COMPARATIVE ANATOMICAL ANALYSIS OF STEM IN FOUR GENERA OF THE TRIBE SALSOLEAE, CHENOPODIACEAE

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The stem anatomy of 18 species belong to the genera *Anabasis* L., *Haloxylon* Bge., *Hammada* Iljin, *Seidlitzia* Bge. ex Boiss. of the tribe *Salsoleae* (*Chenopodiaceae*) was examined. Anatomical characters with numerical analysis provided some significant data for the delimitation of taxa at the generic and specific levels.

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Key words. Anatomy, numerical taxonomy, *Chenopodiaceae, Salsoleae*, Iran.

تشریح مقایسه‌ای ساقه در چهار جنس از قبیله Salsoleae تیره Chenopodiaceae

رضا رمضان نژاد قادی،دینا عزیزیان و مصطفی اسدی

ساختمان تشریحی هجده گونه از چهار جنس *Hammada* , *Anabasis* , *Haloxylon* , *Seidlitzia* از تیره اسفناج مورد بررسی قرار گرفت. با وجود تشابهات مورفولوژیک و اشکالات موجود در تفکیک این تاکسونها بر حسب صفات مذکور،صفات آناتومی متمایز کننده ای در سطح جنس و گونه شناسایی شد. با استفاده از تاکسونومی عددی ،قرابت بین تاکسونها بررسی شده وتفکیک تاکسونها بر حسب صفات مورفولوژیک با نتایج این پژوهش تفاوتهای آشکاری داشته است.

INTRODUCTION

Chenopodiaceae is a family of about 100 genera and more than 1500 species which widely distributed in temperate and subtropical area (Heywood 1978). One of the great diversity and richness centers of the family is in southwestern Asia, especially Iran. The family *Chenopodiaceae* represented in Flora of Iran by 41 genera and about 175 species which grow in various parts of Iran (Assadi 2001). The family comprises annual and perennial herbs mainly growing in saline habitats. Characters of taxonomic value within the family include the vegetative and reproductive organs but mainly on the basis of embryo shape as mentioned in various floras (Assadi 2001, Rechinger1997).

Taxonomy of the family based on the morphological characters has been unsatisfactory to determine relationships among the species and genera of the family. Anatomical characters have been used in the taxonomy of this family (Khatib 1959), (A.Butnik 1991), (Pyankov et al. 1997), (Krumbiegel 1998) and other plant families.

In this work four genera, *Anabasis* L., *Haloxylon* Bge., *Hammada* Iljin and *Seidlitzia* Bge. ex Boiss. Belong to the tribe *Salsoleae* C. A. Mey., subfamily *Salsoloideae* C. A. Mey. of the family *Chenopodiaceae* Vent. has been investigated. Altogether 18 species of four mentioned genera were examined anatomically to determine diagnostic characters to assess interspecific and intergeneric relationships. In comparison with the size of the family and genera few microscopic details on the anatomy of these genera has been published by various authors as Fahn & Arzee (1959), Khatib (1959), Fahn (1963,1982), Fahn & Schori,(1968), Wendelbo & Bokhari(1978), Metcalfe & Chalk (1979), Butnik (1991), and Kadereit & et al. (2003).

In order to attain a deeper insight into these genera and to identify further distinctive characters at different taxonomic level, we carried out anatomical studies on stem of those taxa. Because of leaves reduction in some taxa of these genera, anatomical study performed on stem.

MATERIALS AND METHODS

Following 19 taxa based on the nomenclature of Assadi (2001) were anatomically examined.

Anabasis annua Bge. -*A. aphylla* L. - *A. articulata* (Forssk.) Moq., Syn.: *A. lachnantha* Aellen & Rech. f. - *A. calcarea* (Charif & Aellen) Bokhari & Wendelbo –*A. eriopoda* (Shrenk) Volkens -*A. eugeniae* Iljin –*A. haussknechtii* Bge. ex Boiss. var. *haussknechtii* –*A. haussknechtii* Bge. ex Boiss. var. *iranica* (Iljin) Assadi, Syn.: *A. iranica* Iljin– *A. jaxartica* (Bge.) Benth ex Volkens –*A. salsa* (C. A. Mey.) Benth ex Volkens -*A. setifera* Moq. –*Haloxylon ammodendron* (C. A. Mey.) Bge. -*H. persicum* Bge. ex Boiss. -*Hammada griffithii* (Moq.) Iljin, Syn.: *Haloxylon griffithii* (Moq.) Boiss. - *Hammada salicornica* (Moq.) Iljin, Syn.: *Haloxylon salicornicum* (Moq.) Bge. ex Boiss. - *Seidlitzia cinerea* (Moq.) Bge. ex Botsch. -*S. florida* (M.B.) Bge. ex Boiss. - *S. rosmarinus* (Ehrenb.) Bge. ex Boiss. -*S. stocksii* (Boiss) Assadi, Syn.: *Haloxylon recurvum* sensu Boiss..

For light microscopic studies, dried material was obtained from herbarium specimens of Research Institute of Forests & Rangelands (TARI). In addition some fresh specimens were used for some taxa. The list of species is presented in table 1.

Table1: list of species, their codes, collectors, herbarium numbers and localities.

Species	Code	Voucher specimen
Anabasis annua	a.an	Isfahan: ca. 85 km SE Isfahan. Yangabad, 1450 m, Assadi & Abouhamzeh 36523.
Anabasis aphylla	a.ap	Azerbaijan: W. of Tabriz, Mayan. 1450 m. Assadi & Akhani 61472; N. of Oroumieh lake, Tasuj, 1370 m, Assadi and Salehi 31981.
Anabasis articulata	a.ar	Hormozgan: 205 km from Bandarabbas to Lar, 630 m, Foroughi & Assadi 15072
Anabasis calcarea	a.ca	Yazd: 11 km Dehshir to Abarghu, 1500 m. Assadi & Abouhamzeh 36489; Azerbaijan: 20-30 km from the main road to Ahar, 1500m, Assadi 79070.
Anabasis eriopoda	a.er	Semnan: Touran Protected area, S. of Salehabad to Sanjari, N side of pass, 1275 m, Freitag 13812.
Anabasis eugeniae	a.eu	Azerbaijan: ca. 18 km NW of Marand, between Kashksarai and Erelan, 1500 m, Assadi 79078; Tehran: Firouzkuh, Simindasht road, near Kalak, 2000 m, Assadi & Abouhamzeh 66316.
A.haussknechtii var. *haussknechtii*	a.ah1	Fars: 23 km from Abadeh to Shiraz, 1850 m, Assadi & Abouhamzeh. 36506.
A.haussknechtii var. *iranica*	a.ah2	Isfahan: Abyazan, between Natanz and Ardestan, 1400 m, Wendelbo & Foroughi 18972.
Anabasis jaxartica	a.hi	Gorgan: Golestan forest, from Sulgerd to Lohondor, Assadi 66397.
Anabasis salsa	a.sa	Semnan: Turan Protected area, NW of Dochah, 1150 m, Freitag 14102.
Anabasis setifera	a.se	Semnan: Firouzkuh, near Simindasht, 1550 m, Assadi & Abouhamzeh 66327.
Haloxylon ammodendron	h.m	Isfahan: ca. 25 km SE. Kashsan, near Mohammad abad, 1100 m, Assadi 79095; 30 km S. Dehshir, near Mahmoudabad, 1500 m, Assadi & Abouhamzeh 36484.
Haloxylon persicum	h.pe	Khorasan: ca. 150 km E. of Ghayen, on the road to Yazdan, E. of the village Chahe Zard, 700 m, Assadi & Amirabadi 66657.
Hammada griffithii	h.gr	Balouchistan: SE. Zahedan, Shurak area, 1650 m, Sandoughdaran 1781.
Hammada salicornica	h.sa	Fars: ca. 30 km S. Jahrom, near the village Karian, 800 m, Assadi & Akhani 61854; Kerman: 41 km to Dige Rostam, from Ravar, Assadi & Amirabadi 66552.
Seidlitzia cinerea	s.ci	Yazd: Junction of Kerman road to Bafgh, 1200 m, Assadi & Abouhamzeh 36393.
Seidlitzia florida	s.fl	Azerbaijan: 37 km to Maku, from Marand, ca. 1200 m, Assadi 70808; Azerbaijan: 28 km to Salmas, from Tasuj, 1350m, Assadi & Salehi 31998.
Seidlitzia rosmarinus	s.ro	Tehran: 20 km from Garmsar to Semnan, 800 m, Assadi & Abouhamzeh 40007.
Seidlitzia stocksii	s.st	Balouchistan: Chabahar, between Pasabandar and Guatr, ca. 10 m, Mozaffarian 52851, the same area, Bandare Beris, sea level, Mozaffarian 52821.

In order to study stem characters, materials below the inflorescence were revived by boiling water, cooled and fixed in FAA for 48 hours, and cross sections were prepared by hand using razor blade. Sections were cleared with sodium hypochlorite, dehydrated and stained with methyl green 0.1% and carmine 1% for 30 seconds and 15 minutes respectively, then mounted in gelatin. Observations were carried out with Olympus light microscope.

For numerical analysis 40 characters were studied. Qualitative characters were coded as multistate characters and means of quantitative characters were used. The 40 used characters and their coding presented in table 2. In order to determine the significant differences in quantitative characters between the taxa of *Anabasis* and or *Seidlitzia*, analysis of variance (ANOVA) was performed. But because of limitation of samples in two genera, *Hammada* and *Haloxylon*, the T- test was performed. For grouping the similar taxa, cluster analysis using WARD and ordination of species on the first two principal component axes (PCA) was performed. In order to determine the most variable anatomical characters among the species, a factor analysis based on principal components analysis (PCA) was performed (Sneath1957) and (Stace1989).

Table 2: The 40 used characters and their coding.

1- Arrangement of epidermal layers: Oriented along the stem = 1 , irregular = 2
2- Shape of epidermal cells: Long (length two time more than width) = 1, short = 2
3- Stomata: Present = 1, absent = 2
4- Stomatal canals: Present = 1, absent = 2
5- Crystal in epidermis: Present = 1, absent = 2
6- Hypodermis: Present = 1, absent = 2
7- Continuity of hypodermis layer: Continued = 1, uncontinued = 2
8- Crystal in hypodermis: Present = 1, absent = 2
9- Palisade like chlorenchyma: Present = 1, absent = 2
10- Crystal in palisade like chlorenchyma: Present = 1, absent = 2
11- Continuity of palisade like layers: Continued = 1, uncontinued = 2
12- Short cell chlorenchyma: Present = 1, absent = 2
13- Continuity of short cell chlorenchyma: Continued = 1, uncontinued = 2
14- Crystal in short cell chlorenchyma: Present = 1, absent = 2
15- Cortical collenchyma: Present = 1, absent = 2
16- Position of collenchyma in transverse section: Symmetric = 1, unsymmetric = 2
17- Type of cortical collenchyma: In 4 equal groups = 1, in 4 unequal groups = 2, in 2 groups = 3
18- Crystal in storage cortical parenchyma: Present = 1, absent = 2
19- Ray elongated parenchyma around vascular cylinder: Present = 1, absent = 2
20- Cortical vascular bundles: Present = 1, absent = 2
21- Arrangement of vascular bundles: Symmetric = 1, unsymmetric = 2
22- Type of symmetry in vascular bundles: In 4 group = 1, in 2 group = 2
23- Size of vascular bundles group: Equal = 1, unequal = 2
24- Crystal in vascular tissues: Present = 1, absent = 2
25- Crystal in pith parenchyma: Present = 1, absent = 2
26- Cortical fiber: Present = 1, absent = 2
27- Arrangement of cortical fiber: Symmetric = 1, unsymmetric = 2
28- Type of symmetry in cortical fiber: Round = 1, in 4 group = 2
29- Shape of stem in transverse section: Rounded = 1, elliptic = 2, tetragonal = 3, irregular = 4
30- Diameter ratio of cortex to vascular cylinder
31- Diameter ratio of vascular cylinder to stem
32- Diameter ratio of pith parenchyma to cortex
33- Diameter ratio of crystal to cortex
34- Diameter ratio of protective tissues to stem
35- Diameter of crystals in cortex: (Micron)
36- Number of epidermal layers: One = 1, two = 2, three = 3, four = 4, more than seven = 5
37- Length of epidermal cell: (Micron)
38- Number of hypodermal layers: One = 1, two = 2
39- Number of cortex layers
40- Diameter ratio of cortex to stem

OBSERVATION

The comparison of important anatomical characters of stem for separation of taxa in generic and specific levels are as bellow: Stem TS.: The stem in transverse section was more or less circular in most of the species examined (fig. 2 A-F, fig. 3 A-E, fig.4 E-F). This character was different in genus *Haloxylon* (fig.3 F,G) and also divided the genus *Seiditzia* into two groups. Shape of stem in transverse section was more regular in two species; *S. cinerea* and *S. stocksii* than other species with irregular shape (fig. 4 A-D).

Epidermis: usually consisting of one layer of cells for example in *Hammada griffithii* and *Haloxylon ammodendron* (Figs.4 E, 3 F)**,** but frequently more than one layer present in some species, as distinctly two layered in *Hammada salicornica* and *Haloxylon persicum* (figs. 4 F, 3 G)*,* and three layered epidermal cells in *Seidlitzia rosmarinus* (Fig. 4 C) which can be distinguished within genera and species. Therefore number of epidermal layers separated two species of the genera *Haloxylon* and *Hammada* (Figs.3 F, 3 G and 4 E, 4 F). This character also distinguishes *Seidlitzia rosmarinus* with three layered epidermis from the others with one layer, or *Anabasis clacarea*, with more than seven layers of epidermal cells from the other species of these genera (fig. 2 D). Epidermal cells sometimes have different sizes and shapes as in *Anabasis* species. Shape of epidermal cells is two types, short and long, that is various and distinguishes the species of *Anabasis*.

Arrangment of epidermal layers had two types; regular or irregular along the stem, and constant in species of two genera, *Hammada* and *Haloxylon* with regular arrangment, but distinguished *Seidlitzia rosmarinus* with irregular type, from the other species of this genus (fig. 4 A-D) and divided the genus *Anabasis* into two groups. The first group involved *Anabasis Jaxartica*, *A. eugeniae* , *A. setifera* , *A. aphylla* and *A. haussknechtii* that had regular layers of epiderm, but other species of *Anabasis* had irregular epidermis layers (figs. 3 A-E and 2 A-F).

Crystals present in epidermal cells of some species, which distinguish *S. rosmarinus* (fig. 4 C), *Anabasis annua*, *A. articulata* and *A. calcarea* from the other species of their genera. Presence of superficial stomata is only important and various in the genus *Anabasis*. But presence of stomatal cannals can distinguish *Hammada salicornica* (fig. E, F) and three species of *Anabasis* including *A. calcarea*, *A. Jaxartica* and *A. articulata* from the others (figs. 2 D and 3 C, E). Variation in length of epidermal cells is very important character, especially in two genera *Hammada* and *Haloxylon*.

Hypodermis: Usually one layer of hypodermis presents in *S. stocksii* but absent in other species of this genus. Also all species of the genus *Anabasis* except *A. annua* had hypodermis. Continiuty of hypodermis layer delimitate *A. salsa*, *A. setifera* and *A. eugeniae* from the other group of this genus with continuted hypodermis. Number of hypodermis layers distinguishes two species of *Hammada* and also *A. eugeniae* (with two layers of hypodermis) from the other species of *Anabasis* (figs. 2-4). Cortex: usually involved these parts;

Collenchyma: Cortical collenchyma absent in two genera *Hammada* and *Haloxylon* (fig. 3 F, G and 4 E, F). But presence of this layer distinguishes *S. stocksii* and *A. eugeniae , A. salsa* and *A. annua* from the others (figs. 4 B, 2 B, E, 3 D). Type of symmetry in this layers based on transverse section of stem is different in *A. eugeniae* from the other taxa of *Anabasis* that have collenchyma (fig. 2 B).

Palisade like chlorenchyma: presence of this layer only separates *S. stocksii* from the other species of *Seidlitzia*. Continuation of this layer that is caused by absence of collenchyma, divides the genus *Anabasis* into two groups. The first group involved *A. eugeniae*, *A. salsa*, *A. annua* and *A. setifera* with no continuous chlorenchyma. Presence of crystals in this layer delimitated *A. salsa*, *A. eriopoda* and *A. haussknechtii* var. *haussknechtii* from the other taxa of this genus (figs. 2, 3, 4).

Short cell Chlorenchyma: This layer located under palisade shape chlorenchyma. Species of two genera *Hammada* and *Haloxylon* have this layer, but prese Chenopodiaceae nce of this charcter distinguishes *S. stocksii* from the other taxa of this genus and assign it to genus *Anabasis* (fig. 1 up, 4 A-D). Also presence of crystals in this layer distinguishes *A. setifera* from the other taxa of *Anabasis*. Continuity of this layer divides the genus *Anabasis* into two groups similar to last paragraph.

Storage cortical parenchyma: Persence of crystals in these layers distinguish two species of *Haloxylon* (fig. 3 F-G). There are no crystals in cortical cells of *H. persicum*. This character is not useful in other genera related to presence of crystal in cortical cells of all of them. Existence of cortical bundles was constant in *Anabasis* but separate *S. stocksii* with cortical bundles from the other taxa of this genus that lack this character. Presence of ray elongated parenchyma that arranged vertically around the vascular cylinder is distinctive between two species of *Haloxylon* and also separate *S. rosmarinus* and *A. setifera* that had this character from the other taxa of their genera.

Presence of cortical fibers was constant in *Haloxylon* and *Hammada* but distinguishes *S. stocksii* and *S. rosmarinus* from other group of this genus, and also

distinguishes *A. annua* and *A. salsa* from the other species of *Anabasis*. Number of cortical parenchymatous layers is very important in separation of *S. florida* from the other species of *Seidlitzia* (fig. 4 A-D).

Vascular cylinder: nearly all of genera posses 4 large bundles, but the size of vascular bundles varies among the species and sometimes among 4 bundles of a specimens (figs. 5 A-D, 5 G, 6 A-F, 7 A, B, D) but are different in other taxa (figs. 5 E, F and 7 C, E, F). Each vascular bundle is surrounded by a thick sclerenchymatous sheath.

Arrangment of vascular bundles, distinguish *S. romarinus* from the other species of this genus (fig. 7 C-D). This character distinguishes *A. eriopoda* and *A. jaxartica* from the other taxa of *Anabasis* (fig. 5 E, F). Type of symmetry in vascular bundles based on number, size and position of bundles which distinguish two species of *Hammada* (fig. 6 B, D) and also some species of *Anabasis*. Presence of crystals in vascular fibers distinguishes two species of *Haloxylon* (fig. 7 A, B) and also *A. salsa* from the other species of *Anabasis* (fig. 5 and 6). The pith in all species composed of parenchyma cells. Absence of crystals in pith parenchyma only distinguishes *A. setifera*, from the other taxa of this genus.

Quantitative characters mostly changed to ratio of two characters and were important in specific and generic levels too. The main quantitative characters are diameter ratio of; cortex to vascular cylinder, vascular cylinder to stem in transverse section, pith parenchyma to cortex, epidermal layers to cortex, cortex to stem and crystals to cortex. Other characters are number and length of epidermis and hypodermis layers, number of cortex layers and diameter of crystal in cortex region.

RESULT OF STATISTICAL ANALYSIS

Results of ANOVA and T-test showed the significant difference between quantitative characters. Phenogram of cluster analysis (UPGMA) presented in fig.1. Two major clusters can be recognized as being supported by ordination of the genera based on principal components analysis (fig.1). The first cluster is divided to two groups. The arrangement of species in cluster was written in the left of cluster. The main points in this cluster are location of the genus *Seidlitzia*, separation of the two species of *Haloxylon* and also separation of *Seidlitzia stocksii* from the other species of *Seidlitzia*.

Factor analysis of anatomical characters showed that the first four factors described about 69% of total variance. The first component comprises about 34% of the total variance to which the presence and continuity of hypodermis and chlorenchymatus layers, presence of

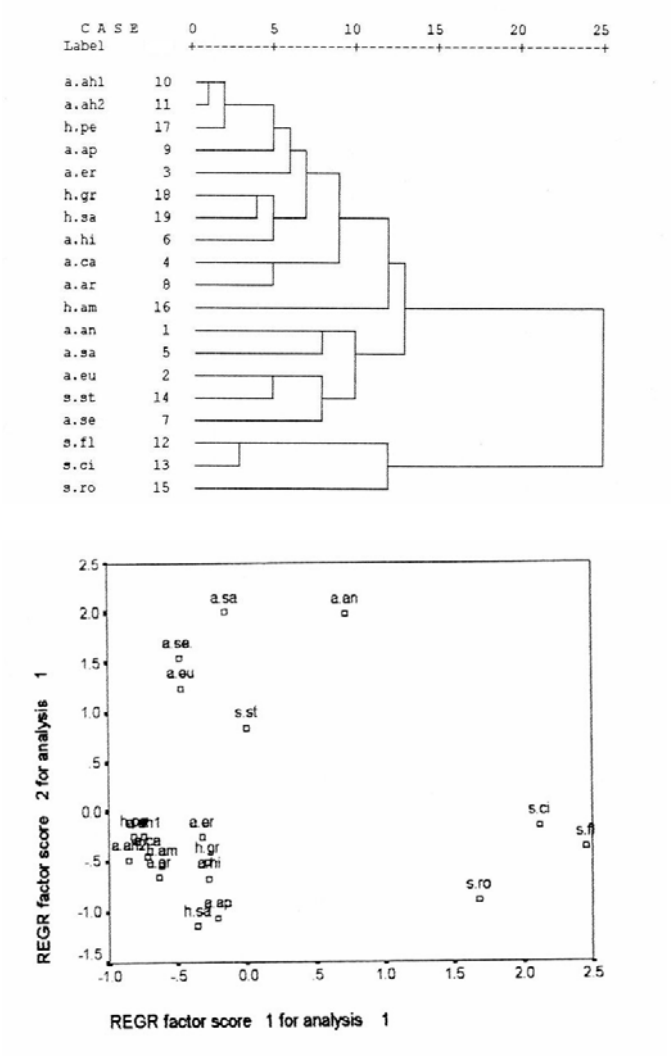

Figure1: Above; Cluster analysis of taxa by UPGMA; Two major clusters are recognized. The first one divided to two groups. In a cluster three species of *Seidlitzia* located. In other cluster one species of *Seidlitzia* with species of other genera located. Below; Ordination of taxa based on PCA;Three species of *Seidlitzia* are separated from the others. Then four species of *Anabasis* with *Seidlitzia stocksii* have longer distance from the other taxa: a. sa : *Anabasis salsa*, a. an: *A. annua*, a.se: *A . setifera*, a. eu: *A. eugeniae*, a. er: *A. eriopoda*, a. ap: *A. aphylla*, a. ca: *A. calcarea*, a. ar: *A. articulata,* a. hi: *A. jaxartica*, a. h 1: *A. h.* var. *haussknekhtii*, a. h 2: *A. h* .var. *iranica*, s. st: *Seidlitzia stocksii*, s. ci: *S. cinerea*, s. ro: *S .rosmarinus*, s fl: *S. florida*, h. sa: *Hammada salicornica*, h. gr: *H. griffithii*, h. pe: *Haloxylon persicum* , h. am: *H. ammodendron*.

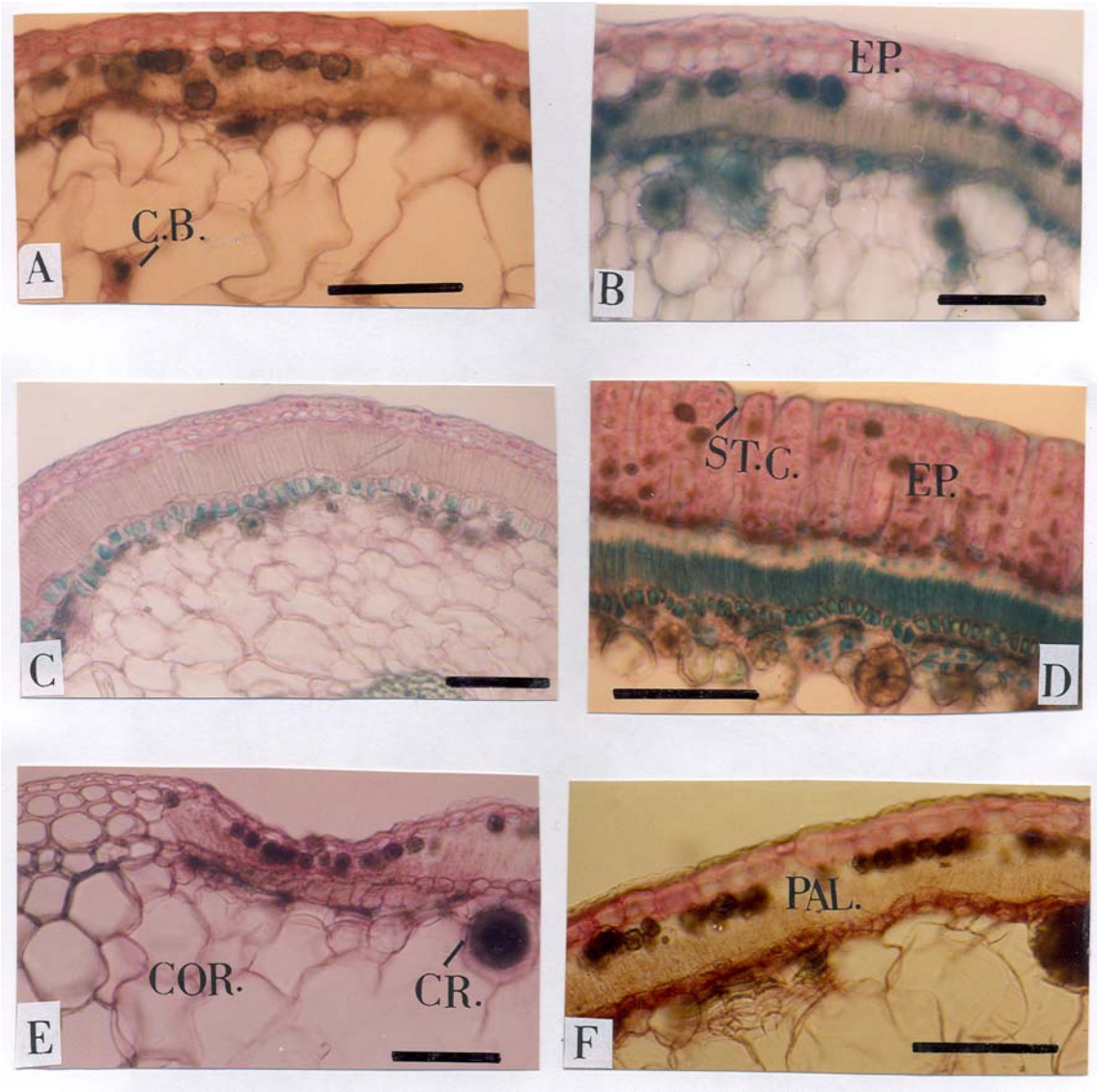

Figure 2: Cortex and epidermal layers: A: *Anabasis eriopoda*, B: *A. eugeniae*, C: *A. aphylla*, D: *A. calcarea*, E: *A. annua*, F: *A. setifera*. All of them have palisade and also spongy shape chlorenchyma. Hypodermis exists below the uni- or multilayered epidermis. This layer has crystals in some species. Some cortical bundles observed in *A. eriopoda.* This species also has crystals in palisade shape chlorenchyma. Size of crystals in cortex is very bigger than the other layers. *A.calcarea* has stomatal canal in multilayered epidermis. This species has crystals in epidermis layers too. C. B. = Cortical bundles, COR = Cortex,CR =Crystal, EP= Epidermis, PAL= Palisade chlorenchym, ST. C.=Stomatal canal.(Bar=200 micron).

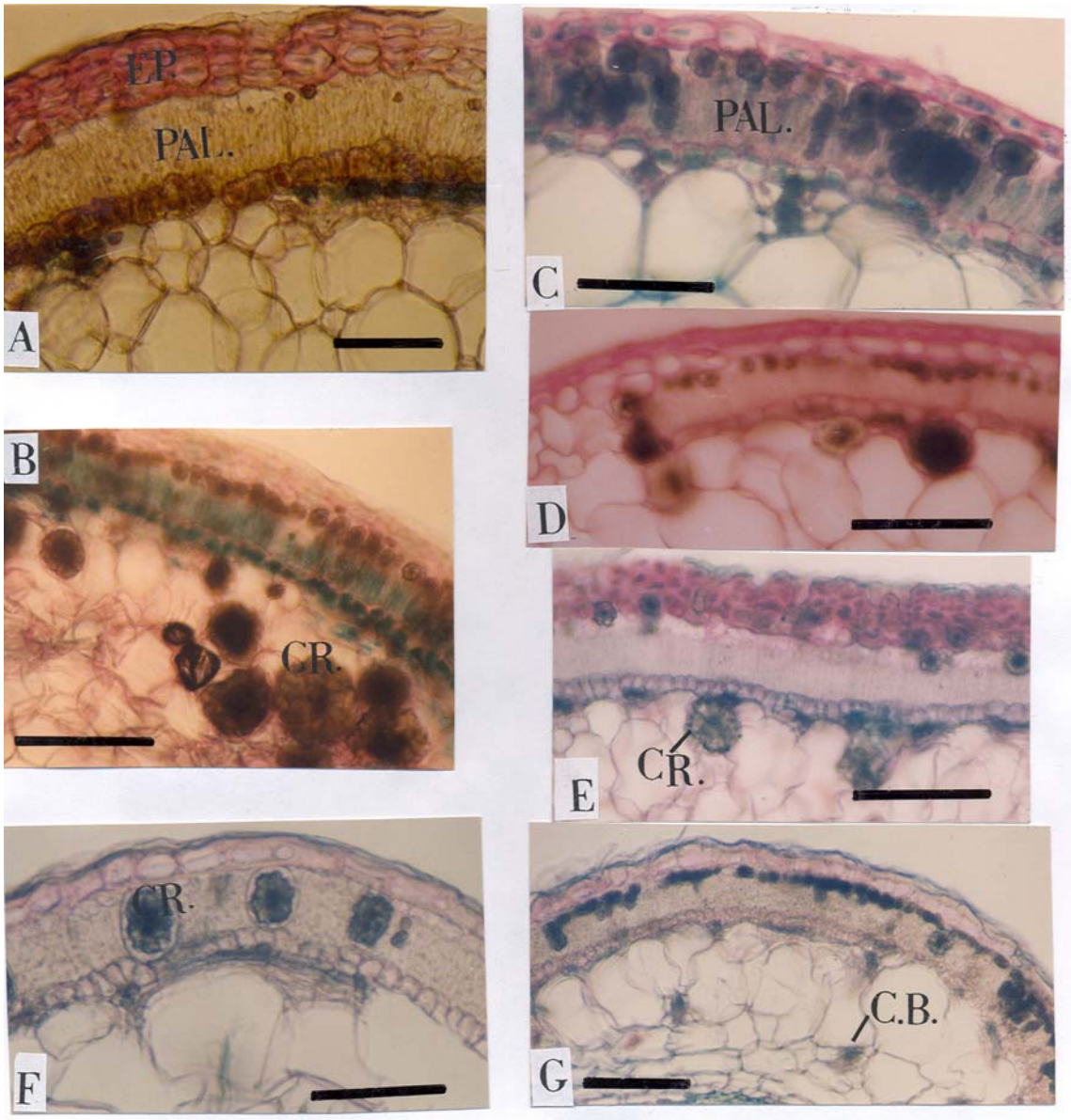

Figure3: Cortex and epidermal layers. A: *Anabasis haussknechtii* var. *haussknechtii*, B: *A. haussknechtii* var. *iranica*, C: *A. jaxartica*, D: *A. salsa*, E: *A. articulata*, F: *Haloxylon ammodendron*, G: *H. persicum*. Pay attention to collenchyma and number and size of crystals. Size of crystals in palisade shape chlorenchyma and cortex parenchyma is very big. Multilayered epidermis has small crystals in *A. articulata*. This species also has stomatal canals. Crystals also observed in hypodermis layer of some species. Density of crystals is very large in *A. haussknechtii* var. *iranica* and *A. jaxartica*. C. B. = Cortical bundles, COR= Cortex, CR= Crystal, EP= Epidermis, PAL= Palisade shap chlorenchyma, ST.C.=Stomatal canal. (Bar =200 micron).

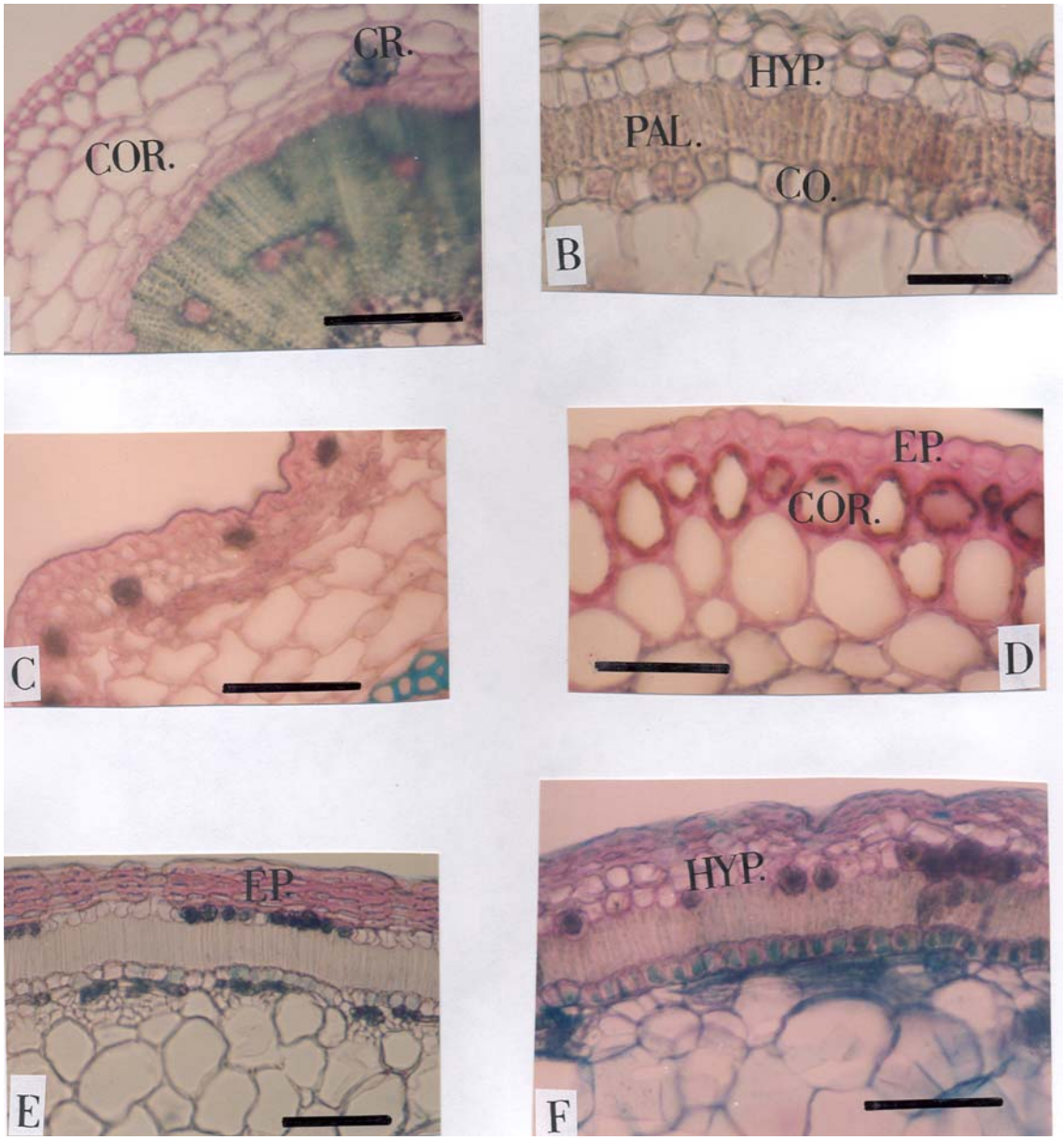

Figure 4: Cortex and epidermal layers: A: *Seidlitzia cinerea*, B: *S. stocksii*, C: *S. rosmarinus*, D: *S. florida*, E: Hammada griffithii, F: *H. salicornica*. *Hammada salicornica* has two layered hypodermis and stomatal canals. *S. cinerea* and *S. rosmarinus* and S. florida don't have palisade and spongy shape chlorenchyma against the *S. stocksii.* Density of crystals is limited in these species. C. B. = Cortical bundles , COR = Cortex , CR = Crystal, EP = Epidermis, PAL = Palisade chlorenchym, ST. C.=Stomatal cannal.(Bar =200 micron).

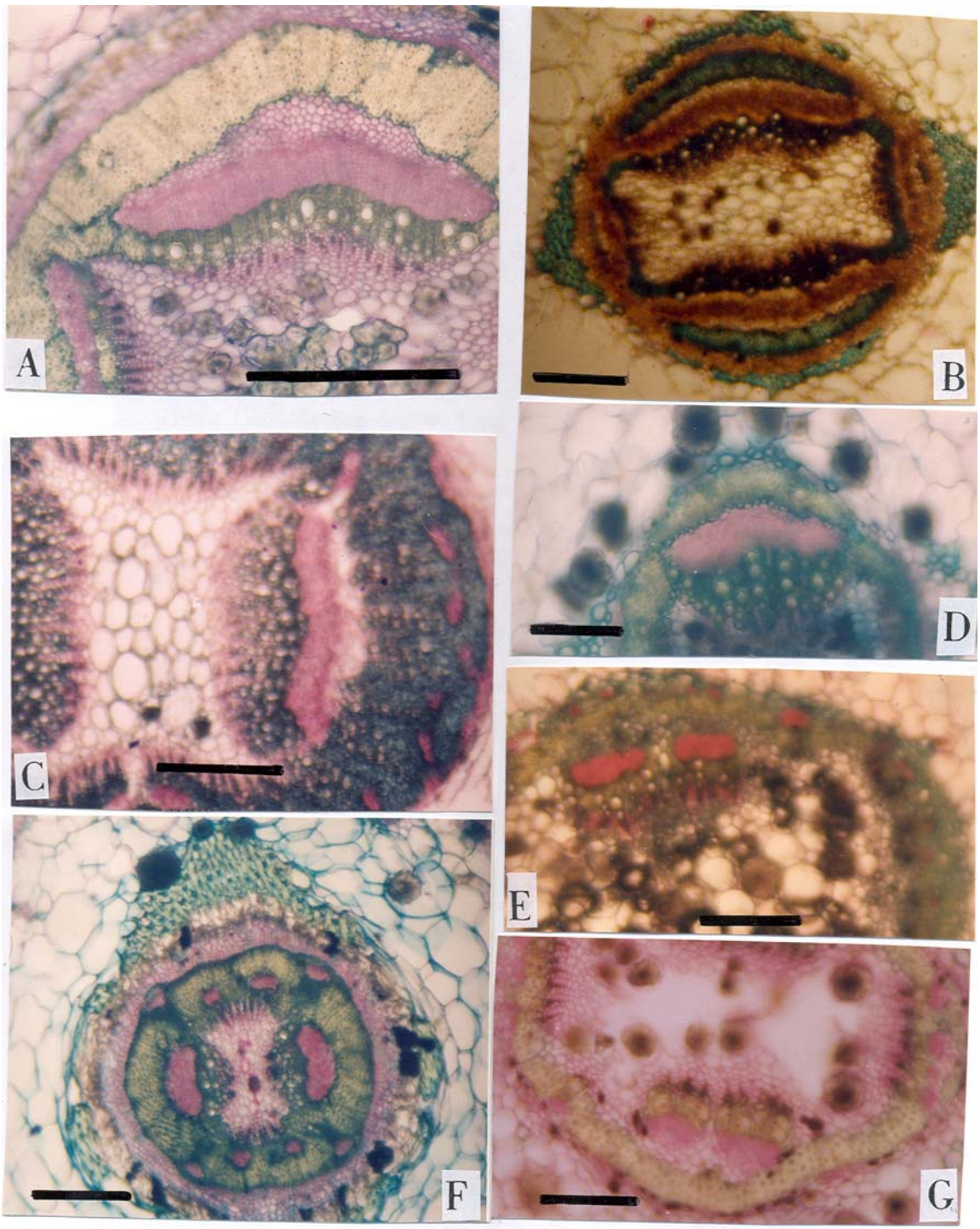

Figure 5: Vascular cylinder or part of it: A: *Anabasis articulata*, B: *A. haussknechtii* var. *haussknechtii*, C: *A. annua*, D: *A. haussknechtii* var. *iranica*, E: *A. eriopoda*, F: *A. jaxartica*, G: *A. salsa*. (Bar = 200 micron).

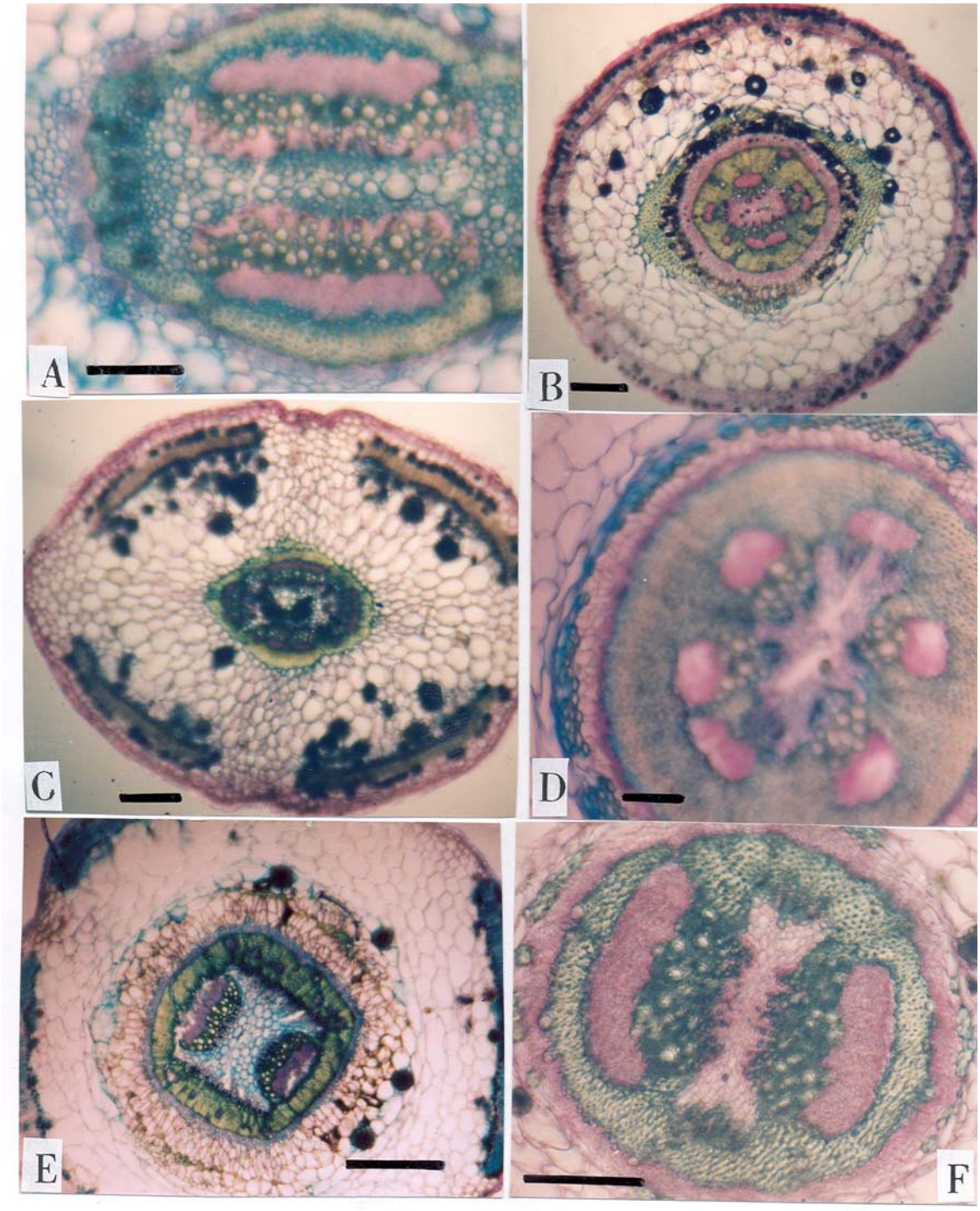

Figure 6: Vascular cylinder or part of it. A: *Anabasis calcarea*, B: *Hammada griffithii*, C: *A. eugeniae*, D: *H. salicornica*, E: *A. setifera*, F: *A. aphylla*.(Bar = 200 micron).

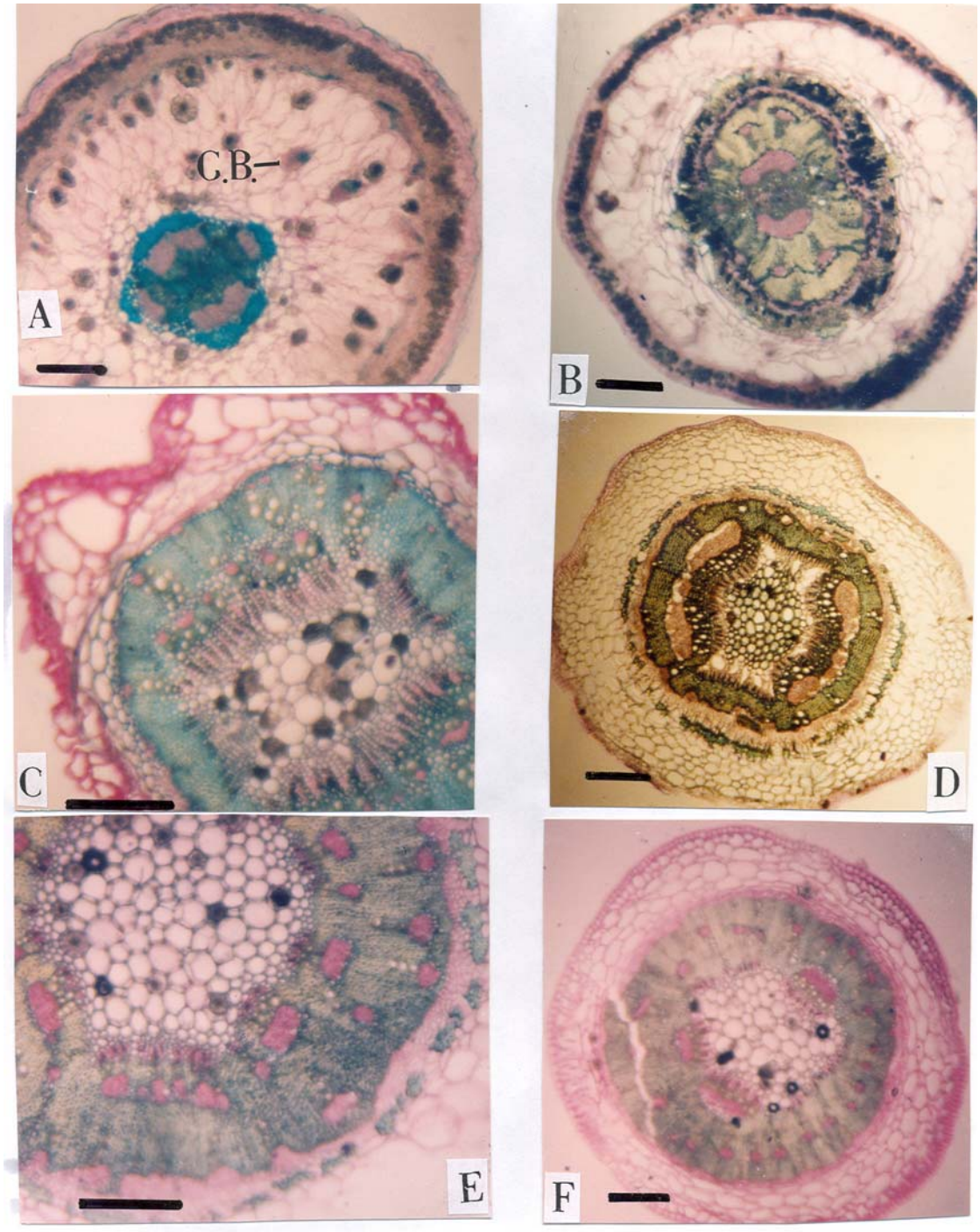

Figure 7: Vascular cylinder or part of it. A: *Haloxylon persicum*, B: *H. ammodendron*, C: *S. florida*, D: *S. rosmarinus*, E: *S. stocksii*, F: *S. cinerea*. (Bar = 200 micron).

crystals in those and presence of cortical bundles are highly correlated. These factors distinguish *S. rosmarinus*, *S. florida* and *S. cinerea* from the other taxa. Diameter of crystals and length of epidermal cells are highly correlated with the second component, these factors separates *A. salsa*, *A. eugeniae*, *A. setifera* , *A. annua* and *S. stocksii* from the others. Arrangment and number of epidermal cells, type and symmetry of vascular bundles, and presence of elongated parenchyma are highly correlated with the other factors. These characters are the most variable characters and may be used to differentiation among the genera and species.

DISCUSSION

The results obtained from this study showed that the anatomical characters can separate the taxa in generic and specific levels, and we made an anatomical key for delimitation of taxa. From morphological point of view we also found that grouping of the genera in this tribe is not correct exactly.

In this study many specimens of each species from different areas of Iran were compared, these specimens had same morphological and anatomical characters.

The genus *Haloxylon* is very similar to *Anabasis* in some Floras such as Flora Iranica (Rechinger 1997), Flora of Iran (Assadi 2001), Flora Palaestina (Zohary 1966). The main morphological difference between these two genera is location of embryo in seed. However in our results general anatomical similarity combined these genera. Two species of *Haloxylon* are separated by some characters of epidermis and cortex, but split the species of *Anabasis*. Therefore we need better morphological characters for delimitation of these two genera.

The genus *Hammada* mentioned as a synonym of *Haloxylon* in Flora Orientalis (Boissier 1879) and Flora Iranica (Rechinger 1997). But Assadi (2001) in Flora of Iran separated these two genera by morphological characters of stamen, inflorescence and phenology of flower. Our anatomical study confirms the distinction of these two genera. Two mentioned species of the genus *Hammada* are very similar morphologically, as recognized in Flora of Iran (Assadi 2001) and Flora Palaestina (Zohary 1966). These two species located together by anatomical evidence (fig.1 up). Species of *Hammada* and *Anabasis* are very similar morphologyically, also based on anatomical analysis, *Hammada* species located among the species of *Anabasis* (fig.1 up). So, we think that location of embryo alone is not a good character for delimitation of these two genera.

Seidlitzia stocksii presented in the genus *Haloxylon* in Flora Orientalis (Boissier1879) and Flora Iranica (Rechinger1997). This species separated from *Hammada* and *Haloxylon* by its succulent leaves, phenology of flowers and embryo location, in Flora of Iran (Assadi 2001). In this study this species located among the species of *Anabasis* because of similar characters (fig.1 up and down). It should be mentioned that oblique embryo in *S. stocksii* is intermediate between horizontal type in *Haloxylon* and vertical type in *Anabasis*.

Seidlitzia cinerea and *S. florida* were regarded as synonyms in Flora Iranica (Rechinger 1997), but separated by some characters of leaves and bracts in Flora of Iran (Assadi 2001). Statistical phenogram in this study separated them but they are very similar and closely related based on anatomical analysis (fig. 1).

Anabasis iranica mentioned as a synonym of *A. haussknechtii* or *A. aphylla* in Flora Iranica (Rechinger 1997) and Flora Orientalis (Boissier 1879) respectively. But they are separated by two quantitative characters of stem in Flora of Iran (Assadi 2001). In anatomical study they located in variety level of *A. haussknechtii* . Also *A. aphylla* is a species that closely related to *A. hausskenchtii* (fig.1 up and down).

Anabasis setifera mentioned as a synonym of *A. annua* in Flora Iranica (Rechinger 1997), but they were distinguished as perennial or annual respectively in Flora of Iran (Assadi 2001). Our study confirmed to distinguish them by some other characters such as presence or absence of elongated ray parenchyma next to vascular cylinder too.

Location of some species in clusters of statistical analysis is similar to morphological delimitation (fig.1 up and down). For example *A. salsa* to *A. eugeniae* , location of *A. jaxartica* between *A. aphylla* and *A. calcarea*, *A. articulata*, *A. aphylla* to *A. haussknechtii*, and also *A. calcarea* to *A. articulata*, are similar to their position in some Floras such as Flora Iranica (Rechinger1997) and especially Flora of Iran (Assadi 2001).

The key to the genera based on stem anatomical characters

1- Epidermal layers with irregular arrangment 2
- Epidermal layers with regular arrangement 3
2- Stomata and cortical vascular bundlles absent
Seidlitzia (*S. rosmarinus*)
- Stomata and cortical bundles present
Anabasis (*A. calcarea*, *A. articulata*, *A. eriopoda*)
3- Cortical bundles absent
Seidlitzia (*S. florida*, *S. cinerea*)
- Cortical bundles present 4
4- Crystals in pith parenchyma absent 5
- Crystals in pith parenchyma present 6

5- Cortical collenchyma present *Anabasis* (*A. setifera*)
- Cortical collenchyma absent *Haloxylon* spp.
6- Elongated ray parenchyma near the vascular cylinder present 7
- Elongated ray parenchyma near the vascular cylinder absent *Anabasis* (*A. salsa*, *A. haussknechtii*, *A. eugeniae*, *A. annua*, *A. jaxartica*)
7- Cortical collenchyma absent 8
- Cortical collenchyma present *Seidlitzia* (*S. stocksii*)
8- Stomata present *Anabasis* (*A. aphylla*)
- Stomata absent *Hammada* spp.

Key to the species of the genus *Anabasis*

1- Cortical collenchyma present 2
- Cortical collenchyma absent 3
2- Epidermis has two layers *A. salsa*
- Epidermis has one layer 4
3- Stomatal canal present 6
- Stomatal canal absent 8
4- Hypodermis has one layer 5
- Hypodermis has two layers *A. eugeniae*
5- Ray elongated parenchyma present *A. Setifera*
- Ray elongated parenchyma absent *A. annua*
6- Epidermis has 4 layers 7
- Epidermis has more than 6 layers *A. calcarea*
7- Epidermis with regular arrangement. Stem tetragonal *A. jaxartica*
- Epidermis with irregular arrangement. Stem round *A. articulata*
8- Epidermis and vascular bundles arrangement irregular *A. eriopoda*
- Epidermis and vascular bundles arrangement regular 9
9- Epidermis has two layers *A. aphylla*
- Epidermis has three layers *A. haussknechtii*

The key for the delimitation of varieties of *A. haussknechtii* is as follows

1-Crystals in palisade shape chlorenchyma absent. Size of vascular bundles unequal *A. haussknechtii* var. *iranica*
- Crystals in palisade shape chlorenchyma present, Size of vascalar bundles equal *A. haussknechtii* var. *haussknechtii*

Key to the species of the genus *Seidlitzia*

1-View of stem in transverse section is regular 2
- View of stem in transverse section is irregular 3
2- Hypodermis and cortical bundles present *S. stocksii*
- Hypodermis and cortical bundles absent *S. cinerea*
3- Epidermis has three layers, *S. rosmarinus*
- Epidermis has one layer *S. florida*

Key to the species of the genus *Haloxylon*

1- Epidermis has one layer, *H. ammodendron*
- Epidermis has two layers *H . persicum*

Key to the species of the genus *Hammada*

1- Epidermis has one layer, Stomatal canal absent *H. griffithii*
- Epidermis has two layers, Stomatal canal present *H. salicornica*

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