different types of trichomes formerly described by Luckwill (1943) and revised by Channarayappa *et al.* (1992) aimed mainly to limit the diversity of trichomes to glandular and non-glandular types. Although, this fundamental classification is unable to account for the vast differences between subtypes of glandular and non-glandular trichomes (Watts and Kariyat, 2021). In this work, the trichome morphology on the abaxial surface of ten wild *Solanum* species in Egypt has been well characterized using a scanning Electron microscope (SEM). The micromorphological investigation of the studied species showed a wide range of variations in trichome density, nature, and structure (Tab. 2).

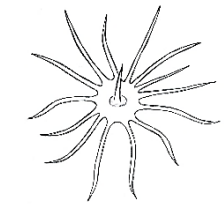
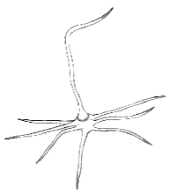
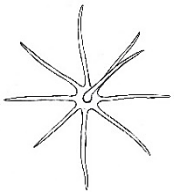
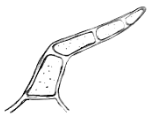
Both non-glandular and glandular trichomes were evidenced in the studied species. The non-glandular trichomes were simple or stellate with a varied number of rays, while the number of cells in the stalk and head of the glandular trichomes varied. The genus *Solanum* and other Solanaceae members are characterized by the presence of glandular trichomes except for *Nicotiana glauca* (Graham, 1828) and *Solandra nitida* (Sw., 1787) as reported by Maiti *et al.* (2002).

Among the studied species, the non-glandular stellate trichomes were found in *S. coagulans* (Pl. 1A, 1B), *S. elaeagnifolium* (Pl. 1G, 1H), *S. forskalii* (Pl. 1J, 1K), *S. incanum* (Pl. 2A), *S. schimperianum* (Pl. 2J) and *S. virginianum* (Pl. 4D, 4E), while absent in *S. diphyllum*, *S. nigrum*, *S. sinaicum* and *S. villosum*. These results agree with the general characteristics of subgenus *Leptostemonum* (Dunal) Bitt. (*S. coagulans*; *S. elaeagnifolium*; *S. forskalii*; *S. incanum*; *S. schimperianum*; *S. virginianum*) which characterizes by the presence of stellate hairs and those of subgenus *Solanum* (L.) Seithe (*S. diphyllum*, *S. nigrum*, *S. sinaicum*, and *S. villosum*) which characterizes by the absence of stellate hairs (Edmonds, 1982; Seithe and Anderson, 1982; Bohs, 1994). However, the density, number, and nature of radiating rays exhibit significant variations among these taxa (Tab. 2).

The stellate trichomes appear dense forming mat-like covering over the leaf surface in *S. coagulans* (Pl. 1B), *S. elaeagnifolium* (Pl. 1G), *S. forskalii* (Pl. 1J) and *S. incanum* (Pl. 2A), moderate in *S. virginianum* (Pl. 4C), while sparse in *S. schimperianum* (Pl. 2J). The dense mat of stellate trichomes acts as a bio-shield against the stresses (Wagner *et al*., 2004).

Table (2): Detailed micromorphological characterization of trichomes on the abaxial leaf surface of the studied *Solanum* species.

Species	Trichome types	Line Drawing	Trichome density (avg. number / cm2)*	Trichome Length (μm) ± st. deviation
S. coagulans (Pl. 1A-C)	1. Non-glandular, porrect-stellate, multiradiate, sessile/ stalked, with 6-8 (9) subulate rays and short central ray.		dense	50-205 ± 50.04
	2. Glandular with unicellular stalk and unicellular globular head.		moderate	no data
	3. Glandular with unicellular stalk and bicellular globular head.		moderate	no data
	4. Glandular with unicellular stalk and multicellular globular head.		moderate	no data
S. diphyllum (Pl. 1D-F)	1. Glandular with unicellular stalk and unicellular globular head.		sparse	no data
	2. Glandular with unicellular stalk and large multicellular doliform head.		sparse	19-68 ± 24.41
	3. Non-glandular, simple multicellular, with obtuse apex.		sparse	75-85 ± 7.07

S. elaeagnifolium (Pl. 1G-I)	1. Non-glandular, porrect-stellate, multiradiate, multiangulate, lepidote, sessile/ stalked, with 13-16 subulate rays and short central ray.		dense	100-284 ± 58.69
S. forskalii (Pl. 1J-L)	1. Non-glandular, porrect-stellate, multiradiate, sessile/ stalked, with 4-8 subulate rays and long-very long central ray.		dense	175-425 ± 92.52
	2. Non-glandular, simple unicellular with acute apex.		sparse	no data
	3. Glandular with unicellular stalk and multicellular globular head.		sparse	no data
S. incanum (Pl. 2A-B)	1. Non-glandular, porrect-stellate, multiradiate, multiangulate, sessile/ stalked, with 8 subulate rays and a long central ray.		dense	180-400 ± 73.28
S. nigrum (Pl. 2C-I)	1. Non-glandular, simple unicellular with acute apex.		sparse	no data
	2. Non-glandular, simple bicellular, with large basal cell and shrivelled apical one.		moderate	113-138 ± 17.68
	3. Non-glandular, simple multicellular (3-4-celled), commonly falcate with acute apex.		dense	163-188 ± 17.67

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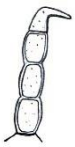
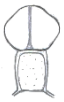
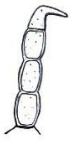
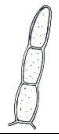
	4. Non-glandular, simple multicellular (3-4-celled) with hooked apex.		moderate	88-94 ± 4.24
	5. Non-glandular, simple multicellular (3-4-celled) with obtuse apex.		dense	138-150 ± 8.48
	6. Glandular with unicellular stalk and large unicellular globular striated head.		moderate	57-64 ± 5.05
	7. Glandular with unicellular stalk and large bicellular globular head.		moderate	35-39 ± 2.73
	8. Glandular with unicellular stalk and large multicellular globular head.		sparse	55-69 ± 9.89
S. schimperianum (Pl. 2J-L, Pl. 3A-C)	1. Non-glandular, porrect-stellate, multiradiate, sessile with 5-6 subulate rays and short central ray.		sparse	100-163 ± 25.92
	2. Glandular with bicellular stalk and unicellular globular head.		moderate	70-75 ± 3.53
	3. Glandular with bicellular stalk and tetracellular globular head.		sparse	77-88 ± 7.78

	4. Glandular with bicellular stalk and multicellular clavate head.		moderate	65-112 ± 33.25
	5. Glandular with no stalk and unicellular clavate head.		sparse	37-44 ± 4.95
S. sinaicum (Pl. 3D-G)	1. Non-glandular, simple, multicellular (3-5-celled), commonly falcate with acute apex.		sparse	no data
	2. Glandular with unicellular stalk and multicellular clavate head.		sparse	no data
	3. Glandular with multicellular [(3)4-5-celled] stalk and small unicellular clavate head.		dense	60-550 ± 190.54
	4. Glandular with multicellular bifurcated stalk and small unicellular globular head.		moderate	no data
S. villosum (Pl. 3H-L, Pl. 4A-B)	1. Non-glandular simple, with multicellular stalk (3-4-celled) and acute apex.		moderate	150-415 ± 90.13
	2. Non-glandular simple, with multicellular stalk (3-4-celled) and hooked apex.		sparse	180-200 ± 14.14
	3. Non-glandular simple, with multicellular stalk (3-4-celled) and obtuse apex.		moderate	165-200 ± 24.74

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	4. Glandular with unicellular stalk and unicellular globular head.		sparse	no data
	5. Glandular with unicellular stalk and multicellular clavate head.		sparse	40-57 ± 7.59
	6. Glandular with multicellular (3-6-celled) stalk and small unicellular clavate head.		moderate	40-315 ± 131.05
S. virginianum (Pl. 4C-I)	1. Non-glandular, porrect-stellate, multiradiate, multiangulate, sessile/ stalked, with 6-8 subulate rays and short central ray.		dense	50-150 ± 33.07
	2. Glandular with unicellular stalk and unicellular globular head.		sparse	38-55 ± 12.37
	3. Glandular with unicellular stalk and tetracellular globular head.		sparse	63-88 ± 17.67
	4. Glandular with unicellular stalk and multicellular clavate head.		sparse	35-40 ± 3.53

* < 300= sparse; 300-600: moderate; > 600: dense; 'no data' means difficulty of measuring length.

The number of radiating rays ranges from 5 in *S. schimperianum* up to 16 in *S. elaeagnifolium* (Tab. 2). The shape of radiating rays is subulate in all the previous species, however, they appear slender in *S. coagulans* (Pl. 1A), *S. elaeagnifolium* (Pl. 1G), *S. forskalii* (Pl. 1J), and *S. incanum* (Pl. 2A), and wide in *S. schimperianum* (Pl. 2J) and *S. virginianum*

(Pl. 4D, 4E). *Solanum elaeagnifolium* is characterized by the lepidote shape of stellate trichomes (Pl. 1H) in which the lateral rays appear fused at the base. This is the same result as Knapp *et al*. (2017). The longest radiating rays are in *S. forskalii* and *S. incanum*, while the shortest is in *S. virginianum* (Tab. 2). *Solanum forskalii* and *S. incanum* are characterized by having long central ray (Pl. 1J, 2A) which appears short in the other species.

Wax orientations patterns are seen on the trichomes in SEM, characterized by their irregular, mostly isodiametric, rounded warty granules described as verrucate sculptures on all the studied species (Pl. 1C, I, L; Pl. 2B, F; Pl. 3G; Pl. 4B, F), except *S. schimperianum* which is found to be distinct from the rest of the species by having a striate sculpture of central ray (Pl. 2 K). The distribution of these granules varied from moderate in most of the studied species to sparse in *S. forskalii*, *S.* sinaicum and *S. villosum.* These granules were mixed with flakes in *S. elaeagnifolium* (Pl. 1I). The latter was confirmed by Burrows *et al.* (2013).

The simple non-glandular unicellular trichomes are traced in *S. nigrum*, and *S. forskalii* (Tab. 2). However, *S. nigrum* is distinct by the presence of non-glandular bicellular type (Pl. 2I; Tab. 2). Mohamed and El-Gohary (2007) and Ewas and Ghaly (2019) support our results.

The simple non-glandular multicellular trichomes with acute apex and verrucate sculpture are found in *S. nigrum* (Pl. 2E), *S. sinaicum*, and *S. villosum* (Pl. 3I). These findings agree with Mohamed and El-Gohary (2007). While the multicellular type with hooked or obtuse apexes is found in *S. nigrum* (Pl. 2C) and *S. villosum* only (Pl. 3J; Tab. 2). The study of Mohamed and El- Gohary (2007) have traced hooked trichomes in *S. villosum* only. Rebora *et al.* (2020) reported the important role of hooked non-glandular trichomes in the entrapment of pests as in *Phaseolus vulgaris* (L. 1753).

The glandular trichomes in the studied *Solanum* species are found in *S. coagulans* (Pl. 1A), *S. diphyllum* (Pl. 1D, E), *S. forskalii* (Tab. 2), *S. nigrum* (Pl. 2G, H), *S. schimperianum* (Pl. 2L; Pl. 3A, B, C), *S. sinaicum* (Pl. 3E, F), *S. villosum* (Pl. 3L, Pl. 4A) and *S. virginianum* (Pl. 4G, H, I). This result agrees with Edmonds (1982), Adedeji *et al.* (2007), Mohamed and El-Gohary (2007), Hamada *et al.* (2010), Bello *et al.* (2017) and Ogundola *et al.* (2017). The glandular trichomes are dense in *S. sinaicum* (Pl. 3A), while sparse to moderately distribute in the other species (Tab. 2). Previous studies reported the function of leaf trichome density as a defensive trait against herbivory among solanaceous species (van Dam and Hare, 1998).

The glandular unicellular type is found in all the above species except *S. schimperianum* which has either a bicellular stalk or no stalk (Tab. 2) as found by Mohamed and El-Gohary (2007). The glandular multicellular type is found in *Solanum sinaicum* (Pl. 3D, E) and *S. villosum* (Pl. 4A). Mohamed and El-Gohary (2007) support our findings. An additional spot character is the presence of a glandular multicellular bifurcated type in *S. sinaicum* but absent in all the studied species (Tab. 2).

The number of cells and shape of the glandular head vary among the studied species. The unicellular globular head with smooth sculpture is found in *S. coagulans* (Pl. 1A), *S.*

diphyllum (Pl. 1D), *S. schimperianum* (Pl. 2L), *S. villosum* (Pl. 3K) and *S. virginianum* (Pl. 4G; Tab. 2). While the unicellular globular head appears in *S. nigrum* with striated sculpture (Pl. 2G; Tab. 2). On the other hand, the unicellular clavate head is found in *S. schimperianum* (Pl. 3C), *S. sinaicum* (Pl. 3F), and *S. villosum* (Pl. 4A). *Solanum coagulans* and *S. nigrum* are distinguished by the presence of large bicellular globular head which is absent in the other species (Tab. 2). Adedeji *et al*. (2007) and Mohamed and El-Gohary (2007) agree with this result in *S. nigrum.* Additionally, *S. schimperianum*, and *S. virginianum* show the presence of a tetracellular globular head (Tab. 2), while the multicellular head is traced in all the above species as reported by Mohamed and El-Gohary (2007). Although, it appears globular in *S. coagulans*, *S. forskalii* and *S. nigrum*, clavate in *S. schimperianum*, *S. sinaicum*, *S. villosum*, and *S. virginianum*, while appears doliform in *S. diphyllum* (Tab. 2).

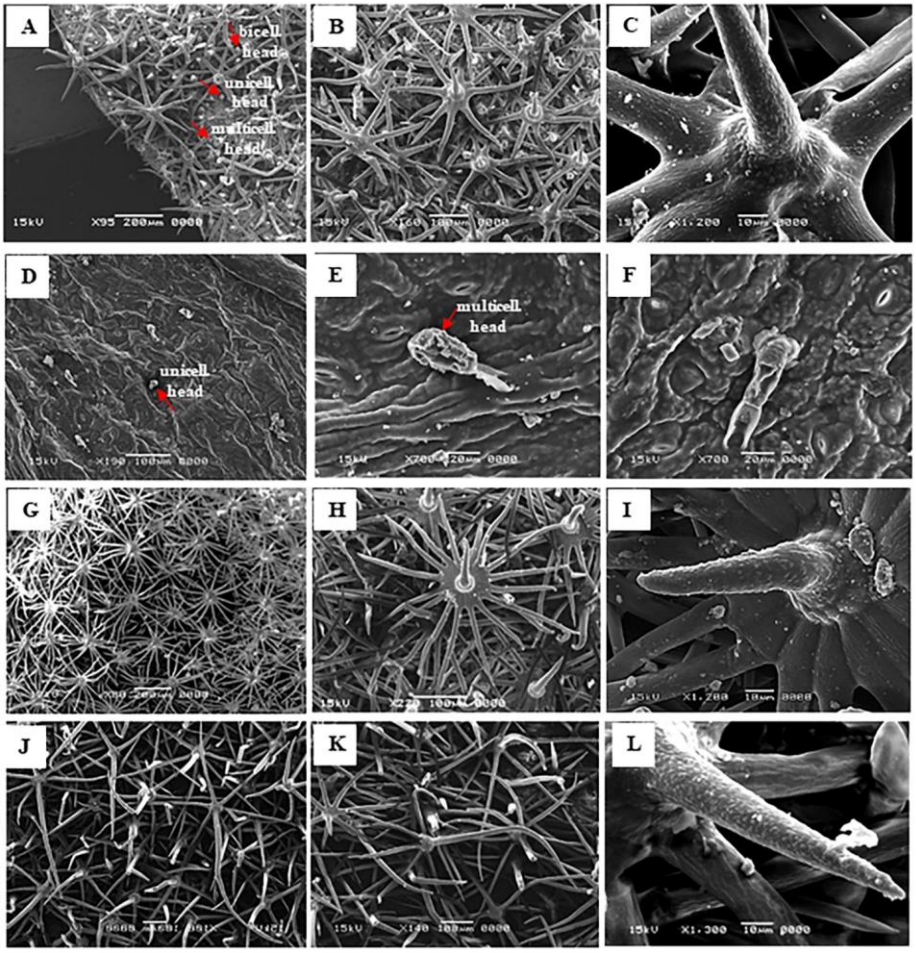

Plate (1): Scanning Electron Micrographs showing trichomes on the abaxial leaf surface of the studied *Solanum* species; (A-C) *S. coagulans*: (A, B) non-glandular porrect-stellate multiradiate hairs with 6-8 subulate rays and short central ray, (A) showing small glandular hairs with uni-, bi-, and multicellular heads, (C) magnified part showing verrucate sculpture of central ray; (D-F) *S. diphyllum*: (D) glandular hair with unicellular stalk and unicellular head, (E) glandular hair with unicellular stalk and large multicellular doliform head, (F) non-glandular multicellular uniseriate hair; (G-I) *S. elaeagnifolium*: (G) non-glandular porrect-stellate multiradiate lepidote hairs with 13-16 subulate rays and short central ray, (H) lepidote hair with lateral rays fused at the base, (I) magnified part showing verrucate sculpture of central ray; (J-L) *S. forskalii*: (J, K) non-glandular porrect-stellate multiradiate hairs with 4-7 subulate rays and long central ray, (L) magnified part showing verrucate sculpture of central ray.

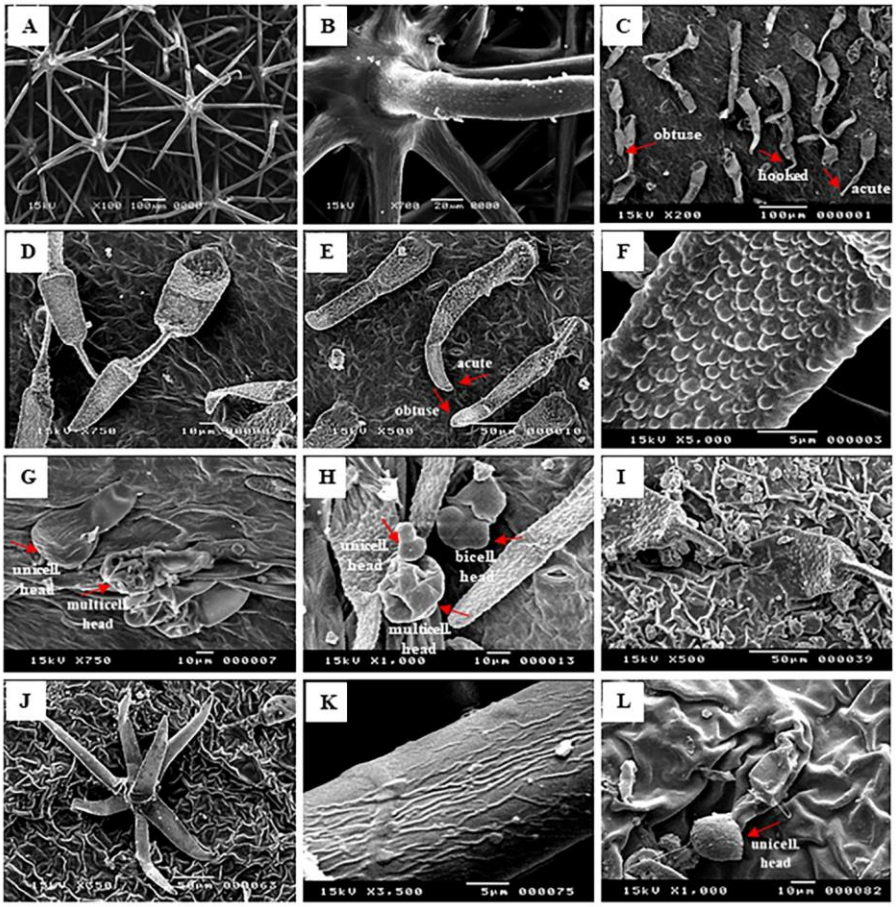

Plate (2): Scanning Electron Micrographs showing trichomes on abaxial leaf surface of the studied *Solanum* species; (A-B) *S. incanum*: non-glandular porrect-stellate multiradiate hairs with 8 subulate rays and long central ray, (B) magnified part showing verrucate sculpture of central ray; (C-I) *S. nigrum*: (C) simple multicellular non-glandular hairs with acute, hooked and obtuse apex, (D) simple multicellular non-glandular hairs with normal base cell and shriveled middle cell, (E) simple multicellular non-glandular hairs with acute or obtuse apex, (F) magnified part showing verrucate sculpture, (G) glandular hairs with unicellular stalk and unicellular striated and multicellular smooth globular heads, (H) glandular hairs with unicellular stalk and uni-, bi- and multicellular smooth head, (I) simple bicellular non-glandular hairs with large normal base cell; (J-L) *S. schimperianum*: (J) porrect-stellate multiradiate non-glandular hairs with 5-6 subulate rays and short central ray, (K) magnified part showing striate sculpture of central ray, (L) glandular hair with bicellular stalk and unicellular head.

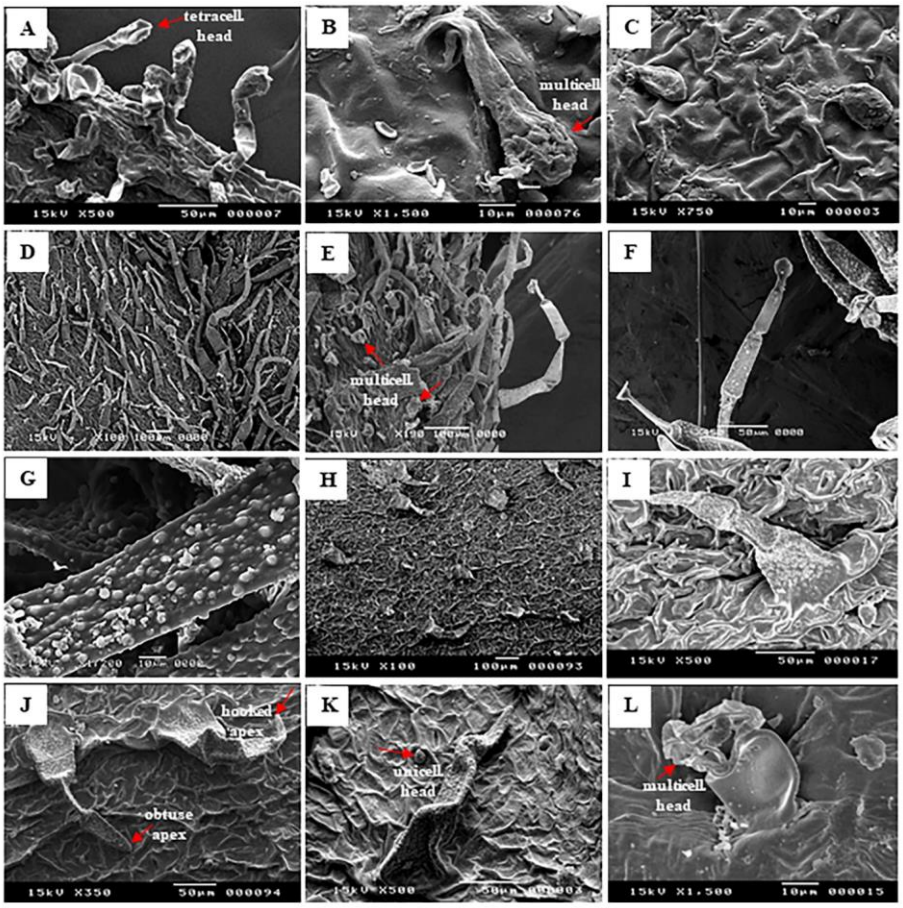

Plate (3): Scanning Electron Micrographs showing trichomes on abaxial leaf surface of the studied *Solanum* species; (A-C) *S. schimperianum*: (A) glandular hair with bicellular stalk and tetracellular clavate head, (B) glandular hair with bicellular stalk and multicellular clavate head,(C) glandular hair with no stalk and unicellular clavate head; (D-G) *S. sinaicum*: (D) unicellular and multicellular glandular hairs, (E) small glandular hairs with unicellular stalk and multicellular heads, (F) multicellular glandular hair with small unicellular clavate head, (G) magnified part showing verrucate sculpture; (H-L) *S. villosum*: (H) small glandular unicellular and long non-glandular multicellular hairs, (I) simple non-glandular multicellular hair with acute apex, (J) simple non-glandular multicellular hairs with hooked and obtuse apex, (K) small glandular hair with unicellular stalk and unicellular head, (L) small glandular hair with unicellular stalk and multicellular shriveled head.

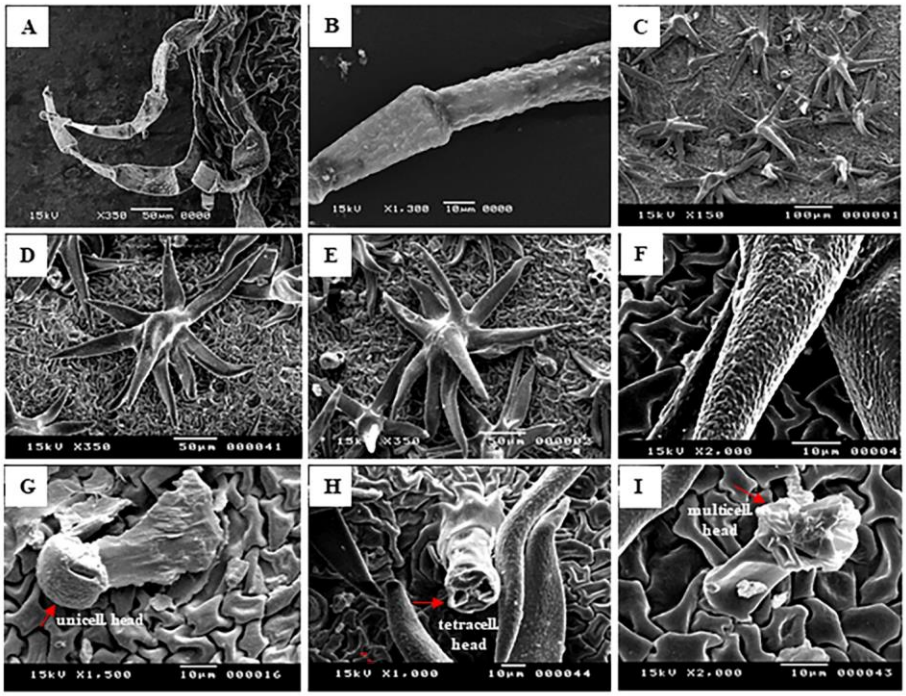

Plate (4): Scanning Electron Micrographs showing trichomes on abaxial leaf surface of the studied *Solanum* species; (A-B) *S. villosum*: (A) multicellular glandular hair with small unicellular clavate head, (B) magnified part showing verrucate sculpture; (C-I) *S. virginianum*: (C-E) porrect-stellate multiradiate non-glandular hairs with 6-8 subulate rays and short central ray along with small glandular hairs, (F) magnified part showing verrucate sculpture of central ray, (G) glandular hair with unicellular stalk and unicellular globular head, (L) glandular hair with unicellular stalk and tetracellular head, (I) glandular hair with unicellular stalk and multicellular head.

CONCLUSIONS

Despite some overlapping trichomes characters, which reflect the relative closeness of the species in this genus, this work highlights the general characters that specify the studied species and greatly supports the use of trichome morphology as valuable taxonomic features for the separation and interspecific delimitation of the studied *Solanum* species.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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دراسة مقارنة لأنواع الشعيرات في الأنواع البرية من جنس *Solanum* L., 1773 (Solanalis, Solanaceae) في مصر وأهميتها التصنيفية

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الخلاصة

الشعيرات هي امتداد لخلايا البشرة وغالبًا ما تستخدم كخصائص تشخيصية لتحديد الأنواع النباتية. جنس *Solanum* L., 1753 رتبة الباذنجانيات Solanaceae، الفصيلة الباذنجانية Solanoideae هو جنس واسع الانتشار و معقد من الناحية التصنيفية؛ على الرغم من أن هذا الجنس كان موضوعاً للعديد من الأبحاث ، فقد تم إيلاء القليل من الاهتمام لترايخومات الأنواع البرية الموجودة في مصر. لذلك ، كان الهدف من الدراسة الحالية هو فحص أنواع الشعيرات في عشرة أنواع برية لجنس *Solanum* و تقييم أهميتها التصنيفية بإستخدام المجهر الإلكتروني الخفيف والمسح الضوئي والتحليل الإحصائي والرسومات الخطية؛ تم مسح الخصائص التعويضية الدقيقة على سطح الورقة المحورية للأنواع المدروسة. أظهرت النتائج مدى واسع من التباين في كثافة الشعر الثلاثي على مساحة 1 ملم ^{2} من نصل الأوراق (متناثر ، متوسط ، كثيف)، الطبيعة (غدية أو غير غدية، بسيطة أو نجمية) والبنية (عدد الخلايا المكونة في الشعيرات البسيطة وغير الغدية -و فى ساق ورأس الشعيرات الغدية؛ عدد الأشعة المشعة في الشعر النجمي). كشفت SEM عن وجود تراكيب شمعية فريدة من نوعها، بما في ذلك الحبيبات التؤلولية بالإضافة إلى الرقائق. تتوافق ملاحظاتنا مع الخصائص العامة لجنيس ال *Leptostemonum* وجنيس الـ *Solanum*. يدعم هذا العمل بشكل كبير استخدام خصائص الشعيرات كميزات تصنيفية قيّمة للفصل بين الأنواع المدروسة وترسيم حدودها بين الأنواع.