COMPARATIVE FOLIAR ANATOMY OF FIVE XEROPHYTE SPECIES FROM IRAN

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The foliar anatomy of the following species from S. Albourz in Tehran area was studied under OM. and SEM.: *Amygdalus lycioides* Spach, *A.scoparia* Spach (Rosaceae), *Atraphaxis spinosa* L. (Polygonaceae), *Berberis vulgaris* L. (Berberidaceae), *Capparis spinosa* L. (Capparidaceae). These species show interesting xeromorphic leaf characters.

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تشریح مقایسه‌ای برگ پنج گونهٔ خشکی پسند در ایران

فاطمهٔ زرین‌کمر

ساختمان تشریحی برگ پنج گونه به شرح زیر:
Amygdalus lycioides Spach, *A.scoparia* Spach, *Atraphaxis spinosa* L., *Berberis vulgaris* L., *Capparis spinosa* L.
از البرز جنوبی، منطقهٔ تهران با استفاده از میکروسکپ نوری و میکروسکپ الکترونی مطالعه گردید. برگ در این گونه‌ها دارای صفات جالبی می‌باشد که نشان‌دهندهٔ شرایط خشک است.

INTRODUCTION

In this work the foliar anatomy of the following species were studied: *Amygdalus lycioides* Spach, *A.scoparia* Spach, *Atraphaxis spinosa* L., *Berberis vulgaris* L., *Capparis spinosa* L.

These plants were collected from southern Albourz in Tehran area at an altitude of 1500-3000m. Annual rainfall average varying between 200 and 400mm, and temperature ranging between -10°C and +34°C, with occasional recording of -30°C. In this area vegetation is low and hardly ever it does fully cover the land (Assadi 1988). Soil is very poor and scarcely formed.

MATERIALS AND METHODS

In order to study histofoliar characters, materials were fixed in FAA and herbarium materials were boiled in water befor sectioning. Materials were sectioned with a sliding microtome. Sections were cleared with sodium hypochlorite, dehydrated and coloured with fastgreen safranine and mounted in artificial canadian balsam.

The dissociate material was obtained according to Boodle technique (1916) and was mounted in jelly glycerine.

In order to study venation and stomata density, the diafanization technique (Dizeo de Strittmater, 1973) was employed.

To identify cell contents, different histochemical tests were developed: a) cresyl blue (mucilage); b) tannin reagent (tannin) and c) sudan IV Ruteno, to distinguish between the cutinized portion of the wall and the actual thickness of the wall (Johansen, 1940; Jensen, 1962; D'Ambrogio, 1986).

Calcium oxalate crystals were identified with polarized light.

For observing the ultrastructural characters under SEM, material was prepared according to conventional techniques.

Drawings were made with a drawing tube of OM.

Photomicrographies were taken with Axioplan-Zeiss photomicroscope.

In order to point to the tissues on the scheme, conventional Metcalfe and Chalk Shadings were used (1957).

ABBREVIATIONS:

CN: Central Nerve

TS: Transversal Section

CL: Collenchyma

VB: Vascular Bundle

PAL:Empalizade Chlorenchyma

SP: Spongy Chlorenchyma

PCH:Parenchyma

ADX:Adaxial

ABX:Abaxial
TS: Tissue
OM: Optical Microscope
SEM:Scanning Electron Microscope
+ :Little quantity
++ :Medium quantity
+++:High quantity
L: Length
W: Width

STUDIED MATERIALS

The studied materials were collected by A.A.Maassoumi, M.Khatamsaz and the author from W. Tehran on August 26th 1992, and also some herbarium materials provided from the herbarium of Research Institute of Forests and Rangelands (TARI). The fixed materials are conserved in the laboratory of vegetal Anatomy of the Faculty of Natural Sciences of the University of Buenos Aires, as follows:

Amygdalus lycioides Spach, FAA No. 505
A. Scoparia Spach, FAA No. 502
Atraphaxis spinosa L. FAA No. 503
Berberis vulgaris L. FAA No. 506
Capparis spinosa L. FAA No. 507

OBSERVATIONS

General Characteristics: Several common characteristics were observed among the 5 studied species.

Superficial view of diafanized leaf: In general, the epidermis of polygonal celles of straight shape shows a thin cuticle, slightly striate with epicuticle waxes shaped into granules. Stomata are slightly sunken and rarely superficial, mainly in abx side, anomocytic and rarely anisocytic with variable density (Table).

Vascularization: Central nerve gets ramified into a dense net towards the distal extreme of the leaf with small and quadrangular areola and venules that get ramified up to three times.

Calcium oxalate druses in the mesophyll termination are generally abundant and intensively refringent with polarized light.

Leaf TS: Cuticle varies its thickness; epidermis is generally one-stratum showing a tendency towards multiple epidermis at SSP in *Amygdalus.* Trichomes, when present, are simple, pluricellular. In *Amygdalus lycioide* some marginal glands are present.

Stomata are generally sunken, leaf mesophyll is isolateral to centric *(Atraphaxis)* or dorsiventral in *Berberis,* VB are generally colateral with exceptionally perifloematic in *Atraphaxis.*

Mechanical T is represented by collenchyma and Sclerenchyma.

Specific characters:

Amygdalus lycioides Spach, Cuticle membrane is thin and the wall is thick, the epidermis is simple with tendency to multiple, some periclinal divisions are superficial. The stomata showing less density than in *Amygdalus scoparia* (Table). At marginal position the presence of pluricellular glands was noticed. Such glands are positioned at vascular endings and accompanied by numerous stomata. Microtests showed the presence of mucilage and tannins, mainly at the sheath and in lower proportion in mesophyll. The idioblasts of calcium oxalate druses were observed in mesophyll.

Amygdalus scoparia Spach, The cuticle membrane shows intermediate thickness. Epidermis is simple with tendency to multiple: some periclinal divisions were observed only in adx epidermis. Adx epidermic cells are quadrangular, relatively large compared to abx cells, the latter are smaller and show a slightly papillose shape. Stomata are slightly sunken and dense (Table). They are anomocytic and are found only on abx side. At marginal teeth, it was observed the presence of pluricellular glands, similar to the ones observed in *A. lycioides*. Mesophyll is isolateral with 6 - 7 dense empalisade layers at adx side and 3 - 4 laxe layers in abx position.

Vascular bundles are colateral with some adx fibres and collenchyma at adx and abx positions of the CN. The greatest proprotion of xylem elements are long tracheids.

Microtests show quantities of tannin and mucilage at the HVS Sheath and in mesophyll. Calcium oxalate druses are abundant and intensely refringent with polarized light.

Atraphaxis spinosa L., Shows a thin cuticle, simple epidermis, anisocytic superficial stomata and rare anomocytic ones with low density (Table).

Mesophyll is centric and shows water storing parenchyma formed by very large cells with thin walls and primary pit field.

VB are perifloematic and open at CN and the minor VBs are colateral with phloematic fibre caps. The presence of very large sclereids among the water storing PCH is noticeable. Microtests show the presence of mucilage and tannins at the water storing PCH cells. Numerous druses of Ca oxalate are observed in mesophyll.

Berberis vulgaris L., Shows epicuticle waxes, thick and striate cuticle membrane.

Epidermis is simple papillose and stomata at adx side are slightly sunken. At abx side they are superficial and anomocytic (Table). Mesophyll is dorsiventral, formed by two adx with low layers of *empalisade* chlorenchyma and 3-4 abx layers of spongy chlorenchyma. VB are colateral and the CN is formed by three bundles with packets of fibres in abx and adx positions. Collenchyma is present also at abx and adx positions at CN level.

Microtests show mucilage and tannins in mesophyll, sheaths and xylematic radio.

Capparis spinosa L., Shows a slightly striate thin cuticule and thick external tangential wall. Epidermis is simple with anisocytic stomata sunken. There are few hairs on both sides, they are simple, pluricellular and rarely malpigeaceous. Mesophyll is isolateral formed by five layers of empalisade chlorenchyma at adx side and three layers at abx side. VB are colateral formed by little xylem and abundant packets of phloem with adx and abx packets of fibres. The CN shows adx and abx chlorenchyma.

Microtests show mucilage and tannins in mesophyll while druses of oxalate are abundant.

DISCUSSION

The study of the compared anatomy of a group of plants that grow in a dry habitat in Tehran allowed to observe interesting anatomic xeromorph characters. In this way, the possible adaptations to the medium were interpreted. Morphologically, these plants have small leaves in order to reduce loss of water through transpiration (MacDouglas & Penfound, 1928; Fahn, 1964), except for the *Amygdalus scoparia* whose leaves do not show so clear xerophyte characters compared to the other studies species. In this species leaves come out in spring and are short-lived. When summer's high temperatures start they drop (Leysle, 1949).

The presence of glands at the teeth of *Amygdalus lycioides* and *Amygdalus scoparia* leaves which are connected to the vascular terminations, and accompanied at the epidermis level by numerous stomata, would allow, after hard rainfall, elimination of excess water through guttation (Haberlandt, 1914). Thus, it gathers the characters of hydathodes.

In order to keep a more effective exchange of gases, these plants show relatively high stomat density. (Table)

To survive the adverse medium with high temperature, hard radiation and water deficit, the analyzed plants have shown

epicuticular waxes and thick cuticle membrane, this being one of the most effective characters to control water loss by transpiration (Mayer, 1938; Schiddes, 1950; Bocher & Lyshede, 1972). Particularly, a very thick cuticle, a dense mesophylle formed by empalisade chlorenchyma and very little spongy mesophyll would allow to enlarge the internal surface of the leaf in relation to the external one, and consequently, photosynthesis may be more effective and loss of water lower. The leaf structure of Bv shows this clearly. Water storing parenchyma at *Atraphaxis spinosa* as well as mucilage in almost all the studied leaves would mean a strategy to keep water.

ACKNOWLEDGEMENTS

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Figure 1: A-K, S, *Amygdalus lycioides* leaf: A, B, Vascularization: A, General aspect; B, detail of areola; C, Central nerve in TS; D, Epidermis in TS; E, Simple hair; F, Parenchymatous cell; G (G-5) Vessel elements; H, Tracheids; I, libriform fibre; J, Fibre in detail; K, Sclereids; S, Leaf stalk in transversal section; T, Idioblasts of Ca oxalate. L,R, *Amygdalus scoparia* leaf: L, M, Vascularization, O, Epidermis in TS; P, Abx Epidermis in superficial view; Q, Stomat in TS; R, Leaf stalk in TS (Scheme);
Reference: A-E, G-I, K, L=100 CN; F,J = 10 CN

Figure 2: A-L, *Capparis spinosa* leaf: A-C, vascularization: A, general aspect; B, detail of areola; C, Vascular endings and sclereids; D-F, Epidermis; D-E in TS; F, superficial view; G, (1-4), Vessel elements; H, sclereids; I, Libriform fibre; J, K, hairs; J, simple; K, Malpigeaceous; L, Leaf petiole in TS; Cu, Cutin, W, Wall; VE, Vascular ending.
Reference: 1,A;2,B; 3, (C,D,E,F,G,H,I,J,K); A,L

Figure 3: A-H, *Berberis vulgaris* leaf: A, B, Vascularization; A, General aspect; B, detail of areola; C, Epidermis in TS; D, SN in TS; E, Vascular elements; F, Tracheids; G, Sclereids;

H, Epidermis in superficial view; C, Epicuticle waxes.
Reference: 1,A; 2,B; 3 (E-H); 4,D;

Figure 4: A-I, *Atraphaxis spinosa* leaf: A,B, Vascularization: A, general aspect; B, detail of areola; C, Leaf in TS; D, Epidermis; G, (1,2,3), Sclereids; H, Epidermis (adx - abx) in superficial view; I, Idioblast with Calcium Oxalate druses; C, Waxes; pa water storing parenchyma.
Reference: 1,A; 2,B,D-I; 3,C;

Figure 5: A-F, *Amygdalus lycioides* leaf: A-B observation under OM in TS; A, Hydathode gland; B, General aspect; C, observation of crystals with polarized light; D-F, Observation of foliar surface under SEM; D, Gland. E, *Amygdalus scoparia* leaf: G-H, Observation under OM in TS; G, Edge; H, CN; I, Observation of crystals with polarized light; J,L, Observation under SEM of foliar surface; J, Gland; K,L, Epidermis general aspect; rf-V Vascular net.
Reference: A-E, G-I, K,L = 100 CN; F,J = 10 CN

Figure 6: A,B,C,E,F, *Berberis vulgaris* leaf: A,B, Observation under OM; A, general aspect in TS; B, Crystal observation with polarized light of superficial view; C,E,F, Observation under SEM of foliar surface; C, General aspect of abx epidermis; E, detail of stomata; F, Adx papillose epidermis; D,G-L, *Capparis spinosa* leaf: D,CS with sclereids; G-I, L, Observation of foliar surface under SEM; G, Stomata; H,I Adx Epidermis with hairs; J,Observation with OM in TS; J;K, Crystals with polarized light; L, Observation of abx epidermis under SEM; E, Stomata; S Sclereid, MH, Malpigeaceous hair; VN Vascular net.
Reference: A-D, F, H-L = 100 CN E,G = 10 CN.

Figure 7: A-F: *Atraphaxis spinosa* leaf: A-C Observation under OM in TS; A, General aspect; B, perifloematic CN; C, Observation of crystals with polarized light; D-F, Observation under SEM of foliar surface; D, General aspect; E,F, detail stomata; F, phloem; pa water storing parenchyma.
Reference: A = 200 CN; B-D = 100 CN; E,F = 10 CN

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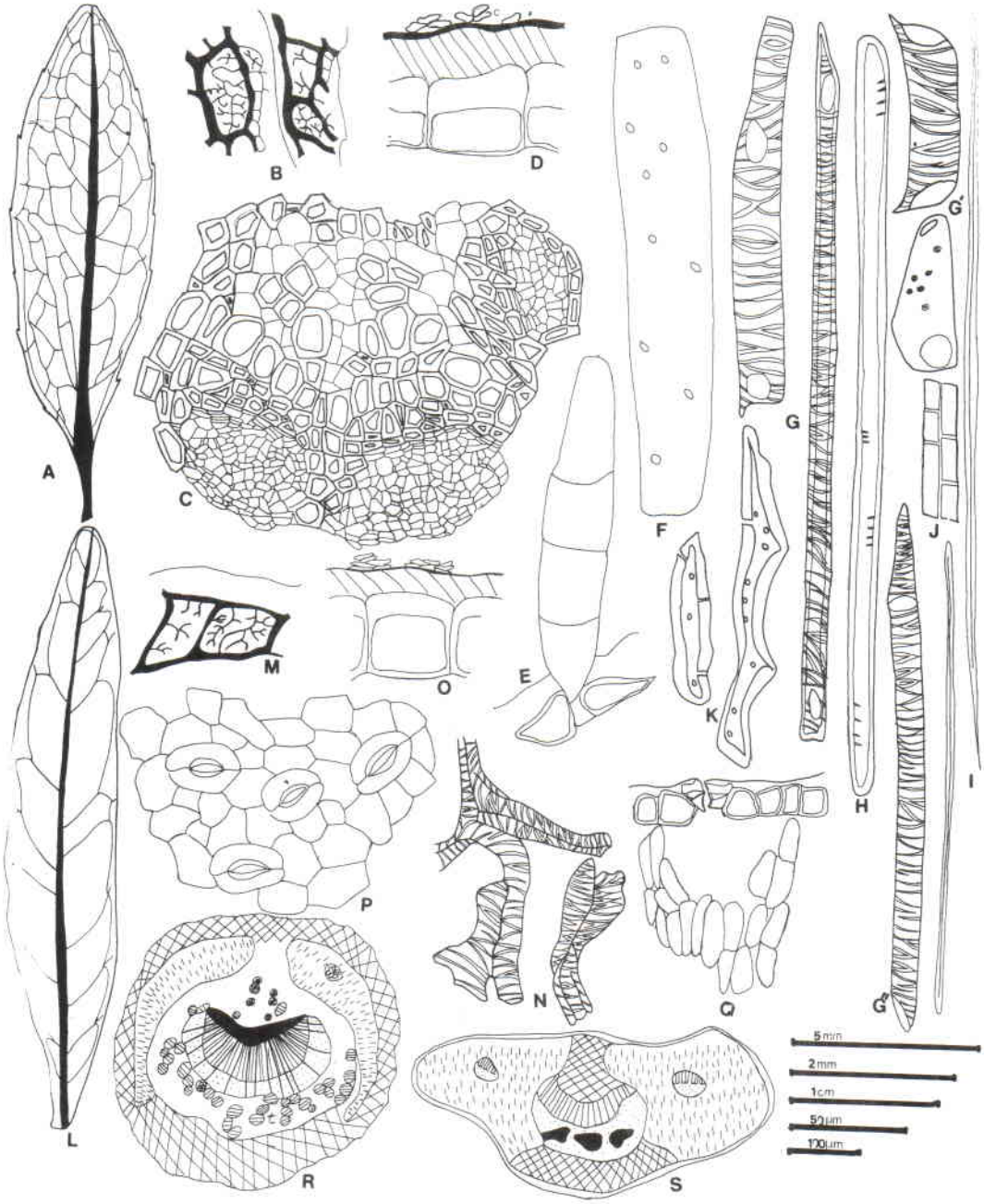


Fig. 1. Amygdalus lycioides - A. scoparia

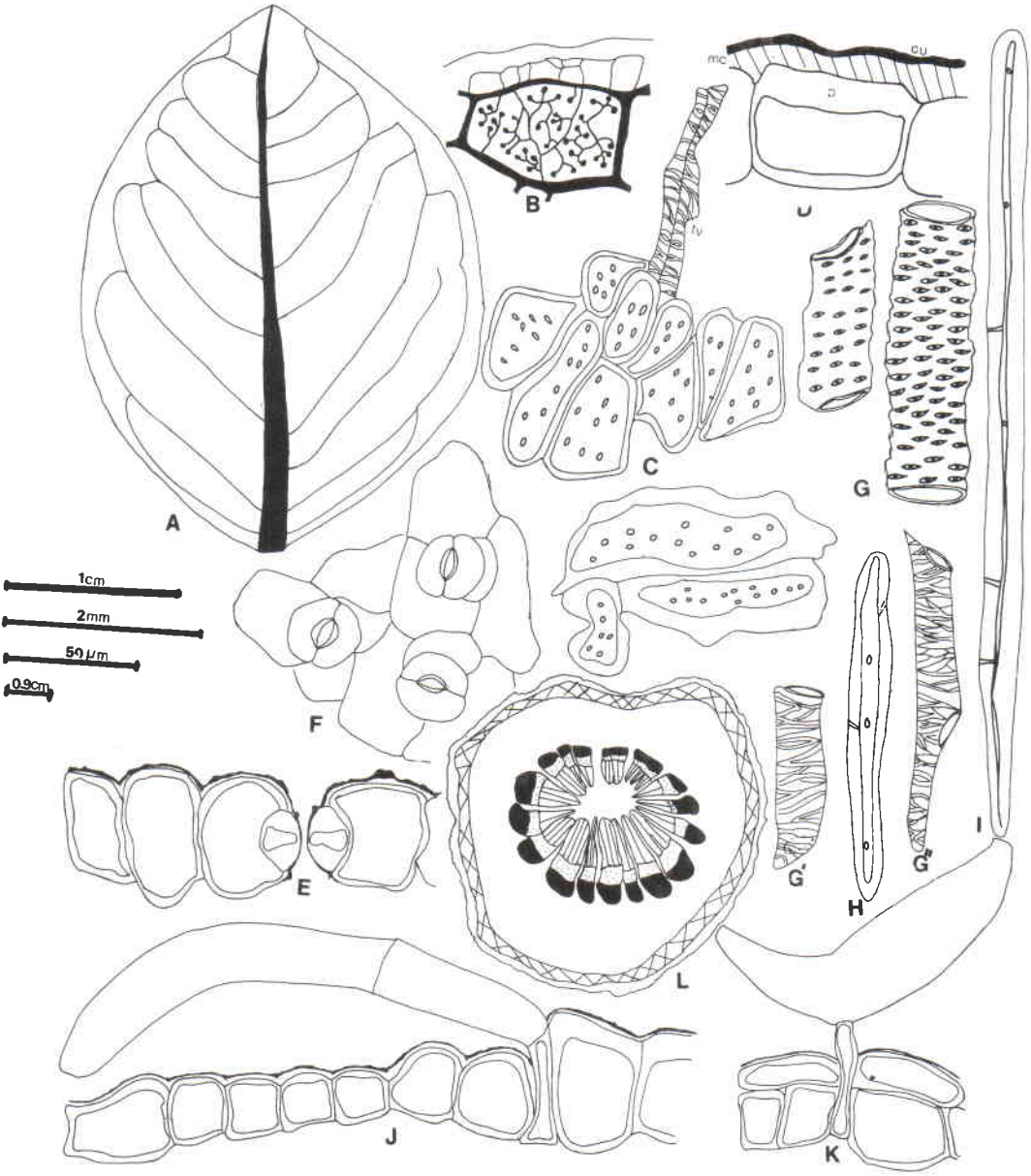


Fig. 2. Capparis spinosa

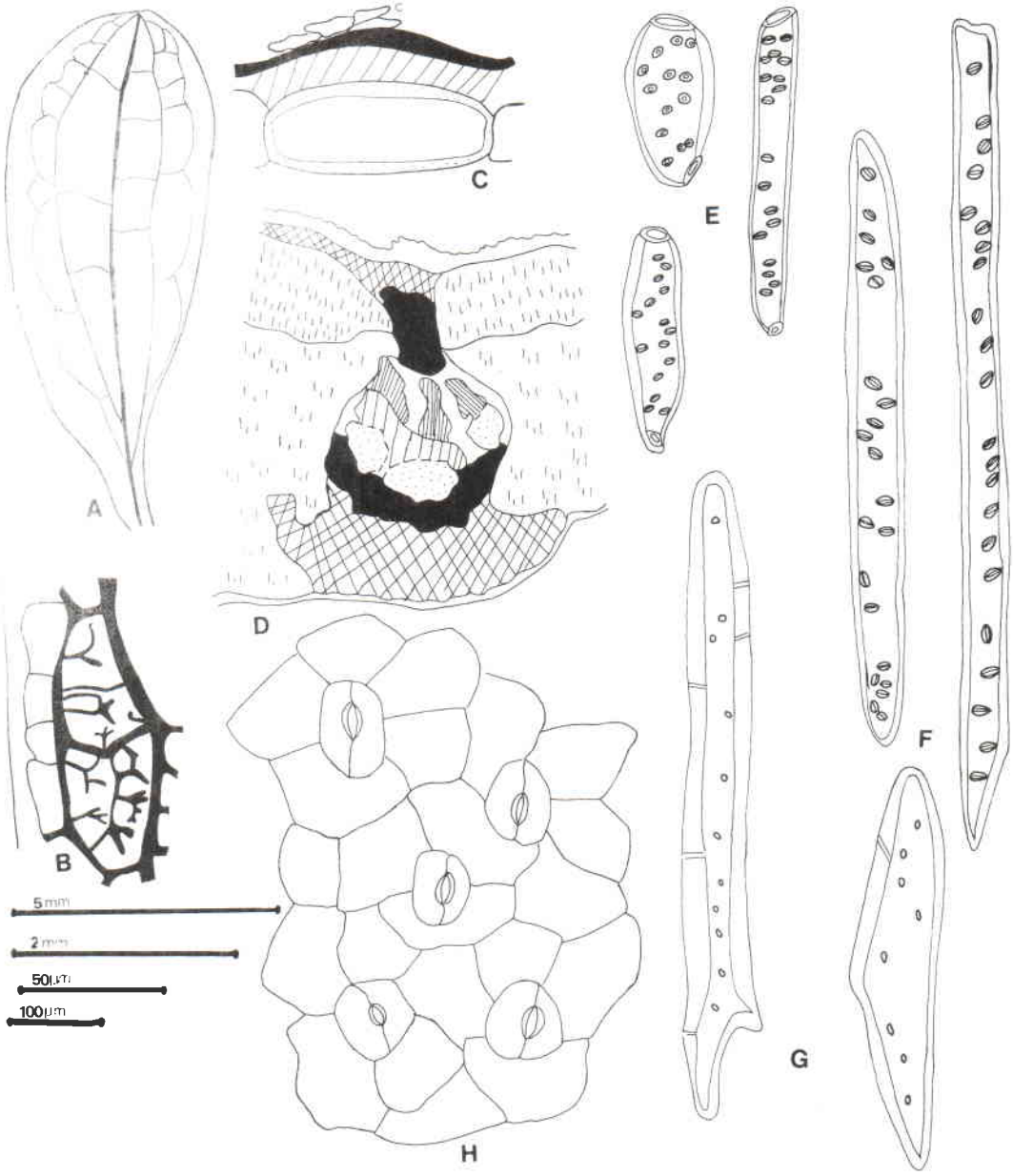


Fig. 3. Berberis vulgaris

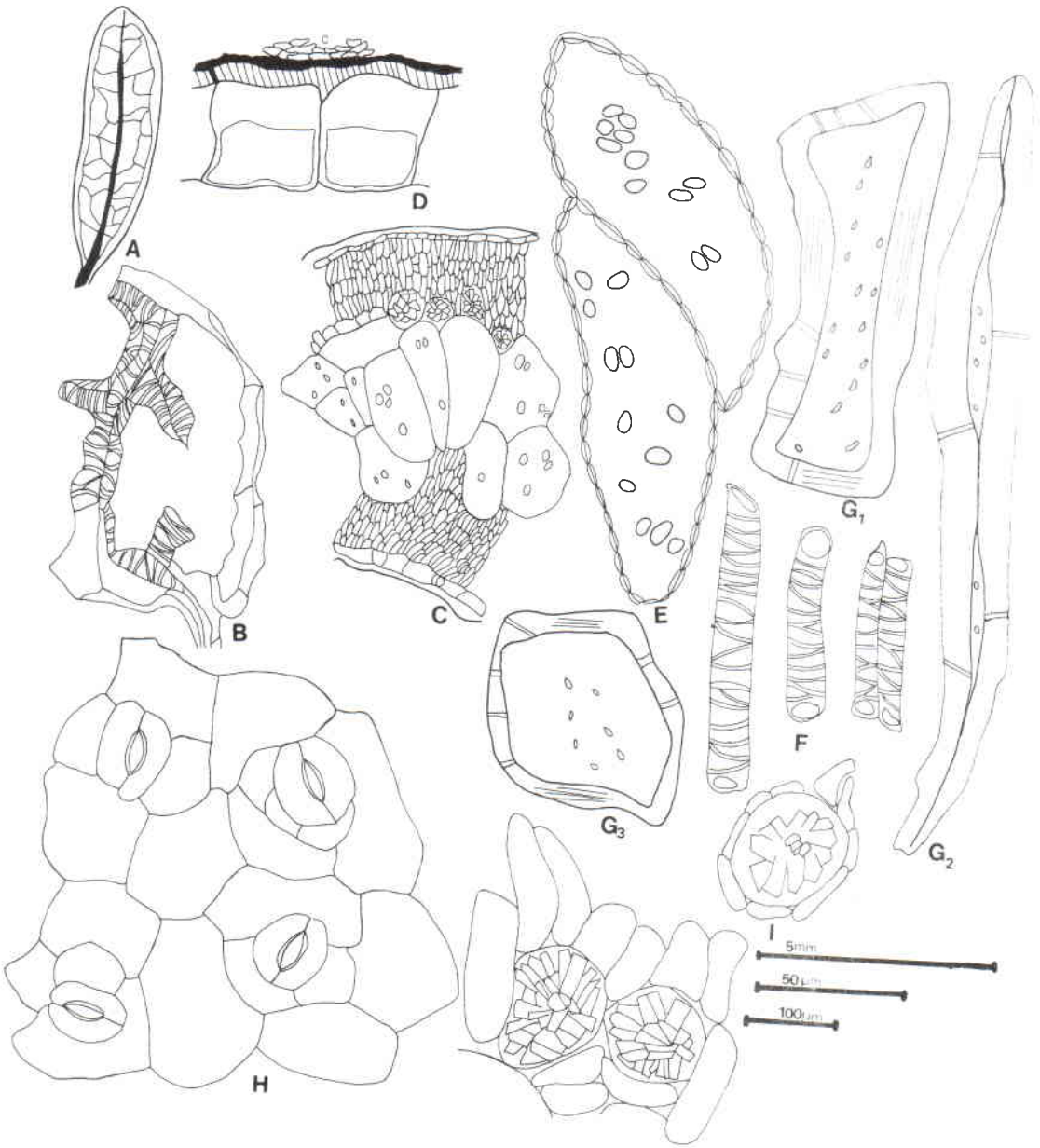


Fig. 4. Atraphaxis spinosa

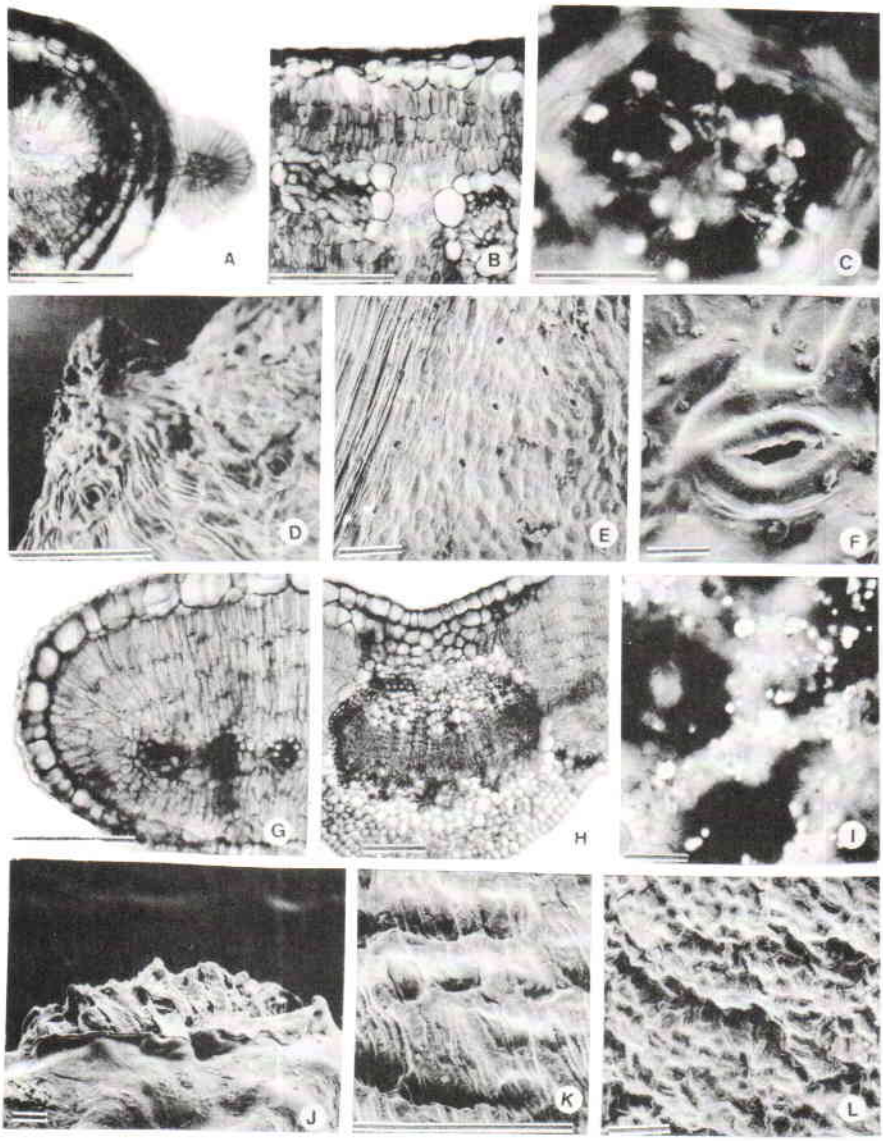


Fig. 5. Amygdalus lycioides - A. scoparia

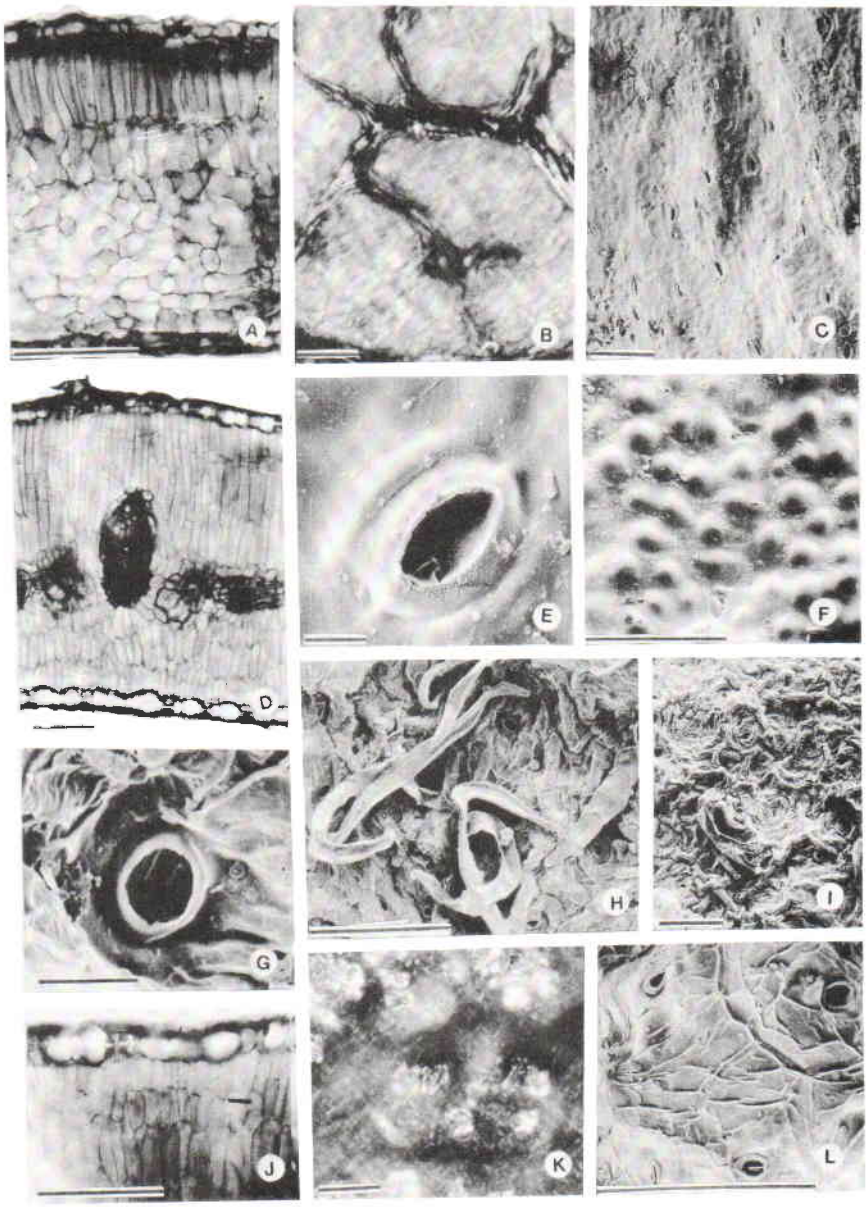
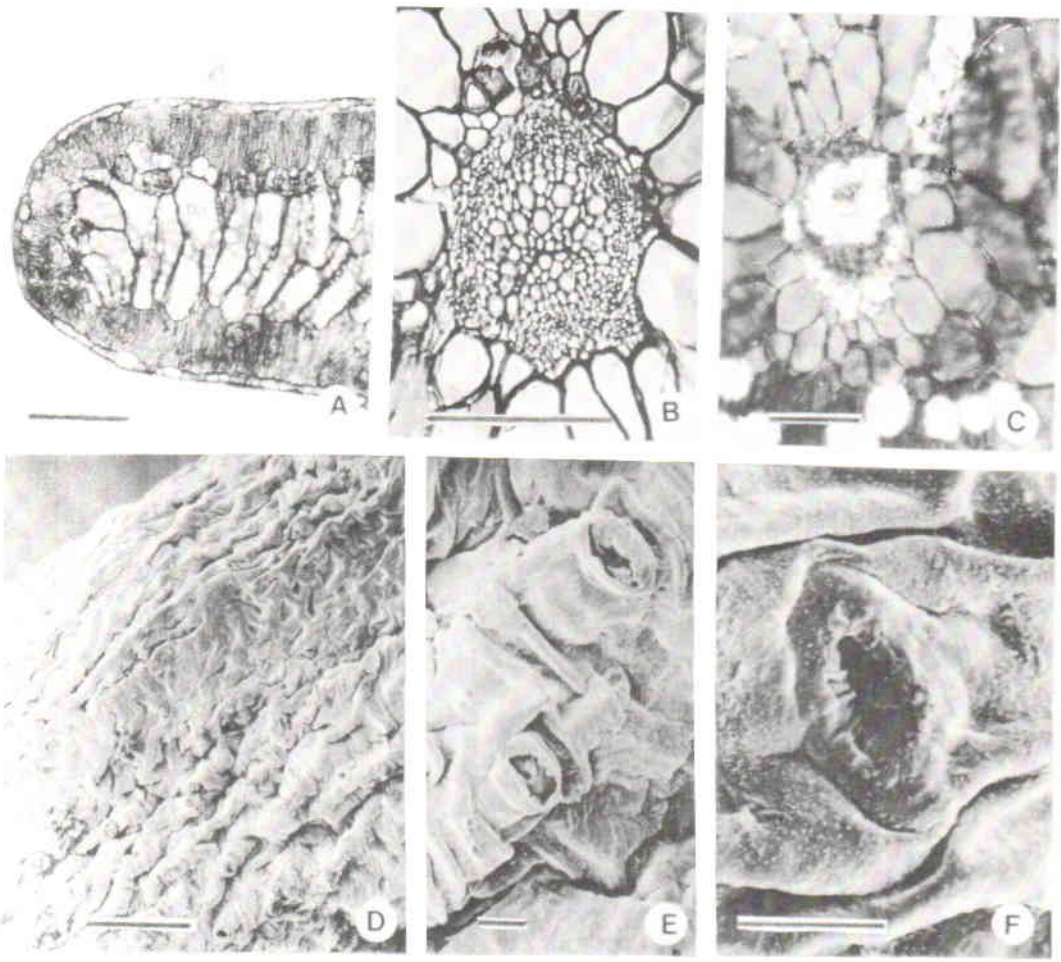


Fig. 6. Berberis vulgaris - Capparis spinosa



Atraphaxis spinosa