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Anatomical Adaptations of Some Egyptian Xerophytes

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ABSTRACT. The anatomical characteristics of leaves of seven xerophytic species namely: *Artemisia monosperma, Zilla spinosa, Farsetia aegyptia, Launaea spinosa, Zygophyllum coccineum, Panicum turgidum,* and *Lasiurus hirsutus* are described. *Artemisia monosperma, Zilla spinosa* and *Farsetia aegyptia* develop multilayered palisade tissue on both sides of their leaves with compact cells and narrow inter-cellular spaces. The leaves of *Zygophyllum coccineum* show large, highly vacuolated, water-storage cells lacking chloroplasts in addition to the photosynthetic mesophyll. *Panicum turgidum, Lasiurus hirsutus, Zilla spinosa* and *Farsetia aegyptia* show slightly sunken stomata, whilst in *Launaea spinosa* and *Artemisia monosperma* stomata are deeply sunken.

The desert vegetation is by far the most important of natural plant life of Egypt. It covers vast areas and is formed mainly of xerophytic shrubs and undershrubs (Zahran and Willis 1992).

Desert plants show many xeromorphic structural adaptations such as: salt glands, water-storage parenchyma, increased succulence, thickening of cuticle, sunken stomata, inrolled leaves, hairy leaf surfaces and early occurrence of lignification (Shields 1951 a, Metcalfe, 1960, Fahn 1964, Esau 1977, Fahn 1983 and Evenari 1985).

Extensive work has been carried out on the distribution, germination, growth and water relation of the Egyptian desert plant, but little work has been done on the anatomical adaptations of these plants *e.g.* Abdel-Rahman *et al.* (1976) who classified some xerophytes according to their xeromorphic anatomical characters and their means of standing xeric conditions into the following groups:

a) Succulent species *(e.g. Zygophyllum coccineum* and *Reaumuria hirtella)* depend for standing xeric conditions on water storage due to presence of large thin walled cells with large vacuoles.

b) Non-succulent perennials *(e.g. Heliotropium arbainense* and *Achillea fragrantissima)* depend on the restriction of water expenditure by dense cover of hairs protecting the transpiring surface from air currents and also on the multilayered palisade tissue on both sides with compact cells and narrow intercellular spaces.

c) The grass *(e.g. Pennisetum dichotomum)* exhibits some xeromorphic characters that help restriction of water expenditure. These characters include the rolling of leaves enclosing the upper surface with the distributed stomata in a closed atmosphere, *i.e.* the stomata become isolated from the dry external atmosphere.

d) The rocky species *(e.g. Capparis aegyptia)* growing under extremely dry conditions exhibits the highest ratio of internal to external surface represented by the multilayered palisade tissue comprising 6 layers of palisade cells with extremely narrow intercellular spaces.

e) The ephemeral species *(e.g. Senecio desfontainei)* characterized by a reduced conducting tissue, widely spaced spongy tissue with wider intercellular spaces which accounts for the higher transpiration rate exhibited by ephemeral plants.

Zahran *et al.* (1993) investigated the anatomical adaptations of some native Egyptian plants growing under saline and/or low soil moisture condition and found that xerophytes are adapted to live under drought either by leaf succulence or by the great reduction in water expenditure.

In the current work, leaf anatomical characteristics were investigated by light and Scanning Electron Microscopy (SEM) in seven xerophytic plant species, namely: *Artemisia monosperma, Zilla spinosa, Farsetia aegyptia, Launaea spinosa, Zygophyllum coccineum, Panicum turgidum,* and *Lasiurus hirsutus* to reveal what are the different ways by which these selected species can adapt themselves against salinity and drought.

Materials and Methods

Four species namely: *Artemisia monosperma, Zilla spinosa, Farsetia aegyptia* and *Zygophyllum coccineum* have been collected from Cairo-Suez Desert Road located in the northern part of the Arabian desert of Egypt during May 1991. While three species namely *Launaea spinosa, Panicum turgidum* and *Lasiurus hirsutus* have been collected from Wadi Hagoul located in the northern part of the coastal desert plain of the Red Sea region of Egypt during June 1991. Voucher specimens are deposited in the herbarium of the Botany Department, Faculty of Science, Mansoura University.

For the preparation of thin leaf sections of the studied species, the paraffin method of Johansen (1940) was followed. Pieces from fresh leaf material, 0.5 cm long obtained from the middle portion, were immediately fixed and preserved in formalin : acetic acid : ethyl alcohol, (FAA) 5:10:85, followed by dehydration using tertiary butyl alcohol.

Infiltration was carried out by melted paraplast and for embedding wax paper boat was made and materials in vials poured in it; after cooling blocks of specimens were kept in a refrigerator until sectioning. Sections 15 μm thick were made using rotary microtome. For staining, safranin and fast green were used and the slides were mounted in Canada balsam. The sections were observed, measurements were made using calibrated ocular micrometer. Photographed were taken by using a research microscope.

Material for scanning electron microscopy was fixed in 3% gluteraldehyde in 0.2 M phosphate buffer for 12-16 hours. It was then rinsed in the same buffer (3 times for 15 min. changes). The material was then post fixed in 2% osmium tetraoxide, for 2-4 hours, rinsed in distilled water (4 times 15 min. changes), and block stained in 0.5% uranyl acetate for one hour. The material was then dehydrated through a graded acetone series to 100% acetone and critical point dried. The critical point dried material was mounted on aluminium stubs, on double-sided carbon coated sellotape, and sputter coated with gold palladium. The samples were examined in a Philips S500 Scanning Electron Microscope at 3 Kv.

Table 1. Anatomical characteristics of seven Egyptian xerophytes. Each value is the mean for three sections in the same leaf. Units in microns (μm)

Xerophytes	Thickness of leaf in T.S.		Epidermis	Cuticle	Trichomes	PP	SP	CL.P	Scl	L	RL	M	Main bundle	Vascular
	middle	ends	ad/ab	ad/ab	hair/gland								height	width
Artemisia monosperma	674	502	27/27	8.4/8.4	–/–	183	153	P	+	S	–	*	218	291
Zilla spinosa	331	257	23/17	7.6/7.6	–/–	31	38	G	+	S	–	*	113	77
Farsetia aegyptia	626	429	20/20	6.4/6.4	+/–	181	80	G	+	–	–	*	245	159
Launaea spinosa	686	613	24/24	8/8	–/–	66	30	G	+	–	–	*	233	208
Zygophyllum coccineum	2830	1838	21/21	7.6	–/–	392	–	P	+	S	–	*	200	168
Panicum turgidum	272	184	24/24	3.2/5	+/–	–	–	PV	+ +	–	–	–	109	109
Lasiurus hirsutus	262	135	17/17	3.2/5	+/–	–	–	PV	+ +	–	–	–	98	69

CL.P. = Chlorophyllic parenchyma S = Succulent RL = Rolled leaf – = Absent M = Mesophyll G = Ground
PP = Palisade parenchyma P = Peripheral ab = Abaxial + = Present Scl = Sclerenchyma L = Leaf type
SP = Spongy parenchyma * = Isobilateral leaf ad = Adaxial ++ = Abundant PV = Around the vascular bundle

Results

Data of anatomical measurements and leaf characteristics of the investigated xerophytic plant species are shown in Table (1).

Artemisia monosperma

This is a desert shrublet (Family Compositae) with finely dissected leaves. As seen in cross section (Fig. 1a), the leaf thickness at the middle is 674 µm and 502 µm at the margins whilst the epidermis is 27 µm and covered by 8.4 µm cuticle.

The leaf is isobilateral with upper and lower palisade layers (183 µm thick) enclosing a water-storage large-celled parenchyma layer 153 µm thick. There are 8-10 vascular bundles with the large central one 218 µm high and 291 µm wide.

SEM of the leaf surface shows higher stomatal density on the abaxial surface compared to the adaxial. The stomata in both cases are slightly sunken (Fig. 1b and c).

Zilla spinosa

This is a spiny desert shrub (Family Cruciferae), with deciduous fleshy leaves. The leaf thickness is 331 µm in the middle and 257 µm at the margins. The epidermal cells vary in thickness from 17 µm to 23 µm and are covered with a 7.6 µm cuticle.

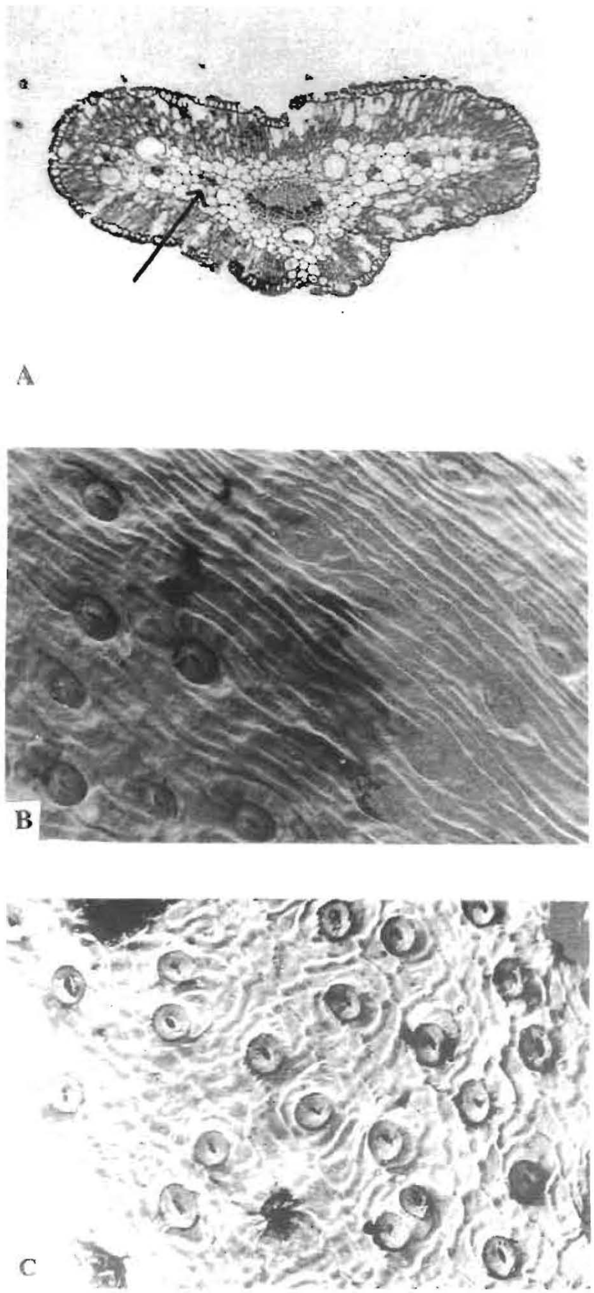
The leaf is isobilateral with palisade layers on both sides (31 µm thick) enclosing a central compact storage parenchymatous layer 38 µm thick. The height and the width of the vascular bundle are 113 µm and 77 µm.

SEM of the leaf surface shows sunken stomata (Fig. 2). The epidermal cells and the guard cells are covered with wax deposits in the form of granules.

Farsetia aegyptia

It is a desert shrublet (Family Cruciferae), with narrow leaves covered by white hairs. The leaf thickness is 626 µm in the middle and 429 µm at the margins. The epidermal cells are 20 µm and covered with a 6.4 µm thick cuticle (Fig. 3a).

The leaf is isobilateral, the palisade parenchyma is differentiated into upper and lower layers (181 µm thick) which extend to the mid-rib, enclosing a layer of storage parenchyma 80 µm thick. The largest vascular bundle in the centre of the leaf (245



A

B

C

Fig. 1. *Artemisia monosperma*, (A) leaf cross section (x26) showing the water storage layer (arrow), (B) SEM (x960) of the adaxial surface of the leaf and (C) SEM (x960) of the abaxial surface of the leaf showing higher stomatal density on the abaxial surface (C) compared to the adaxial (B) and the stomata in both cases are slightly sunken.

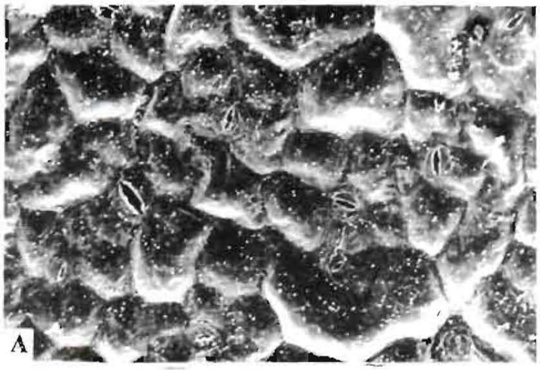


Fig. 2. *Zilla spinosa,* (A) SEM (x960) of abaxial leaf surface showingsunken stomata and the guard cells are covered with wax deposits in the form of granules.

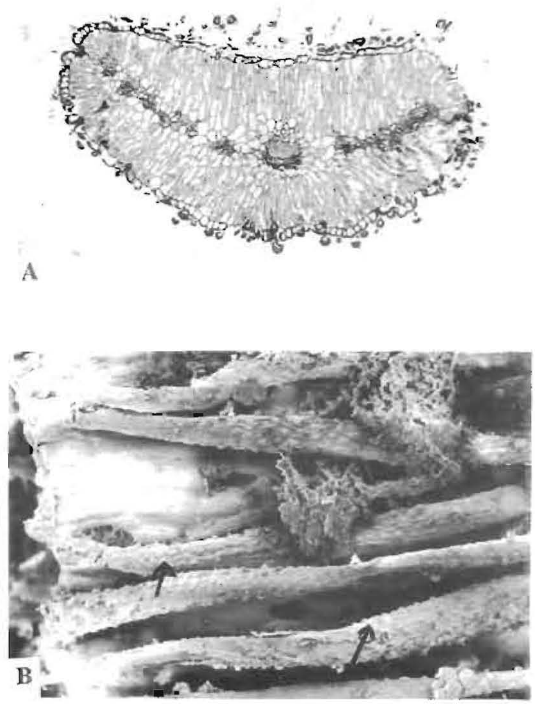


Fig. 3. *Farsetia aegyptia,* (A) leaf cross section (x26), (B) SEM of leaf surface (x960) covered with horizontally extended hairs (arrow).

μm high and 159 μm wide) is accompanied on both sides by smaller ones.

SEM of the leaf surface (Fig. 3b) shows it to be covered with hairs which extend horizontally to cover the surface which may protect the stomata from the direct heat of the sun. The surface of the hairs is covered with wax deposits.

Launaea spinosa

This is spinescent shrub with milky sap (Family Compositae). It has evanescent deciduous leaves. The thickness of the leaf is about 686 μm in the middle and 613 μm at the margins. The epidermis is 24 μm thick and is covered with 8 μm thick cuticle (Fig. 4a).

The leaf is isobilateral, the mesophyll is differentiated into upper and lower palisade layers (66 μm in thickness) enclosing a narrow layer of spongy parenchyma (30 μm). The largest vascular bundle is 233 μm high and 208 μm wide.

SEM of the leaf surface (Fig. 4c-f) shows that the stomata are deeply sunken on both the adaxial and the abaxial surfaces. The surface of the leaf is heavily cutinized.

Zygophyllum coccineum

This is a succulent xerophyte (Family Zygophyllaceae), with fleshy cylindrical leaves. The diameter of the leaf ranges between 1838 μm and 2830 μm (Fig. 5a).

Examination of the internal structure of the leaf reveals that there are three distinct tissues: photosynthetic tissue represneted by an outer palisade mesophyll layer 392 μm thick, water-storage tissue represented by large storage parenchyma (992 μm thick) and conducting tissue represented by a large vascular bundle at the center with height and width 200 μm and 168 μm respectively, and small bundles forming a ring between the palisade mesophyll and the storage parenchyma (Fig. 5a). The epidermis is 21 μm thick and covered by a cuticle 7.6 μm thick.

SEM of the leaf surface (Fig. 5b) shows numerous stomatal apertures which are slightly sunken below the level of epidermal cells. Each is surrounded by two guard cells. A little wax is present on the leaf surface (Fig. 5b), especially on stomatal apertures.

Panicum turgidum

It is a tussocky desert grass with reduced leaves (Family Gramineae). The thickness of the leaf (Fig. 6a) ranges between 184 μm and 272 μm. The leaf margin

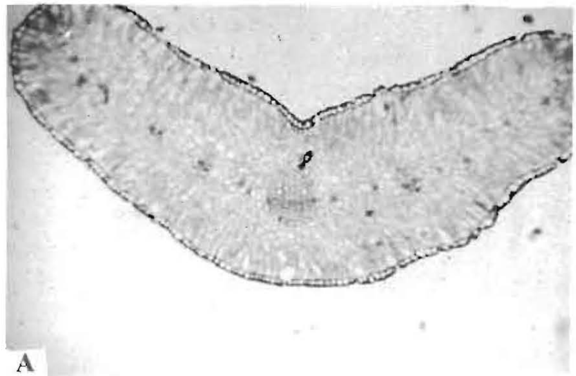


Fig. 4. *Launaea spinosa,* (A) leaf cross section (x64).

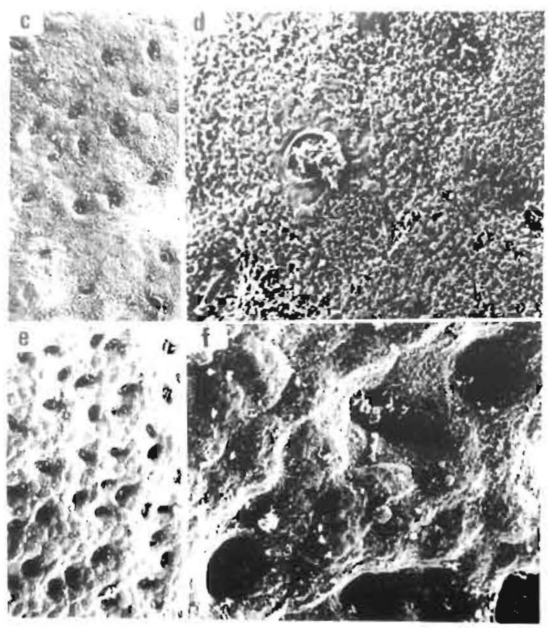
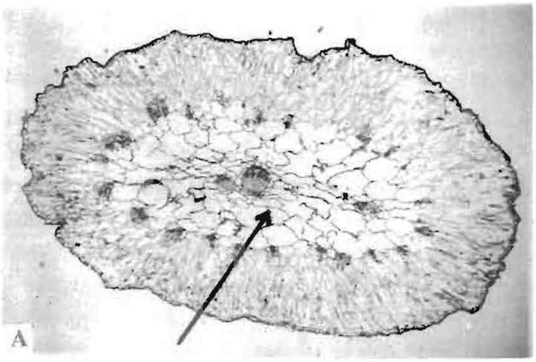


Fig. (c-f). SEM leaf surface shows the stomata are deeply sunken and the leaf is heavily cutinized.

Fig. (c). (x320) of the adaxial leaf surface, (d) enlarged part of (c) x960.

Fig. (e). (x320) of the abaxial leaf surface and (f) is magnified part of (e) x960.



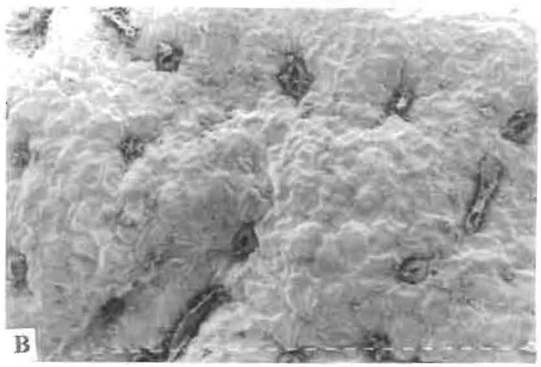
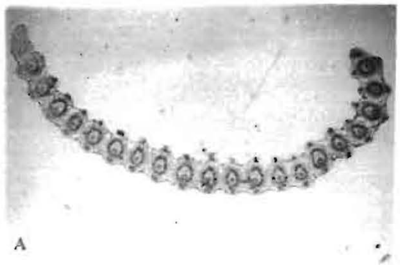
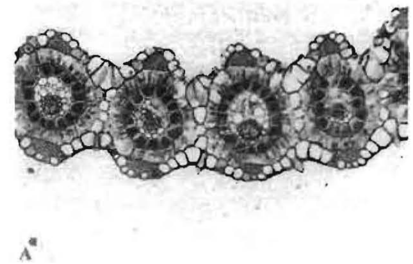


Fig. 5. *Zygophyllum coccineum,* (A) leaf cross section (x64) showing storage parenchyma (arrow) and (B) SEM of leaf surface (x960) showing slightly sunken.

is supported by a strand of sclerenchyma. The thickness of the epidermis is 24 μm and it is covered by about 4.1 μm thick cuticle. Small girders of adaxial sclerenchyma are associated with the vascular bundles. Chlorophyllous parenchyma surrounds the vascular bundles in a Kranz formation (Fig. 6a*). Bulliform cells are well developed on the adaxial epidermis while on the abaxial surface are very short hairs (scale-like). The height and the width of the vascular bundles are similar (109 μm).

SEM of the leaf surfaces (Fig. 6b-e) shows parallel flat ribs on the abaxial surface carrying scale-like hairs whilst the stomata lie in rows in the sides of these ribs towards the furrows. The adaxial surface of the leaf shows rows of stomata running lengthwise and appear to be of two kinds, the first type is on the ribs while the second is in the furrows.





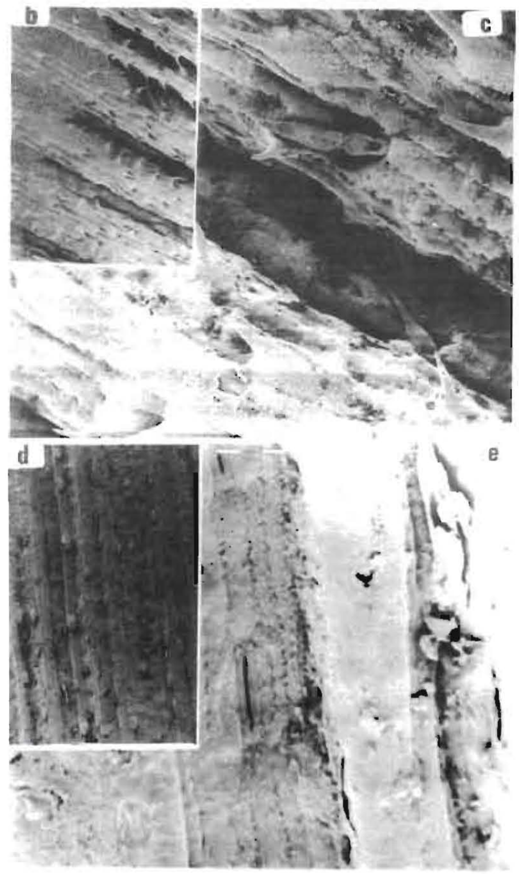


Fig. 6. *Panicum turgidum,* (A) T.S. of the leaf balde (x18), (A*) part of leaf cross section (x70) showing Kranz structure, (b) SEM of adaxial surface (x350), (c) magnified part of (b) x1050, showing scale-like hairs and stomata lie in rows. (d) SEM of abaxial leaf surface (x350) and (e) magnified part of (d) x1050 showing rows of stomata of two kinds, the first type is on the ribs while the second is in the furrows.

Lasiurus hirsutus

This is a xerophytic perennial grass (Family Gramineae), with inrolling leaves (Fig. 7a). The thickness of the leaf ranges between 135 µm and 262 µm. The epidermis is 17 µm thick and is covered with a thin adaxial cuticle and thick abaxial cuticle (3.2 µm and 5 µm thick respectively). The bulliform cells are well developed on the adaxial surface. Fig. 7a shows that chlorophyllous parenchyma surrounds the vascular bundles in a Kranz formation.

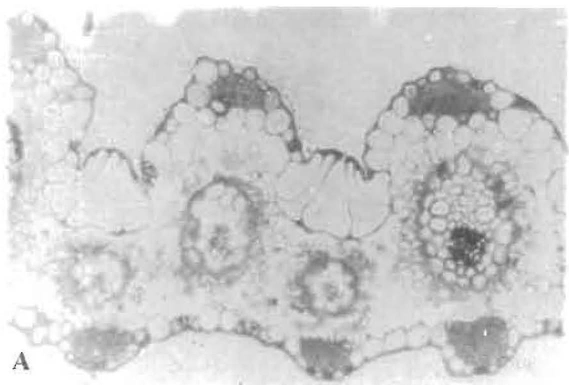


Fig. 7. *Lasiurus hirsutus,* (A) part of leaf cross section (x960).

The large vascular bundles alternate with smaller ones: the large vascular bundles are 98 µm and 69 µm in height and width respectively. They are supported adaxially and abaxially by sclerenchyma but the smaller vascular bundles are supported abaxially only or are without sclerenchyma support.

SEM of the leaf surfaces (Fig. 7b and c) shows short trichomes on the ribs of the adaxial epidermis. The stomata are present in one row in the sides of the ribs and wax deposits occur on the leaf surface and also trichomes. While Fig. 7d and e shows that, the abaxial leaf surface is flat, covered with wax and the stomata are arranged in parallel rows.

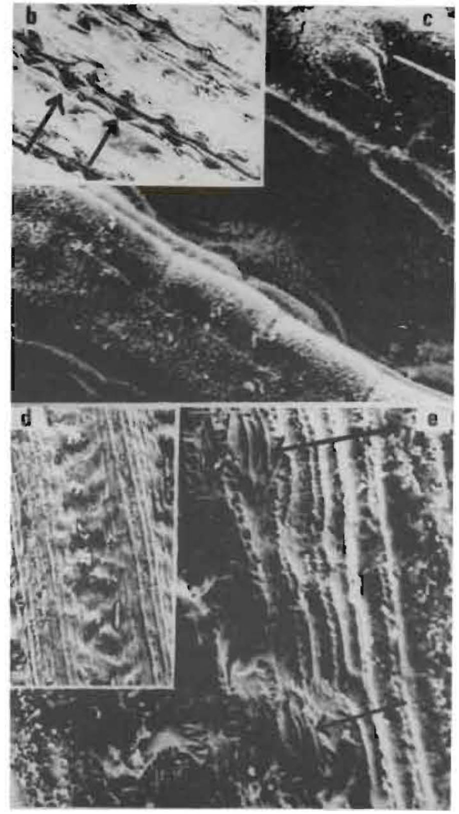


Fig. (b). (x320) and c (x960) SEM of adaxial leaf surface shows short trichomes on the ribs, and the stomata in rows (arrow). Wax deposits on leaf surface and trichomes.

Fig. (d). (x320) and e (x960) SEM of abaxial leaf surface is flat, covered with wax and slightly sunken stomata are arranged in parallel rows.

Discussion

On the basis of leaf structure, the species investigated showed some similar adaptive characteristics whilst others showed particular characters related to drought and salinity stress.

The thickness of the cuticle varied on the leaf surface of only two species (*Lasiurus hirsutus* and *Panicum turgidum*) which showed a thicker cuticle on the abaxial than the adaxial surface of the leaf whilst other species *(Artemisia monosperma, Zilla spinosa, Farsetia aegyptia* and *Launaea spinosa)* have the same thickness of cuticle on both sides of the leaf.

Some authors found little correlation between xeromorphic adaptation and the thickness of the cuticle and the amount of wax present on plant surface (Priestley 1943, Kurtz 1958), while others (Lee and Priestley 1924, Mc Nair 1931, Bleckman *et al.* 1980) believe that some environmental conditions, such as high light intensities or reduced soil moisture content, stimulate the formation of a thick cuticle and wax deposition.

The thickness of the epidermal layer is the same on the abaxial and the adaxial side in all the species studied except in *Zilla spinosa* where the adaxial epidermal layer is thicker than the abaxial epidermis.

Inrolled leaves is a well known adaptation of xerophyes (Shields 1951b, Metcalfe 1960, Oppenheimer 1960, Hansen *et al.* 1976) especially in grasses. In the present study, the two xerophytic grasses (*Panicum turgidum* and *Lasiurus hirsutus*) do not show the truly rolled leaf; this may be related to the reduction in their leaf blade.

Nautiyal and Purohit (1980) stated that plant responses to environment are mainly influenced by its effect on the qualitative and quantitative behaviour of stomata and on the structural pattern of leaves. Position and shape of the stomata in the leaves of the selected species seem particularly well suited for the existence of these plants in arid and semi-arid habitats.

The stomata in some of the investigated xerophytes are slightly sunken (*Panicum turgidum, Lasiurus hirsutus, Zilla spinosa* and *Farsetia aegyptia*), whilst in other species the stomata are deeply sunken (*Launaea spinosa* and *Artemisia monospirma*).

Succulence in many species is regarded as a physiological adaptation to the dry conditions that develop where there are high level of sodium chloride and other salts (Poljakoff-Mayber 1975, Saad Eddin and Doddema 1984). Succulent leaves show large, highly vacoulated, water-storage cells lacking chloroplasts in addition to the photosynthetic mesophyll. In the most xerophytic species the succulence develops from the time of germination and provides a water reservoir for the leaf during times of drought (Crawford 1989). This condition was observed in seedlings of *Zygophyllum coccineum* and *Zilla spinosa.*

Trichomes are commonly found on leaves of plants growing in more xeric habitats (Esau 1977), and papillae, especially overarching ones. These could play a similar role in reducing the transpiration gradient of a leaf. In *Farsetia aegyptia* trichomes cover both sides of the leaf, but other species (*Zilla spinosa, Launaea spinosa* and *Artemisia monosperma*) do not have such trichomes. The xerophytic grasses *Panicum turgidum* and *Lasiurus hirsutus* have very short scale-like trichomes on the abaxial surface of the leaf.

The distribution of C_3 and C_4 plants is apparently affected by temperature and aridity (Terri and Stowe 1976, Stowe and Terri 1978, Kaufman *et al.* 1985). Kranz formation is considered as an adaptation mechanism of plants to environment with water deficit (Bjorkman 1973, Mooney *et al.* 1975, Osmond *et al.* 1980 and Kemp *et al.* 1983). C_4 plants usually have higher "water use efficiency" than species with C_3 photosynthesis, *i.e.* they show higher ratios of CO_2 assimilation or dry matter production (Winter and Troughton 1978). Terri and Stowe (1976) claimed that the xerophytic grasses *Panicum turgidum* and *Lasiurus hirsutus* possess the C_4 pathway. These two species have short scale-like hairs on the abaxial side of the leaf. Although both have high frequencies of bulliform cells, they do not show true inrolment of the leaf.

The development of several layers of chlorenchymatous cells in *Zygophyllum coccineum* increases photosynthetic activity (Fahn 1983).

SEM studies give considerable information about leaf surfaces in relation to habitat conditions. The side surfaces of the cuticle seem to be quite different in *Panicum turgidum* and *Lasiurus hirsutus.* However, in others they are closely similar *e.g. Artemisia monosperma, Launaea spinosa* and *Zilla spinosa.*

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References

Abdel-Rahman, A.A., Ibrahim, A. and **Hassan, H.T.** (1976) Contribution to the anatomical characters of some xerophytes. *Bull. Fac. Sci.* Cairo University, **49:** 139-162.

Bjorkman, O. (1973) Comparative studies on photosynthesis in higher plants. *In:* **Giese, A.C. (ed.).** Photophysiology Vol. 8. Academic Press, London, New York.

Bleckman, C.A., Hull, H.M. and **Hashaw, R.W.** (1980) Cuticular ultrastructure of *Prosopis velutina* and *Acacia greggi* leaflets. *Bot. Gaz.,* **141:** 1-8.

Crawford, R.M.M. (1989) *Studies in plant survival. Ecological case histories of plant adaptation to adversity.* Blackwell Scientific Publications. Oxford. 296 p.

Esau, K. (1977) *Anatomy of seed plants.* John Wiley and Sons. New York.

Evenari, M. (1985) Adaptations of plants and animals to the desert environment. *In:* **Evenari, M., Noy-Meir, I.** and **Goodall, D.W. (eds.).** Ecosystems of the world. Hot deserts and arid shrublands. Amsterdam., **12:** 79-92.

Fahn, A. (1964) Some anatomical adaptations of desert plants. *Phytomorphyology.* **14:** 92-102.

Fahn, A. (1983) *Plant anatomy.* 3rd ed. Pergamon Press. Oxford.

Hansen, D.J., Dayanandan, P., Kaufman, P.B. and **Brotherson, J.D.** (1976) Ecological adaptations of salt marsh grass, *Distichlis spicata* (Gramineae), and environmental factors affecting its growth and distribution. *Amer. J. Bot.,* **63**(5): 635-650.

Johansen, D.A. (1940) *Plant microtechnique* (2nd ed.) Tata McGrow-Hill Publishing Co. Bombay.

Kaufman, P.B., Dayanandan, P. and **Franklin, C.I.** (1985) Structure and function of silica bodies in the epidermal system of grasses bodies. *Annals of Botany,* **55:** 487-507.

Kemp, P.R., Cunningham, G.L. and **Adams, G.L.** (1983) Specialization of mesophyll morphology in relation to C_4 photosynthesis in the Poaceae. *Amer. J. Bot.,* **70**(3): 349-354.

Kurtz, E.B. (1958) Asurvey of some plant waxes in southern Arizona. *J. Amer. Oil. Chem. Soc.,* **35:** 465-467.

Lee, B. and **Priestley, J.H.** (1924) The plant cuticle. I. Its structure, distribution and function. *Ann. Bot.,* **38:** 525-545.

Mc Nair, J.B. (1931) Some properties of plant waxes in relation to climate of habitat. *Amer. J. Bot.,* **18:** 518-525.

Metcalfe, C.R. (1960) *Anatomy of the Monocotyledons.* Clarendon Press, Oxford.

Mooney, M., Bjorkman, O. and **Berry, J.A.** (1975) Photosynthetic adaptations to high temperatures. *In:* **Hadley, N.F. (ed.).** Environmental physiology of desert organisms. Dowden, Hutchinson and Ross Inc. Stroudsburg PA, 19-75 pp.

Nautiyal, S. and **Purohit, A.N.** (1980) High altitude acclimatization in plants: Stomatal frequency and anatomical changes in leaves of *Artemisia* spp. *Biologia Plantrum* (PRAHA), **22**(4): 282-286.

Oppenheimer, H.R. (1960) Adaptation to drought. Xeromorphism UNESCO-publ. Arid Zone Research, **15:** 105-138.

Osmond, C.B., Bjorkman, O. and **Anderson, D.J.** (1980) Physiological process in plant ecology. Towards a synthesis with *Atriplex.* Springer Verlag, Berlin.

Poljakoff-Mayber, A.M. (1975) Morphological and anatomical changes in plants as response to salinity stress. *In:* **Poljakoff, A.** and **Gale, J. (eds.),** plants in saline environments, Springer-Verlag, New York. 97-117 pp.

Priestley, J.H. (1943) The cuticle in angiospermae. *Bot Rev.,* **9:** 593-616.

Saad-Eddin, R. and **Doddema, H.** (1984) Anatomy of extreme halophyte *Arthrocnemum fruticosum* (L.) Moq. in relation to its physiology. *Annals of Botany,* **57:** 531-544.

Shields, L. (1951a) Leaf xeromorphy in dicotyledon species from a gypsum sand deposit. *Amer. J. Bot.,* **38:** 175-189.

Shields, L. (1951b) The involution mechanism in leaves of certain xeric grasses. *Phytomorphology.* **1:** 225-241.

Stowe, L.G. and **Terri, J.A.** (1978) The geographic distribution of C_4 species of dicotyledonae in relation to climate. *American Naturalist,* **112:** 609-623.

Teeri, J.A. and **Stowe, L.G.** (1976) Climatic pattern and the distribution of C_4 grass in north America, *Oecologia,* **23:** 1-12.

Winter, K. and **Troughton, J.H.** (1978) Photosynthetic pathways in plants of coastal and inland habitats of Israel and Sinai. *Flora, Bd.,* **167:** 1-34.

Zahran, M.A. and **Willis, A.J.** (1992) *The vegetation of Egypt.* Chapman and Hall, London, (1st ed.) 424 p.

Zahran, M.A. Shukry, W.M., Mashaly, I.A. and **El-Soud, M.** (1993) Anatomical adaptations of some native Egyptian plants growing under salinity and/or aridity stresses of Egypt. *Bull. Fac. Sci.* Mansoura Univ., **20**(1): 71-96.

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التأقلم التشريحي لبعض النباتات الصحراوية في مصر

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يهدف هذا البحث إلى دراسة الصفات التشريحية التأقلمية لأوراق سبعة نباتات صحراوية تنمو في الصحراء المصرية وهي :

Artemisia monosperma, Zilla spinosa, Farsetia aegyptia, Launaea spinosa, Zygophyllum coccineum, Panicum turgidum and *Lasiurus hirsutus.*

وحيث أن هذه النباتات الجفافية تؤقلم نفسها في الظروف البيئية القاسية مثل ندرة الماء ودرجة الحرارة العالية والجفاف الشديد فقد لوحظ في الأنواع النباتية : *Artemisia monosperma, Zilla spinosa* and *Farsetia aegyptia* ان النسيج العمادي للورقة مكون من عدة طبقات على سطحيها العلوي والسفلي وتكون الخلايا العمادية لهذا النسيج متماسكة وفراغاتها البينية ضيقة للغاية وهذا التأقلم يعمل على تقليل فقد الماء .

كما أنه في بعض النباتات الجفافية والتي تؤقلم نفسها في بيئتها الجافة من خلال ظاهرة العصيرية كما في نبات *Zygophyllum coccineum* فإنها تعتمد في مقاومتها للجفاف على تخزين الماء ويرجع ذلك إلى وجود خلايا كبيرة ذات جدر رقيقة وفجوة عصيرية كبيرة ، حيث يوجد هذا النسيج التخزيني بالإضافة إلى النسيج الوسطي التمثيلي .

كما اتضح أن بعض الأنواع النباتية الجفافية الحشائشية مثل :
Lasiurus hirsutus, Panicum turgidum تتميز بصغر نصل أوراقها بل وأحيانا تكون عديمة الأوراق تماماً .

وقد لوحظ أيضاً أن الثغور تكون غائرة لحد ما في الأنواع النباتية :
Panicum turgidum, Lasiurus hirsutus, Zilla spinosa and Farsetia aegyptia
أما في الأنواع الأخرى مثل *Launaea spinosa* و *Artemisia monosperma* فتكون الثغور غائرة تماما .

ويبدو مما تقدم أن هذه النباتات تستطيع البقاء في مواجهة تلك الظروف البيئية القاسية من ارتفاع درجة حرارة الجو وانخفاض معدل الرطوبة النسبية وقلة الأمطار في صحاري مصر .