



## ANATOMICAL STUDIES ON WILD *SOLANUM* TAXA IN EGYPT

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**Keywords:** Egyptian *Solanum*, *Solanum* anatomy, Solanaceae, Key of taxa

### ABSTRACT

The comparative study on anatomical structure of stems and leaves in 12 wild *Solanum* taxa revealed that the outline of cross sections of stem and petiole, presence or absence of hypodermis, structure of cortex, pericycle and types of steles vary considerably in different studied taxa. It was also evident that other anatomical features of leaf including mesophyll types, arrangement and number of the bundles at the mid-rib region, presence or absence of bundle sheath and idioblast cells as well as the vascular system of petiole are important diagnostic characters in the proposed key for identification. A key including variations in anatomical characters of stems and leaves of the investigated taxa is provided

### INTRODUCTION

The genus *Solanum* is represented in Egypt by nine species, of which *S. villosum* Mill. is represented by two subspecies and *S. nigrum* L. is represented by three varieties (Hepper, 1998 and Boulos, 2002).

The species have variable morphological characteristics, both vegetative and floral ranging from herbs to small trees plants with alternate entire or lobed leaves. Flowers in lax racemes or cymes, pedicel prickly or non prickly. Corolla white or violet. Fruit variously colored (Täckholm, 1974; Hepper, 1998 and Boulos, 2002).

Although the literature on the anatomical structure of *Solanum* taxa growing elsewhere other than Egypt is extensive (Metcalfe & Chalk, 1950; Seithe, 1962 & 1979; Son, 1979; McCauley & Evert, 1988; Cosa & Bruno, 1998; Luna-Cavazos & Garcaia-Moya, 2002; Elias *et al* 2003; Falcão *et*

*al* 2003; Granada-Chacon & Benitez de Rojas, 2004; Chiarini & Barboza, 2007 and Mbagw *et al* 2007), this aspect of anatomy in wild *Solanum* taxa growing in Egypt is not yet properly projected. Therefore, our knowledge about the anatomy of these plants is only meager. So far only a few Egyptian taxa have been worked out, Al-Nowaihi & Khalifa (1974); Al-Nowaihi & Mourad (1999) and Mohamed & Al-Gohary (2007).

The present study, basically yielding information on the anatomical structure of stems and leaves of Egyptian *Solanum* to evaluate their taxonomic significance as key characters for differentiation.

### MATERIALS AND METHODS

Twelve samples of *Solanum* taxa were collected fresh from field work during the years 2000-2002 of which nine taxa namely, *S. coagulans* Forssk. *S. elaeagnifolium* Cav, *S. virginianum* L., *S. incanum* L., *S. forsskaolii* Dunal, *S. villosum* (L.) Mill. ssp. *villosum*, *S. villosum* (L.) Mill.ssp. *miniatum* (Bernh.ex Willd) Edmonds, *S. nigrum* L. var. *elbaensis* Täckh. & Boulos and *S. schimperianum* Hochst.ex A. Rich. were collected from Gebel Elba, while *S. nigrum* L. var. *nigrum* was collected from El-Sharkia, *S. nigrum* L. var. *incisum* Täckh. & Boulos from Ismailia and *S. sinaicum* Boiss. from wadi El- Nasb, Sinai. The samples were identified according to keys of Täckholm (1974); Hepper (1998) and Boulos (2002) and compared with samples from herbaria of Desert Research Center (CAIM) and Cairo University (CAI).

For anatomical investigation each specimen was fixed according to (Nassar & El-Sahhar, 1998) in F.A.A. (formalin - glacial acetic acid - 70% ethyl alcohol) with the ratio of 5: 5: 90 by volume.

The stems were hand sectioned at 20-30 $\mu$  in thickness in the concerned organs taken from 2<sup>nd</sup> and 4<sup>th</sup> internodes below the apex, while the

(Received April 14, 2008)

(Accepted May 17, 2008)

leaves were microtomed at 10-15 $\mu$  after being dehydrated in n-butyl alcohol series and embedded in paraffin wax (m.p.56-58%). The sections were stained according to Dilcher (1974) in safranin (1% solution in 50% ethanol), and light green (1% solution in 96% ethanol), mounted in Canada balsam and photographed using Zeiss Research Microscope.

The terminology concerning the mesophyll type is given according to Fahn (1974) and Metcalfe & Chalk (1979).

## RESULTS

The different anatomical features of stems and leaves (petioles and blades) of *Solanum* taxa were extensively studied to imitate the importance of these characters (Tables 1 and 2) and (Plates 1, 2 and 3).

### A. Stem Anatomy (Table1, Plate 1)

The cross sections of stems are terete in some studied taxa, but angular with wavy margin in *S. villosum* ssp. *villosum* (Plate1, Fig. 4) and *S. virginianum* while folded to ovoid with wavy margin in *S. villosum* ssp. *miniatum*, *S. nigrum* var. *nigrum*, *S. nigrum* var. *incisum* and *S. nigrum* var. *elbaensis*. Epidermal cells are radially elongated interrupted by papillose cells in all studied taxa except in *S. nigrum* var. *nigrum* the epidermis consists of radially elongated intermixed with tangentially cells. Cuticle is thick in 8 taxa and thin in the remainders. Hypodermis presents in the form of one layer of parenchyma in most taxa but absent in *S. elaeagnifolium*, *S. nigrum* var. *incisum* and *S. sinaicum*. Cortex consists of two types of cells in most studied taxa: the outer 2-5 layers of collenchyma, and the inner 3-6 layers are parenchymatous cells. However, the cortex is composed of 4-6 layers of collenchyma in *S. virginianum*, *S. incanum* and *S. villosum* ssp. *miniatum*. Pericycle is composed of parenchymatous cells in 7 taxa, but interrupted by small groups of lignified fibers in the remainders (Table 2).

Vascular system consists of a central cylinder which is formed of an outer phloem and a wide lignified xylem. Cambium forms an irregular wavy ring. Vascular cylinder is siphonostele in most species, but eustele (about 8-14 bundles) in the two ssp. of *S. villosum* and the three variety of *S. nigrum* (Plate 1, Fig. 6). Pith is wide or narrow and consists of round to polygonal thin walled parenchymatous cells, Schizogenous canals are observed in *S. coagulans*, *S. elaeagnifolium*, *S. incanum*, *S. villosum* ssp. *villosum* (Plate 1, Fig. 4)

and *S. nigrum* var. *elbaensis*, while Idioblasts are recorded only in 4 *Solanum* taxa and absent in the remainder.

### B. Leaf Anatomy (Table2, Plates 2 & 3)

#### 1- Blade (Table 2, Plate 2)

The lower and upper epidermal cells are radially oriented with papillose in six studied taxa or tangentially intermixed with radially in the remainders. Cuticular layer is thick in six taxa and thin in the rest. The mesophyll is dorsiventral in the majority of the studied taxa and isolateral in *S. schimperianum* or bilateral in *S. coagulans* and *S. elaeagnifolium*.

The palisade tissue is consisted of 1-2 rows of narrow small length chlorenchymatous cells being discontinuous at midrib region in all studied taxa. Spongy tissue is represented by 2-5 layers of thin walled parenchymatous cells. Mechanical tissue in the form of collenchyma situated abaxially and adaxially at midrib region in the investigated taxa as shown in (Table 2) or situated abaxially in *S. forsskaolii*, *S. nigrum* var. *incisum* and *S. nigrum* var. *elbaensis*. The vascular supply of the mid-vein is crescent form and consists of number of vascular bundles. The bundle sheath is recorded only in *S. sinaicum* and *S. schimperianum* and absent in the remainder taxa. Idioblast is recorded in most studied taxa.

#### 2- Stomatal types

Anomocytic and / or anisocytic being in accordance with (Mohamed & Al-Gohary (2007)

#### 3- Foliar trichomes

Diversity of glandular, nonglandular and stellate in agreement with (Mohamed & Al-Gohary (2007).

#### 4- Petiole (Table 2, Plate 3)

The petiole outline in cross sections of the studied taxa is crescent in *S. coagulans*, *S. villosum* ssp. *miniatum* and *S. nigrum* var. *elbaensis*, Y-shaped in *S. elaeagnifolium*, angular with wavy in *S. incanum* and *S. forsskaolii*, folded with or without wings in the rest. The epidermal cells are radially elongated intermixed with papillose (Plate 3, Fig. 4) in most studied taxa or tangentially with papillose in *S. incanum* and *S. nigrum* var. *incisum* (Plate 3, Fig. 12). Ground tissue is in the form of two types of cells; collenchyma and parenchyma in all studied taxa.

Table 1. The stem anatomical differences among the studied taxa of *Solanum*

Taxa	1- <i>S. coagulans</i> .	2- <i>S. elaeagnifolium</i> .	3- <i>S. virginianum</i> .	4- <i>S. incanum</i> .	5- <i>S. forsskaolii</i>	6- <i>S. villosum</i> . ssp. <i>villosum</i>	7- <i>S. villosum</i> . ssp. <i>miniaturum</i>	8- <i>S. nigrum</i> . var. <i>nigrum</i>	9- <i>S. nigrum</i> . var. <i>incisum</i>	10- <i>S. nigrum</i> . var. <i>albaensis</i>	11- <i>S. sinaleucum</i> .	12- <i>S. schimperianum</i> .
Characters												
Outline in T.S.	Terete	Terete	Angular with wavy margin	Terete	Terete	Angular with wavy margin	Folded-ovoid	Folded-ovoid	Folded-ovoid	Folded-ovoid	Terete	Terete
Cutin	Thick	Thin	Thick	Thick	Thin	Thick	Thin	Thick	Thick	Thick	Thick	Thin
Epidermis	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Tangential+ radially	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose
Hypodermis	Present	Absent	Present	Present	Present	Present	Present	Present	Absent	Present	Present	Present
Cortex	Collen.+ parenchyma	Collen.+ parenchyma	Collenchyma	Collenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collen.+ parenchyma
Pericycle	Paren. + fiber	Paren. + fiber	Paren. + fiber	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Paren. + fiber	Paren. + fiber
Stele	Siphonostele	Siphonostele	Siphonostele	Siphonostele	Siphonostele	Eustele	Eustele	Eustele	Eustele	Eustele	Siphonostele	Siphonostele
Schizogenous canal	Present	Present	Absent	Present	Absent	Present	Absent	Absent	Absent	Present	Absent	Absent
Idioblasts	Absent	Absent	Absent	Present	Absent	Present	Absent	Absent	Absent	Present	Absent	Present

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Characters												
Outline in T.S.	Terete	Terete	Angular with wavy margin	Terete	Terete	Angular with wavy margin	Folded-ovoid	Folded-ovoid	Folded-ovoid	Folded-ovoid	Terete	Terete
Cutin	Thick	Thin	Thick	Thick	Thin	Thick	Thin	Thick	Thick	Thick	Thick	Thin
Epidermis	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose	Tangential+ radially	Radially + papillose	Radially + papillose	Radially + papillose	Radially + papillose
Hypodermis	Present	Absent	Present	Present	Present	Present	Present	Present	Absent	Present	Present	Present
Cortex	Collen.+ parenchyma	Collen.+ parenchyma	Collenchyma	Collenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collen.+ parenchyma	Collen.+ parenchyma
Pericycle	Paren. + fiber	Paren. + fiber	Paren. + fiber	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Parenchyma	Paren. + fiber	Paren. + fiber
Stele	Siphonostele	Siphonostele	Siphonostele	Siphonostele	Siphonostele	Eustele	Eustele	Eustele	Eustele	Eustele	Siphonostele	Siphonostele
Schizogenous canal	Present	Present	Absent	Present	Absent	Present	Absent	Absent	Absent	Present	Absent	Absent
Idioblasts	Absent	Absent	Absent	Present	Absent	Present	Absent	Absent	Absent	Present	Absent	Present

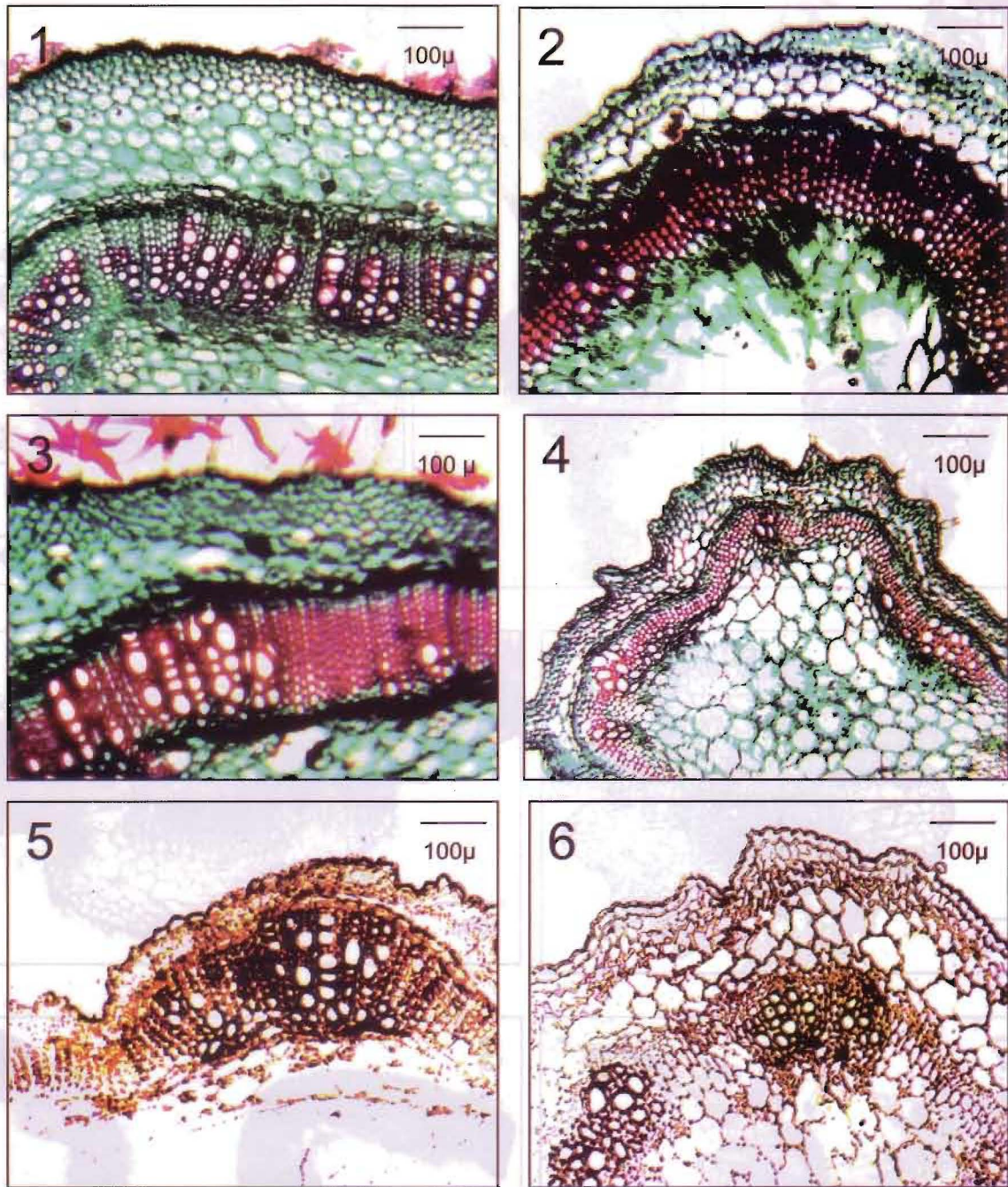


Plate 1. Transections of stems

1-*Solanum coagulans*

2-*S. sinaicum*

3-*S. incanum*

4- *S. villosum* ssp. *Villosum*

5- *S. villosum* ssp. *miniaturum*

6-*S. nigrum* var. *elbaensis*



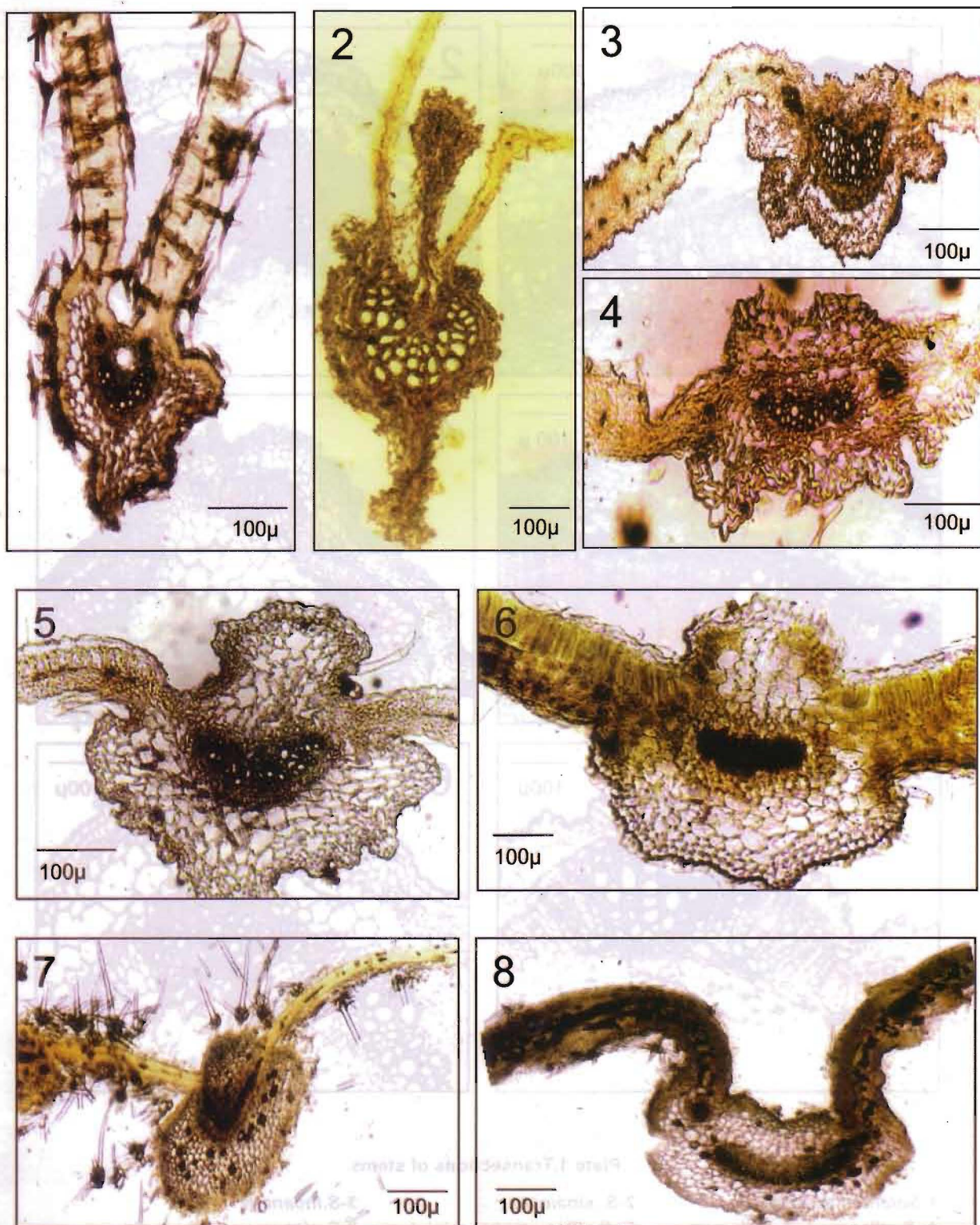


Plate 2. Transsections of leaf blade

1- *S. elaeagnifolium*2- *S. villosum* ssp. *miniaturum* 3- *S. nigrum* var. *incisum*4- *S. nigrum* var. *elbaensis*5- *S. villosum* ssp. *villosum* 6- *S. nigrum* var. *nigrum*7- *S. incanum*8- *S. coagulans*



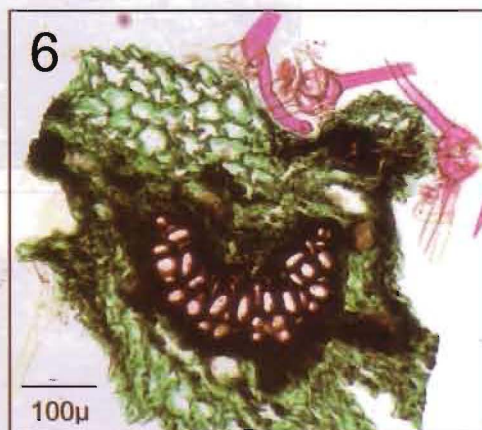
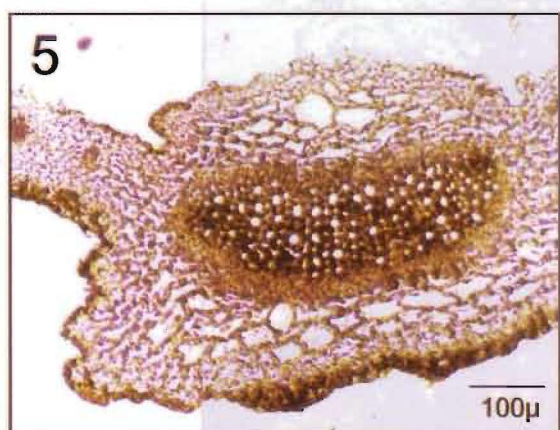
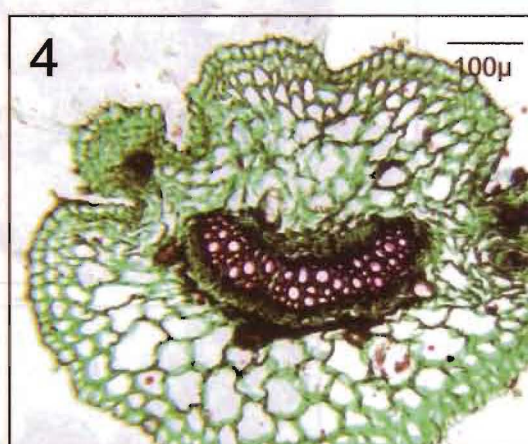
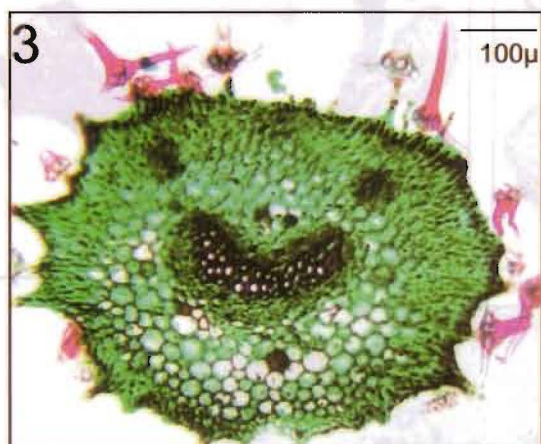
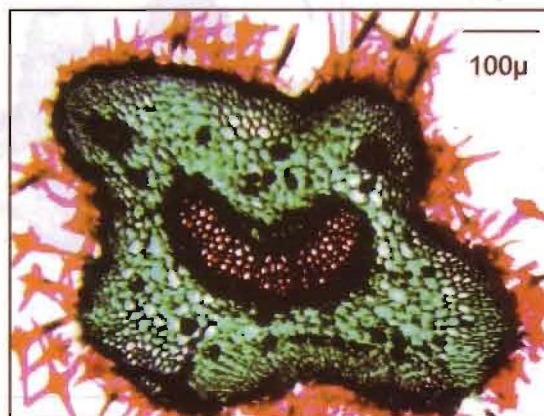
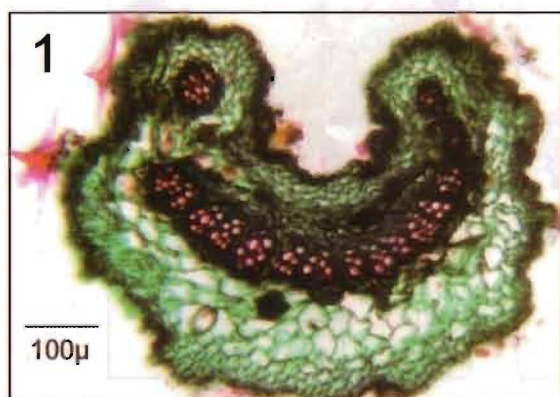


Plate 3. Transsections of petiole

1- *S.coagulans*

2- *S.incanum*

3-*S. forsskaolii*

4-*S.sinaicum*

5- *S. nigrum* var. *nigrum*

6-*S.schimperianum*

(cont.)



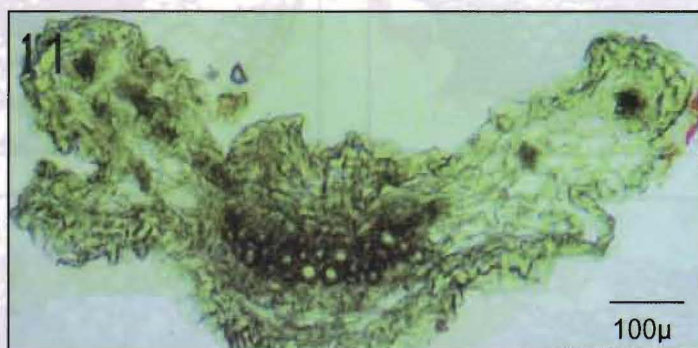
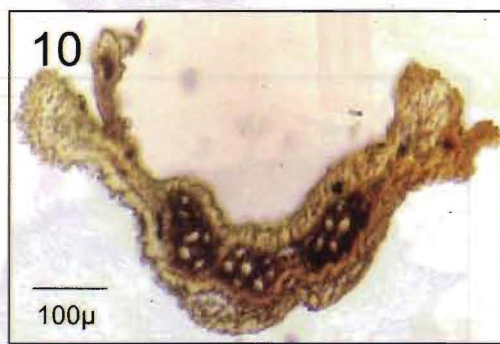
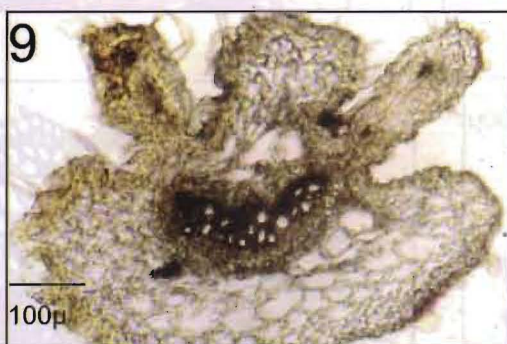
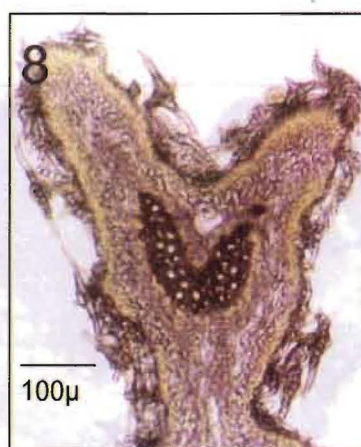
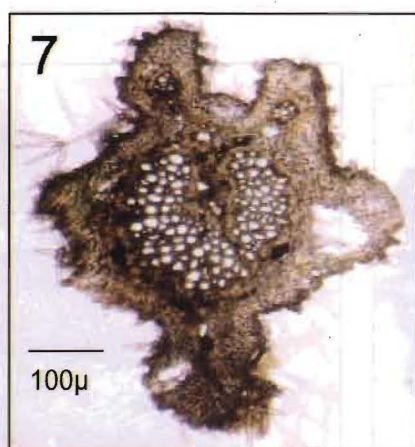


Plate 3 Cont.: Transsections of petiole

7- *S. virginianum*                      8- *S. elaeagnifolium*                      9- *S. villosum* ssp. *villosum*  
10- *S. villosum* ssp. *miniatum*                      11- *S. nigrum* var. *elbaensis*                      12- *S. nigrum* var. *incisum*



The petiole vascular system is crescent shape in all of the investigated taxa. The number of median bundles ranged between 3 dissected bundles in *S. villosum* ssp. *villosum* and 13 bundles in *S. coagulans*. Lateral or subsidiary bundles ranged between 2-3 (Plate 3, Fig. 5) in all studied taxa.

### DISCUSSION

A summary of the anatomical differences of stem, petiole and blade between the twelve studied *Solanum* taxa is given in Tables (1&2).

The morphology of *Solanum* taxa in Egypt and diagnostic characters of their differentiation were reported by Täckholm (1974), Edmonds and Chweya (1997), Hepper (1998) and Boulos (2002). The criteria used for the above studies were some morphological characters which were not clear distinction for critical identification, particularly as at the subspecies and varieties levels. Therefore, it is pertinent to considerations of dynamic phylogeny to point out that the determination of detailed micromorphological features of each taxon are frequently of major importance in solving problems associated with speciation, evolution and correlation.

Mohamed & Al-Gohary (2007) studied some microscopic characteristics such as trichome morphology, stomata and leaf sculpture of Egyptian *Solanum* which were proved to be of systematic value.

The anatomical structure of the stem and leaves in *Solanum* taxa generally agree with the feature of the axis and leaves in Solanaceae as described by Metcalfe & Chalk (1950) and Al-Nowaihi & Khalifa (1974).

This investigation of the anatomical structure of the stems and leaves in *Solanum* taxa has shown that some micromorphological features proved to be diagnostic for the identification of the species, subspecies and varieties viz, the outline in cross sections of stem and petiole, presence or absence of hypodermis, cortical composition and types of steles, in addition to some anatomical features of leaf including mesophyll types, the number of the main bundles at the mid-rib region, presence or absence of the bundle sheath. On the basis of these micromorphological diagnostic attributes, the following key is suggested for the identification of the studied Egyptian *Solanum* taxa.

A- Vascular cylinder eustele

B- Stem angular

C- Cortex of two types of cells, hypodermis, schizogenous canals and idioblast present,

petiole folded .....

..... *S. villosum* ssp. *villosum*

BB- Stem folded

C- Cortex of one type of cells, hypodermis present, schizogenous canals and idioblast absent, petiole crescent .....

..... *S. villosum* ssp. *miniaturum*

CC- Cortex of two types of cells

D- Hypodermis present

E- Schizogenous canals and idioblast absent, petiole folded.....

..... *S. nigrum* var. *nigrum*

EE- Schizogenous canals and idioblast present, petiole crescent .....

..... *S. nigrum* var. *elbaensis*

DD- Hypodermis absent Schizogenous canals and idioblast absent, petiole folded.....

..... *S. nigrum* var. *incisum*

AA- Vascular cylinder siphonostele

B- Stem angular,

C- Cortex of one type of cells, schizogenous canals and idioblast absent, petiole folded.....

..... *S. virginianum*

BB- Stem terete

CC- Cortex of two types of cells

D- Mesophyll isobilateral

E- Hypodermis absent, petiole Y-shaped, with one bundle.....

..... *S. elaeagnifolium*

EE- Hypodermis present, petiole crescent, with 13 separate bundles .....

..... *S. coagulans*

DD- Mesophyll dorsiventral, hypodermis present

E- Petiole angular, bundle sheath absent.....

..... *S. forsskaolii*

EE- Petiole folded, bundle sheath present .....

..... *S. sinaicum*

DDD- Mesophyll isolateral, hypodermis present

E- Petiole folded, bundle sheath present .....

..... *S. schimperianum*

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## دراسات تشريحية للفئات التصنيفية البرية لجنس السولانم في مصر

[١٨]

إيمان حسين الجوهري<sup>١</sup> - آمال حسن محمد<sup>٢</sup>

١. وحدة تقسيم النبات-مركز بحوث الصحراء-المطرية-القاهرة- مصر

٢. قسم النبات -كلية العلوم (فرع البنات) - جامعة الأزهر - القاهرة- مصر

غلاف الحزمة الوعائية والخلايا الراتنجية وكذلك النسيج الوعائي في الاعناق ؛ لها أهمية في عمل المفتاح التصنيفي المقترح لتعريف هذه النباتات. وقد تم عمل مفتاح اصطناعي علي اساس الصفات التشريحية للسيقان والأوراق لهذه الفئات التصنيفية لسهولة التعرف عليها والتمييز بينها حيث ان الصفات المورفولوجية لها قليلة وغير كافية للفرقة بينها وخاصة الوحدات التصنيفية تحت النوع والسلالات في هذا الجنس.

اتضح من الدراسة التشريحية المقارنة لسيقان وأوراق عدد اثنتا عشرة وحدة تصنيفية من جنس السولانم النامية برياً بمصر: أن هناك اختلافاً في شكل السيقان والاعناق في القطاعات المستعرضة وجود أو غياب طبقة تحت البشرة، تركيب القشرة والطبقة المحيطية ، نوع الاسطوانة الوعائية في السيقان. وقد دلت النتائج أيضاً أن الصفات التشريحية للورقة والتي تشمل: النسيج التمثيلي ، عدد الحزم الوعائية في منطقة العرق الوسطي، وجود أو غياب