Available online on www.ijppr.com
International Journal of Pharmacognosy and Phytochemical Research 2016; 8(1); 174-192

ISSN: 0975-4873

Research Article

A Pharmacognostical Study of *Russelia equisetiformis* Sch. & Cham.

Eman M. Ahmed,Samar Y. Desoukey *,Mostafa A. Fouad, Mohamed S. Kamel

Department of Pharmacognosy, Faculty of Pharmacy, Minia University, Egypt

Available Online: 31st January, 2016

ABSTRACT

Russelia equisetiformis Sch.& Cham.is a perennial plant native to South America. Various traditional systems enlightened the importance of different parts, especially the aerial parts of the plant to have a great medicinal value. The present study aimed detailed pharmacognostic evaluations of the plant-physical, macro and micromorphological features. The findings will be useful towards establishing pharmacognostic standards needed for identification and classification of the plant in both entire and powdered form which is gaining relevance in plant drug research.

Keywords *Russeliaequisetiformis*, Plantaginaceae, pharmacognostical parameters, macro & microscopical evaluation.

INTRODUCTION

*Russelia equisetiformis*Sch. & Cham., formerly belonging to the polyphyletic family Scrophulariaceae and recently introduced into the new monophyletic family Plantaginaceae, is native to Tropical South America especially in Mexico.[1-3] It is an evergreen, perennial, weeping shrub with attractive looking, green arching stems and tubular red blossoms, commonly named as firecracker plant, coral plant, coral blow or fountain plant.[4]*R. equisetiformis* is traditionally used in Nigeria to cure malaria, cancer, inflammatory disorders, diabetes, leukemia, and in hair preparations to promote hair growth.[5,6]The fresh entire plant decoction is taken orally to cure kidney stones in Colombia[7], and the whole plant is utilized as complementary therapy for DM2 patients in Mexico.[8,9]Additionally an anti-oxidant, anti-inflammatory,[6]antinociceptive and analgesic properties[10,11]were reported for different extracts of *R. equisetiformis*, as well as antibacterial[10], antimicrobial, cytotoxic[12], CNS depressant[13],hepatic function[5], membrane stabilizing[15]and hair growth promotor[14]activities. Literature survey didn't provide sufficient information about pharmacognostical studies of this plant. So, various macro and micromorphological studies on both fresh and dried root, stem, leaf and flower were carried out in the present study.

MATERIALS AND METHODS

Collection and authentication: The plant *Russelia equisetiformis* Sch. & Cham. was collectedin February 2008 from El-Zohria garden, Cairo, Egypt, and was kindly authenticated by Mr. Mamdouh Shokry, Agr. Eng. The former director of El-Zohria garden and Dr. Ahmed wahba present director of El-Zohria garden, Cairo, Egypt besides the available literature.[1]

Botanical informations

Botanical name: *Russeliaequisetiformis* Sch. & Cham.
Synonym: *Russeliajuncea*Zucc.
Family: Plantaginaceae

Reagents and chemicals

All reagents and chemicals employed in this work were commercial grade obtained from El-Nasr Company for Pharmaceuticals and Chemicals, A.R.E., and were subjected to purification before use.[16]

Pharmacognostical studies

Pharmacognostical studies include morphological and microscopical studies of the plant.

Morphological studies

Fresh samples of the plant including root, stem, leaf, petiole and flower were used to study the external texture together with colour, odour, taste, size, shape, etc. Photographs were taken by a Fuji Cyber-shot digital camera and results were reported.

Microscopical studies

Samples from the root, stem, leaf, petiole and flower were cut using a microtome into sections of 10-20 µ or up to 30 µ, stained with Safranin (1% solution in 50% ethanol) for 15 minutes then washed in alcohol (50%, 70%, 100%) respectively for 5 minutes. Then all sections were stained with light green for 90 seconds, washed with alcohol (96%, 100%) respectively for 5 minutes, immersed in xylol for 5 minutes, dried at 50°C for 72 hours and became ready for examination.[17] The photographs were taken using a microscope with camera Leica, model DM1000 (a US listed microscope). The dried fine powdered materials: Samples from all organs were separately air-dried, then reduced to powder by a milling machine. Powder of each organ was cleared with NaOH, mounted in glycerine medium after staining and different cell components were studied and measured.[18,19] Magnifications of the figures are indicated by the scale-bars, and descriptive terms of the anatomical features are as given in the standard anatomy books.[20]

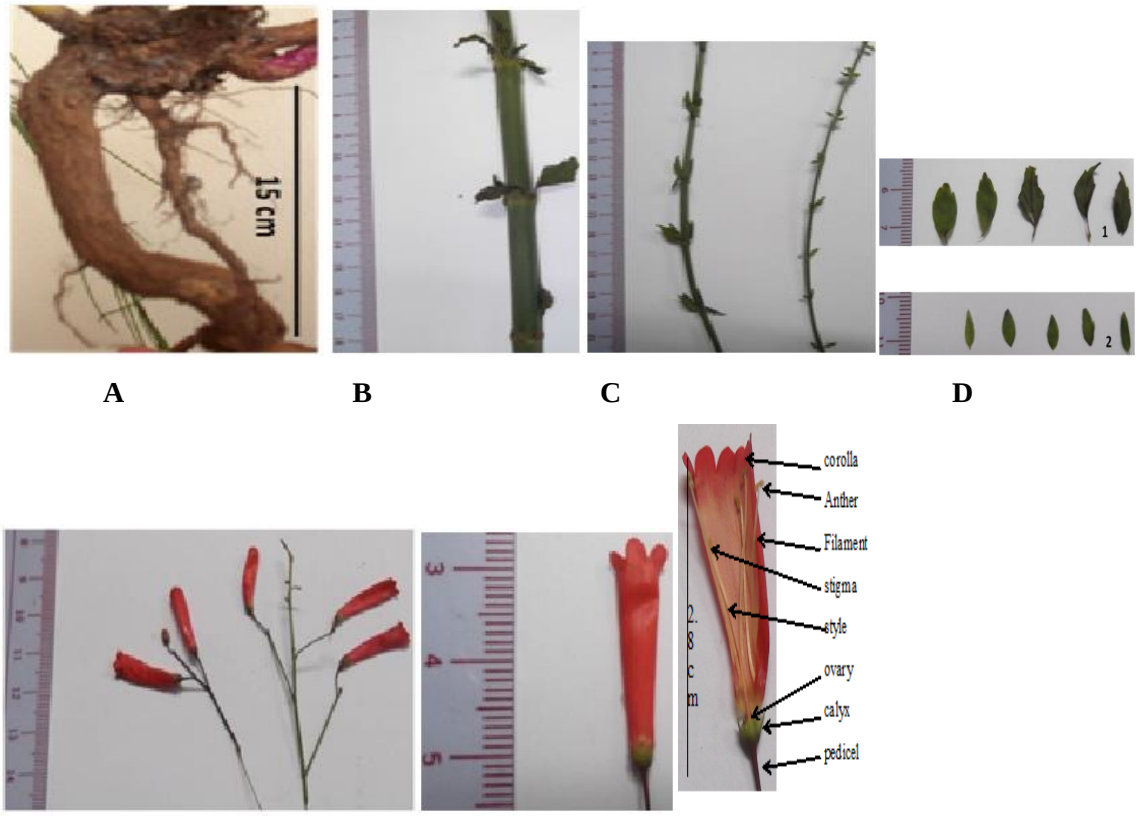
Phytochemical screening

**Author for Correspondence*

Air-dried powdered aerial parts (stems and leaves) were macerated in methanol (70%) in large glass containers, subjected to soxhlet extraction till exhaustion, concentrated using a rotary evaporator (BÜCHI R-144, Switzerland)to give 500 g of dried extract which was subjected to preliminary phytochemical screening using standard methods.[21]

A **B**

Figure 1 Photographs of *Russelia equisetiformis*. A, the whole plant; B, the flowering branch.



A **B** **C** **D**

E **F** **G**

Figure 2 Photographs of *Russelia equisetiformis* Sch. & Cham. A, the root; B, the main stem; C, the lateral branches; D, the leaves (1, lower leaves; 2, upper leaves); E, the inflorescence; F, the flower; G, internal view of the flower.

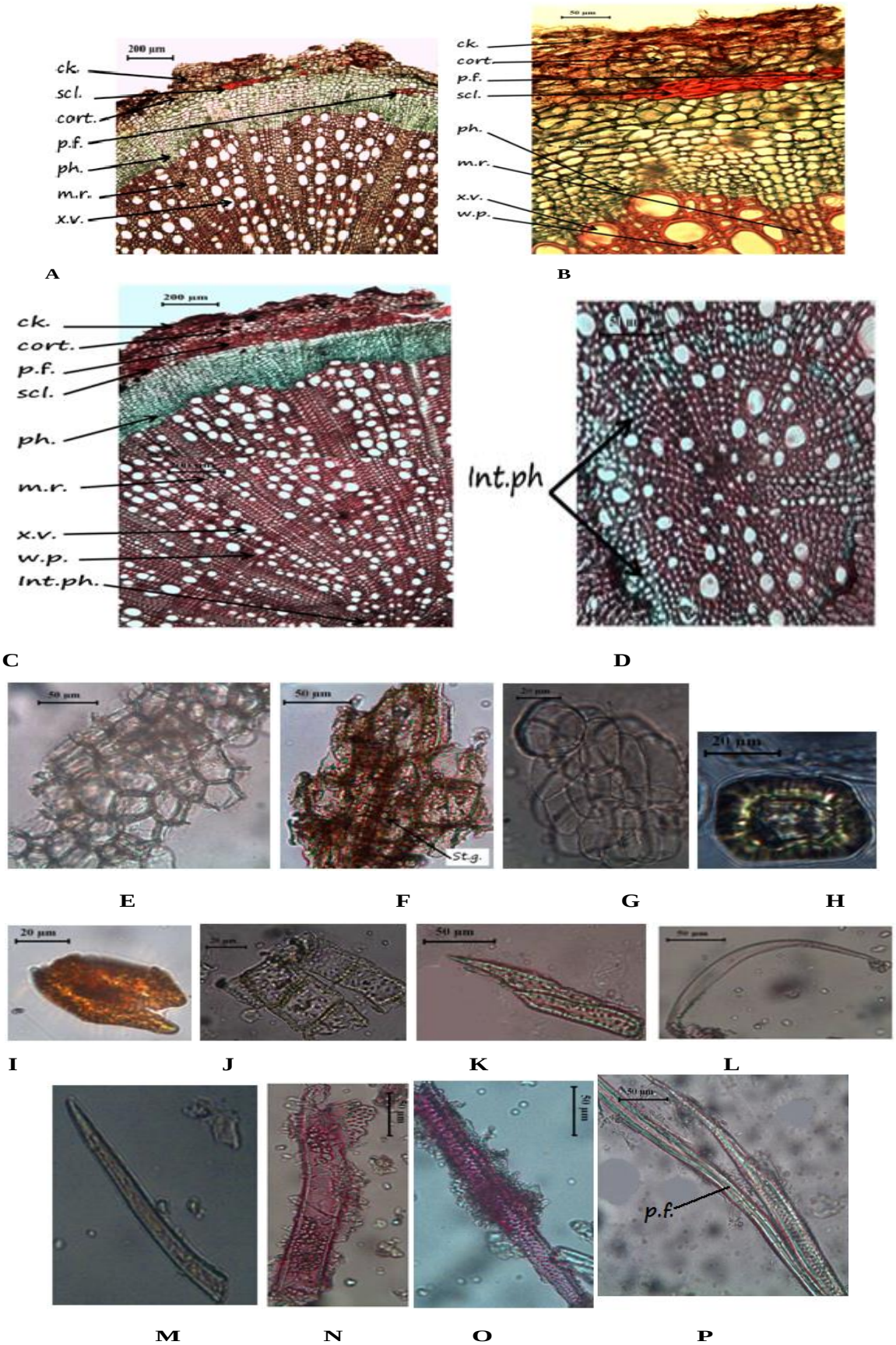
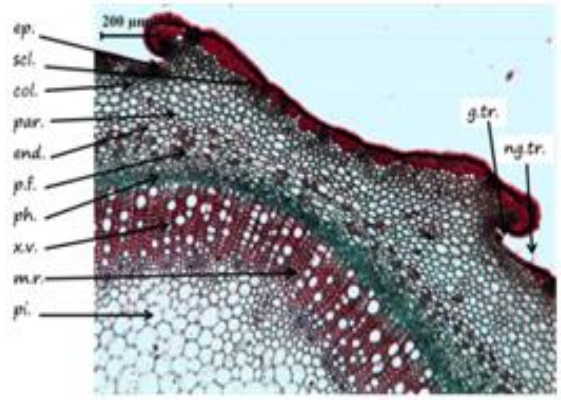
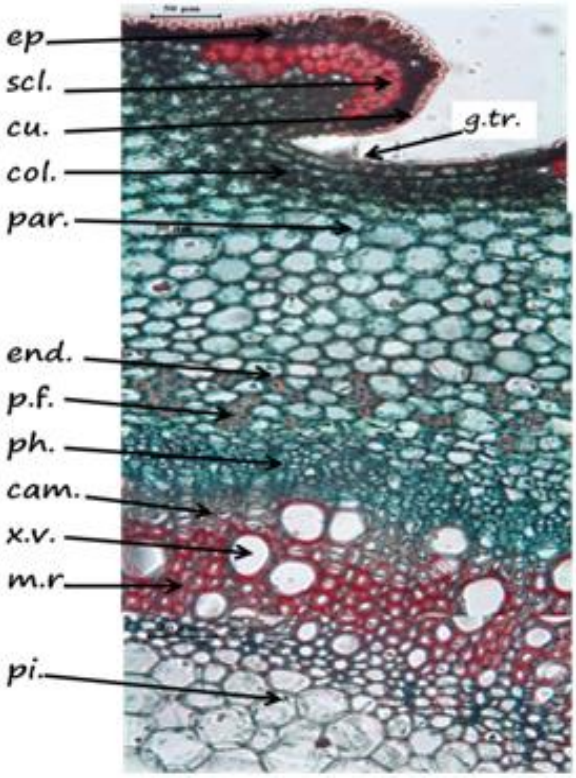


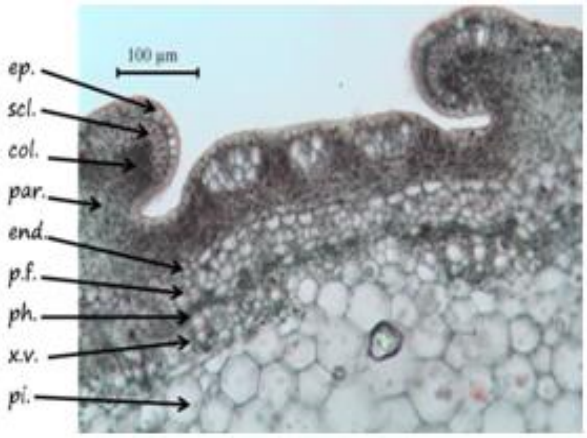
Figure 3 Photographs of the root. A, T.S. of the moderate root; B, detailed T.S. of the moderate root; C, T.S. of the old root; D, intraxylary phloem of the old root; E, F, cork cells showing starch granules; G, parenchyma cells; H, I, sclerenchyma cells; J, wood parenchyma; K, tracheids; L, M, wood fibers; N, medullary rays; O, pitted xylem vessel; P, pericyclic fiber.


ep.
scl.
col.
par.
end.
p.f.
ph.
x.v.
m.r.
pi.
g.tr.
ng.tr.

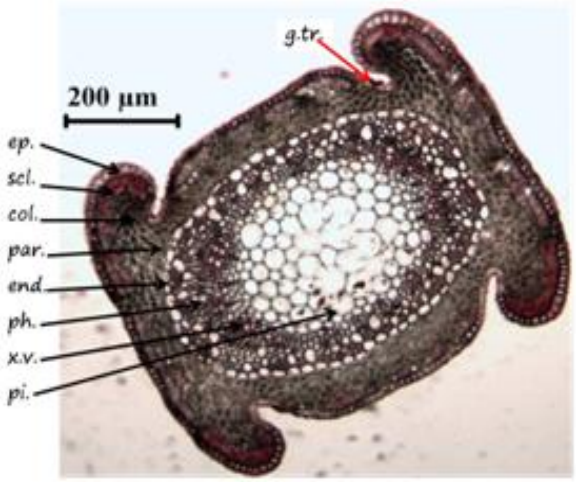
A


ep.
scl.
cu.
col.
par.
g.tr.
end.
p.f.
ph.
cam.
x.v.
m.r.
pi.

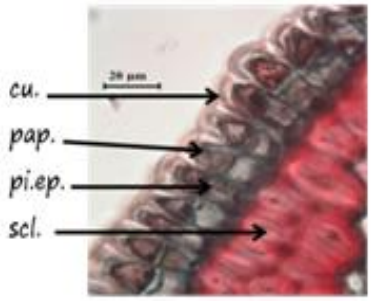
B


100 µm
ep.
scl.
col.
par.
end.
p.f.
ph.
x.v.
pi.

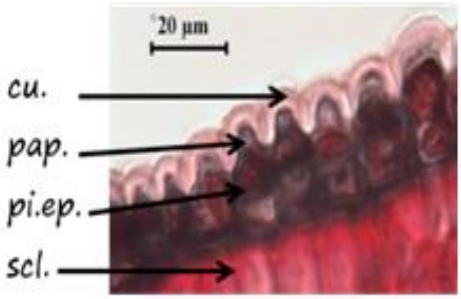
C


g.tr.
200 µm
ep.
scl.
col.
par.
end.
ph.
x.v.
pi.

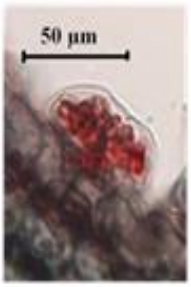
D


cu.
pap.
pi.ep.
scl.

E


20 µm
cu.
pap.
pi.ep.
scl.

F


50 µm


50 µm

G

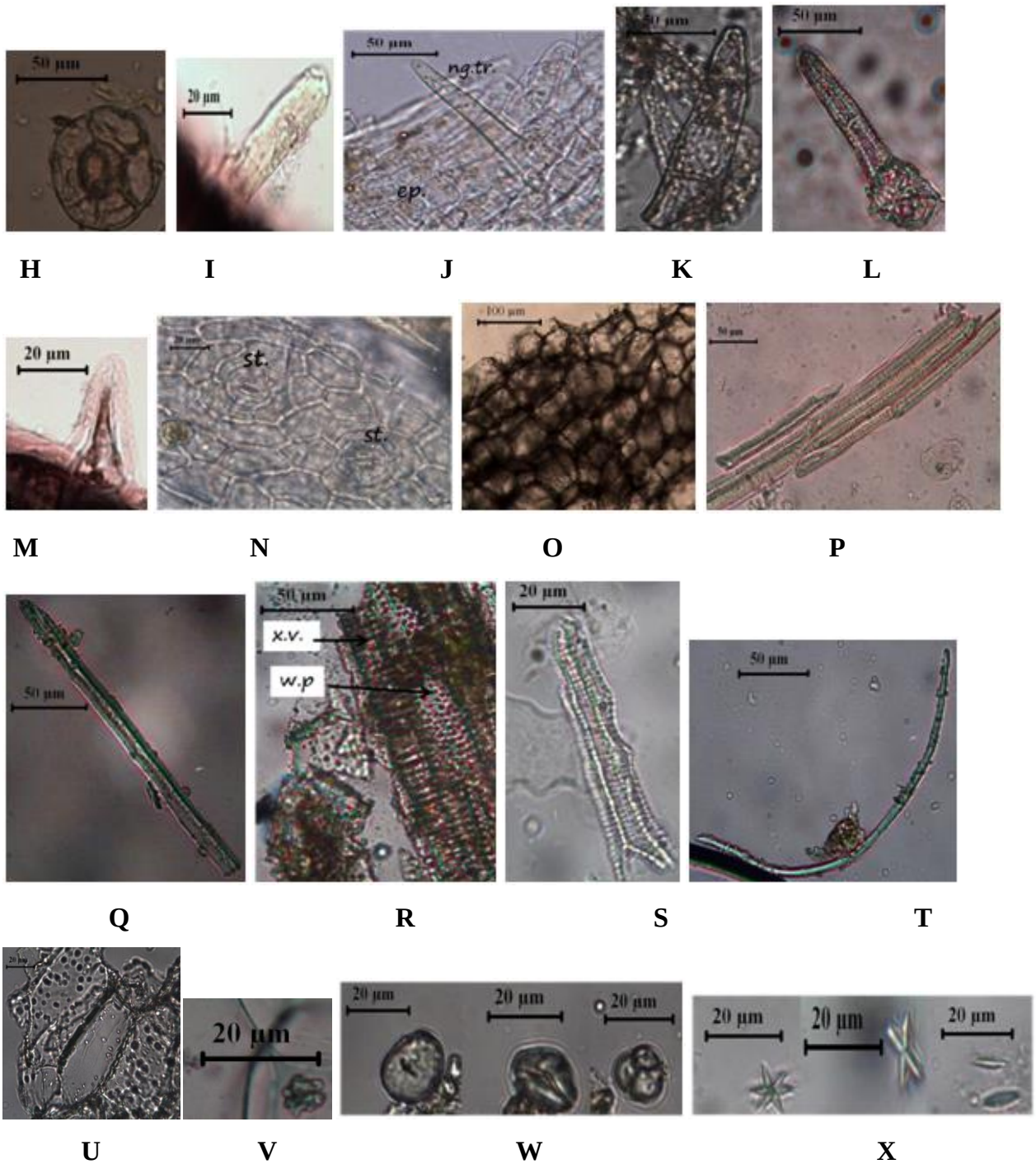


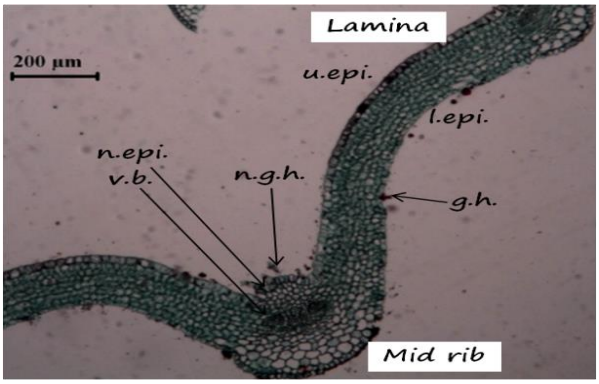
Figure 4 Photographs of the stem. A, T.S. of the old stem; B, detailed T.S. of the old stem; C, T.S. of young stem; D, T.S. of a young branch of stem; E, F, papillosed bi-epidermis of the old stem; G, glandular hair (side view); H, glandular hair (top view); I-M, non-glandular hairs; N, fragment of epidermis with anomocytic stomata; L, fragment of parenchyma of pith; P, elongated sclerenchyma cells; Q, pericyclic fiber; R, annular xylem vessels with wood parenchyma; S, tracheids; T, wood fiber; U, wood parenchyma; V, cluster of CaOX; W, simple and compound starch granules; X, simple and compound protein crystals.

RESULTS AND DISCUSSION

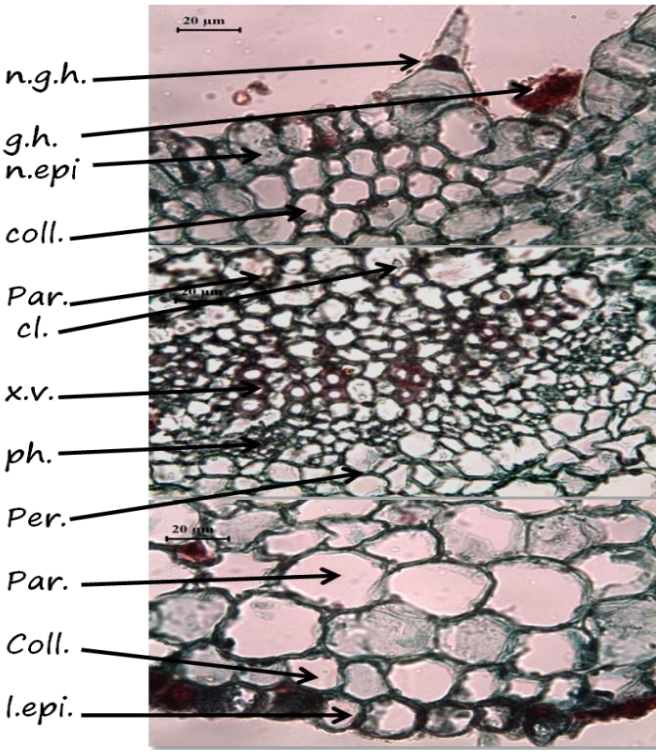
Macromorphology (Fig. 1,2) *Russelia equisetiformis*Sch. & Cham. is a perennial, evergreen, erect , half-woody shrub, about 1-1.2 meter high. The ribbed, branched stems carry tiny, scale-like, dark green leaves and beautiful hanging clusters of red tubular flowers blooming in spring and summer.

The root (Fig. 2A) is tap, woody, with wrinkled surface and lateral rootlets, measuring about 17-20 cm in length and 1.3-1.5 cm in diameter. It exhibits a woody fracture and it is brown in colour, odourless with a slight bitter taste.

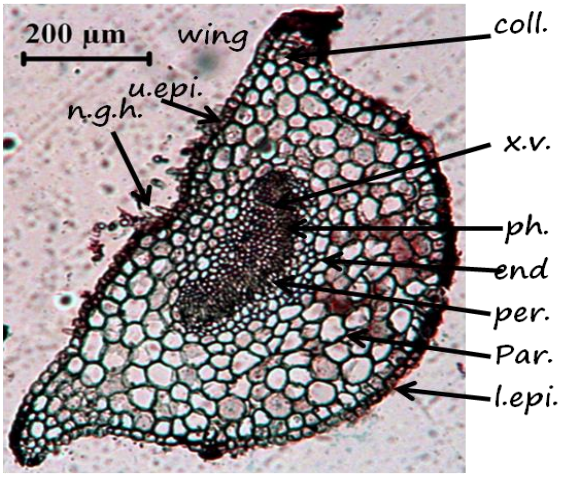
The stem (Fig. 2 B, C) The main stem starts erect then becomes pendulous giving rush-like branches. It is woody at the base, herbaceous above and monopodially branched. The stem and branches are pubescent, angular with 2-7 angles, although mentioned in literature to be glabrous having 4-12 angles.[1]They have prominent ridges on angles and striations inbetween. The main stem measures about 80-150 cm in height and 0.6-0.8 cm in diameter, internodes are 6-6.5 cm in length. The branches are thinner showing short internodes, measuring from 1.5-3.5 cm in length and 0.1-0.5 cm in diameter. The stem breaks with a fibrous fracture on drying and it is green in colour, odourless with a slight bitter taste.



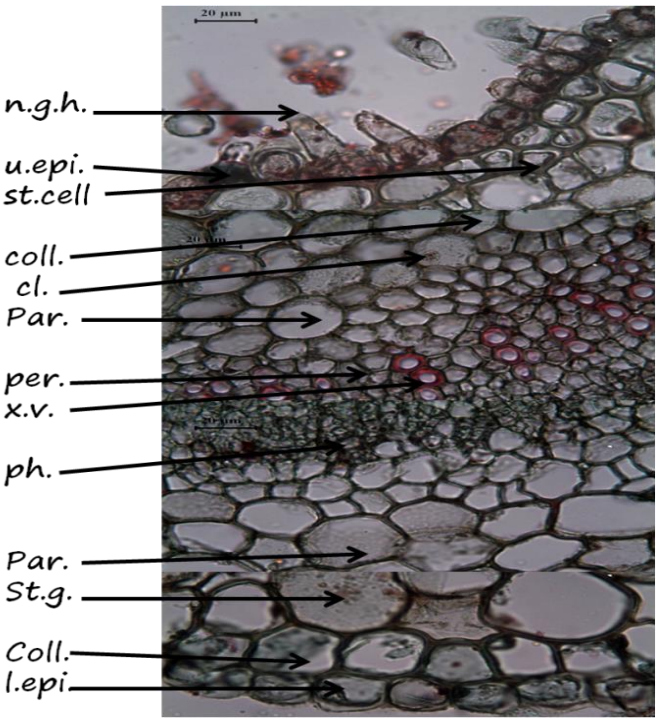
A



B



C



D

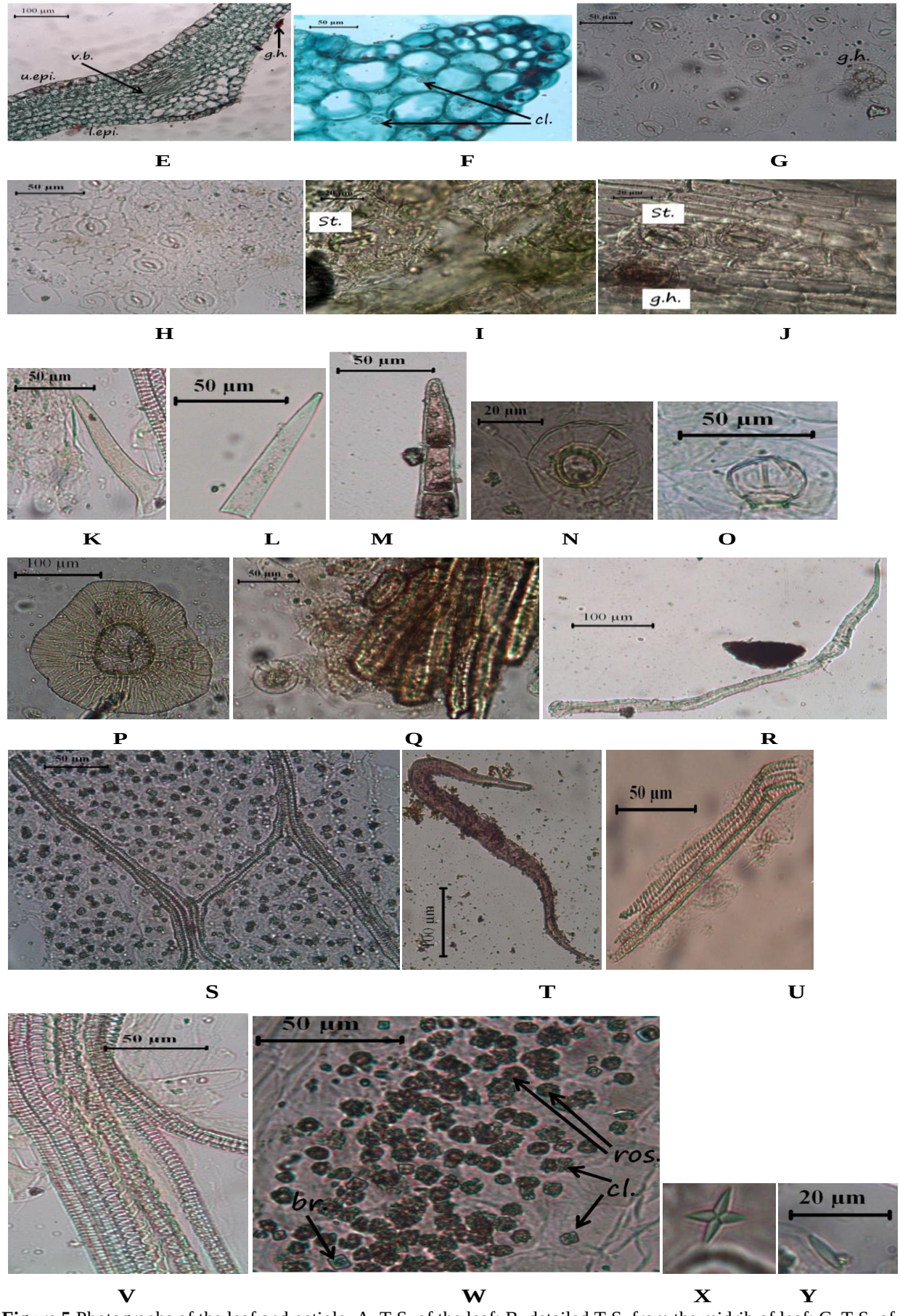
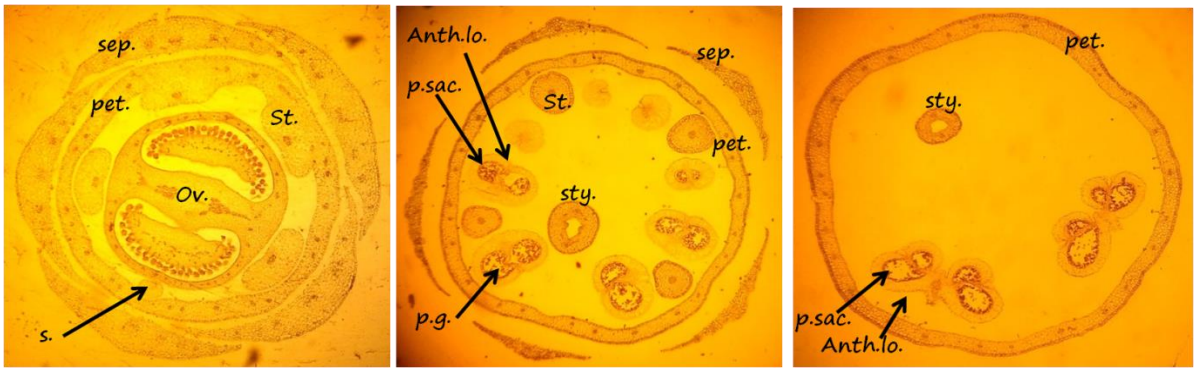


Figure 5 Photographs of the leaf and petiole. A, T.S. of the leaf; B, detailed T.S. from the midrib of leaf; C, T.S. of the petiole; D, detailed T.S. of petiole; E, detailed T.S. from the lamina of leaf; F, detailed T.S. from wing of the petiole; G,

fragment of upper epidermis of leaf; H, fragment of lower epidermis of leaf; I,fragment of neural epidermis of leaf; J, fragment of epidermis of petiole; K,L,M, non-glandular hairs; N,O, glandular hairs; P, peltate hair; Q, sclerenchyma cells; R, tortuous pericyclic fiber; S, crystal layer; T, wood fiber; U, tracheids; V, xylem vessels; W, different crystals of CaOX; X,Y, protein crystals.



A **B** **C**

Figure 6 Photographs of transverse sections of the flower; A, (x = 11) lower level showing the four didynamous stamens together with the staminode;sep., sepal; pet, petal;st, stamen; s, staminode; ov., ovary; B, (x = 10) middle level showing the style and only remnants of the two short stamens; anth.lo., anther lobe; p.sac., pollen sac; p.g., pollen grains; sty., style; C, (x = 8) upper level.

The leaves (Fig. 2D) are simple, pubescent, shortly petiolate and exstipulate with few circular resinous dots on the surface. The upper leaves are small, opposite or whorled, entire, ovate or elliptic, 5-8 mm long and 2-4 mm wide, and mostly reduced to minute scales on the branches, while the lower ones are larger, 8.5-15 mm long and 6-9 mm wide, whorled, 3-6 in a whorl, ovate or elliptic with few large teeth on each side. The lamina has an acute to short-acuminate apex; a symmetric base; and a pinnate venation. The leaves have green upper surfaces and paler lower ones, with rough surfaces and few circular resinous dots, odourless with a slight bitter taste. The petiole is 1-2 mm long for the upper leaves and 3-4 mm long for the lower ones.

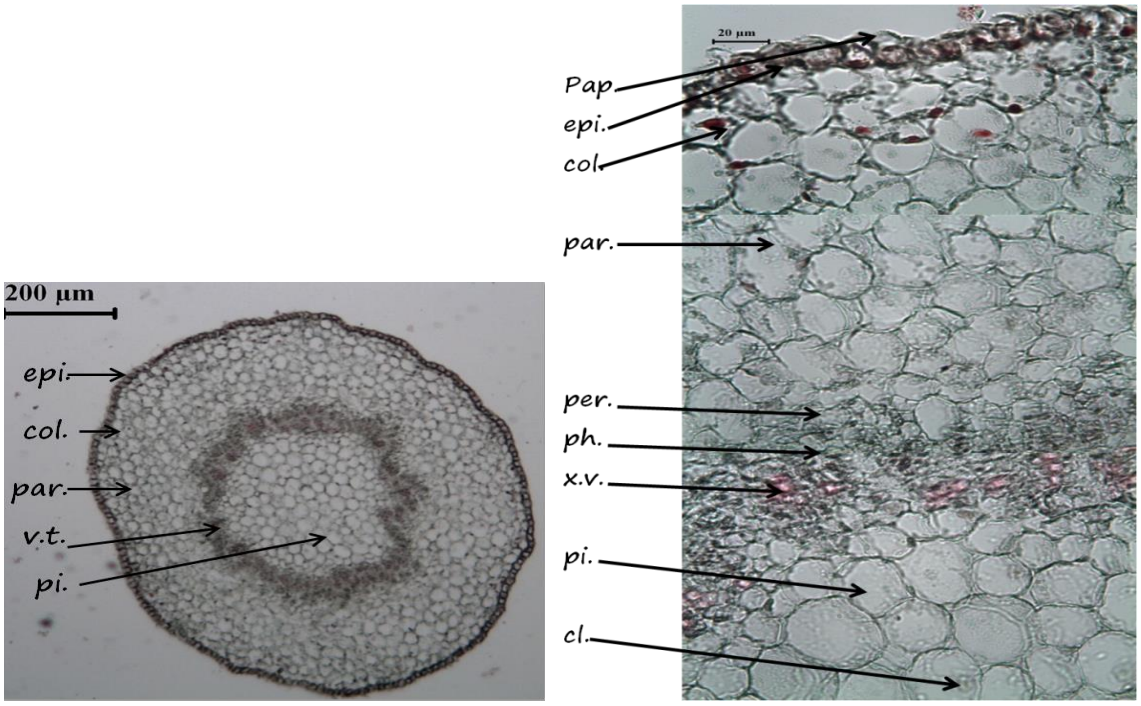
The flower (Fig. 2E-G)The inflorescence is terminal, 2.5-3 cm long, opposite or verticillate, erect to drooping racemes of 1-3 bell-shaped red flowers. Bracteoles are very small, linear and leafy with a few resinous dots. Flowers are bright red, pedicellate, slender, and pubescent from inside, ebracteate, zygomorphic, hermaphrodite, hypogenous, pentamerous, measures from 1.5 to 2 cm long. They possess the following floral formula:

ebr ,%, ♂, K 5, C (5),⁀A2+2+1, G (2)

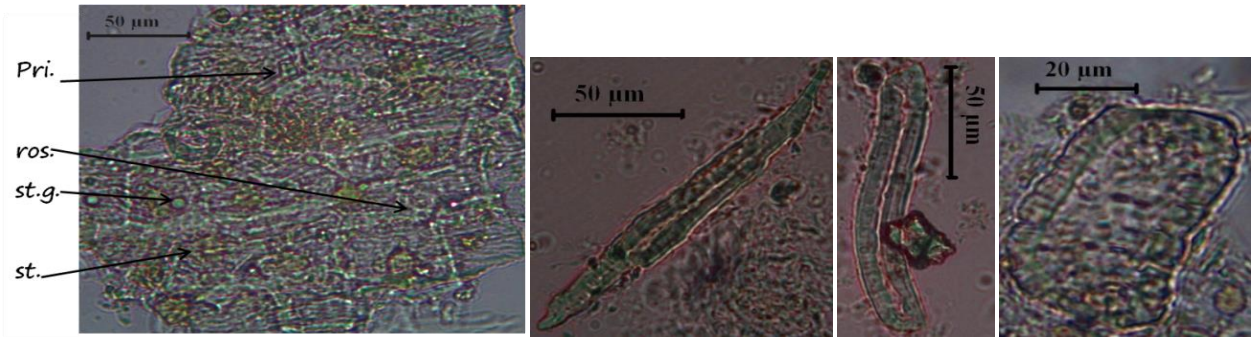
The pedicel is cylindrical, glabrous, purplish green in colour and ranges from5-10 mm in length and about 0.5 – 1 mm in diameter. The calyx is persistent, consisting of five free sepals, with imbricate aestivation. Sepals are dark green in colour, measuring about 2-3 mm long and 1-1.5 mm wide at the middle. Calyx lobes are broadly ovate, and acute to mucronate. The calyx outer surface is glabrous while the inner one is pubescent. The corolla is tubular, gamopetalous with five petals forming a corolla tube with valvate aestivation. It is bell-shaped and coloured bright red; measuring about 1.5-2 cm long and about 0.5 cm wide with glabrous outer surface and pubescent inner one. The androecium is formed of four didynamous, epipetalous stamens with free glabrous filaments extending to top of corolla tube. Each stamen has a long, pale yellow filament attaining 18-20 mm in length and 0.5-1 mm in width. The anthers are orbicular, divaricate, or somewhat pendulous, greenish yellow in colour, reaching up to 1 mm in length and 0.5 mm in width. Staminodes are very short and small. The gynoecium consists of a single pistil measuring about 15 mm long, shorter than the corolla tube, with a superior bilocular bicarpellary ovary; each locule has an enlarged, thick placenta bearing numerous anatropous ovules. The style is apiculate and the stigma is divided.

Micromorphology

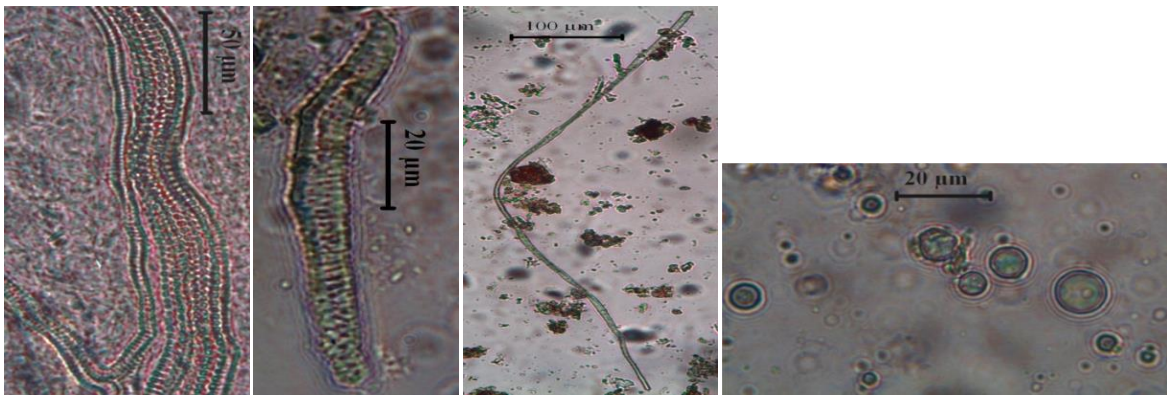
The root (Fig. 3)A transverse section in the **moderate root**(Fig. 3 A, B)is circular in outline rupturing at intervals. The outermost layer of cork is made up of 4-6 layers of equally thickened, suberized-walled, tangentially elongated cells containing starch granules with central point-like hilum either simple or a muller-shaped. The cortex is formed of 3-5 layers of thick-walled parenchymatous cells containing starch granules. The pericycle zone is relatively wide formed of 9-11 layers of polygonal, cellulosic, thick-walled parenchyma cells containing few alternative patches of sclerenchymatous cells towards the periphery and pericyclic fibers towards the center. The sclerenchyma consist of 1-2 layers of polygonal, isodiametric, sometimes elongated, lignified, pitted with thick walls and narrow lumen. The pericyclic fibers have thick, lignified walls, narrow to fairly wide lumen and blunt apices. The vascular tissue is wide occupying nearly almost the whole section. The phloem is interrupted by the extended medullary rays and consists of a narrow and collapsed region of thin-walled parenchymatous cells containing starch granules. The cambium is indistinct. The xylem consists of lignified vessels, fibers, tracheids, wood parenchyma and traversed by 4-7 cells wide multiseriate medullary rays. The vessels are mainly pitted. The fibers are elongated with a narrow



A **B**



C **D** **E** **F**



G **H** **I** **J**

Figure 7 Photographs of the pedicel. A, T.S. of the pedicel; B, detailed T.S. of the pedicel; epi., epidermis; col., collenchymas; par., parenchyma; v.t., vascular tissue; pi., pith; per., pericycle; ph., phloem; x.v., xylem vessel; cl., cluster of CaOX; C, epidermal cells of the pedicel; pri., prism; ros., rosette; st.g., starch grain; st., stomata; D&E, sclrenchyma cells; F, wood parenchyma; G, xylem vessels; H, tracheids; I, wood fibers; J, starch grains.

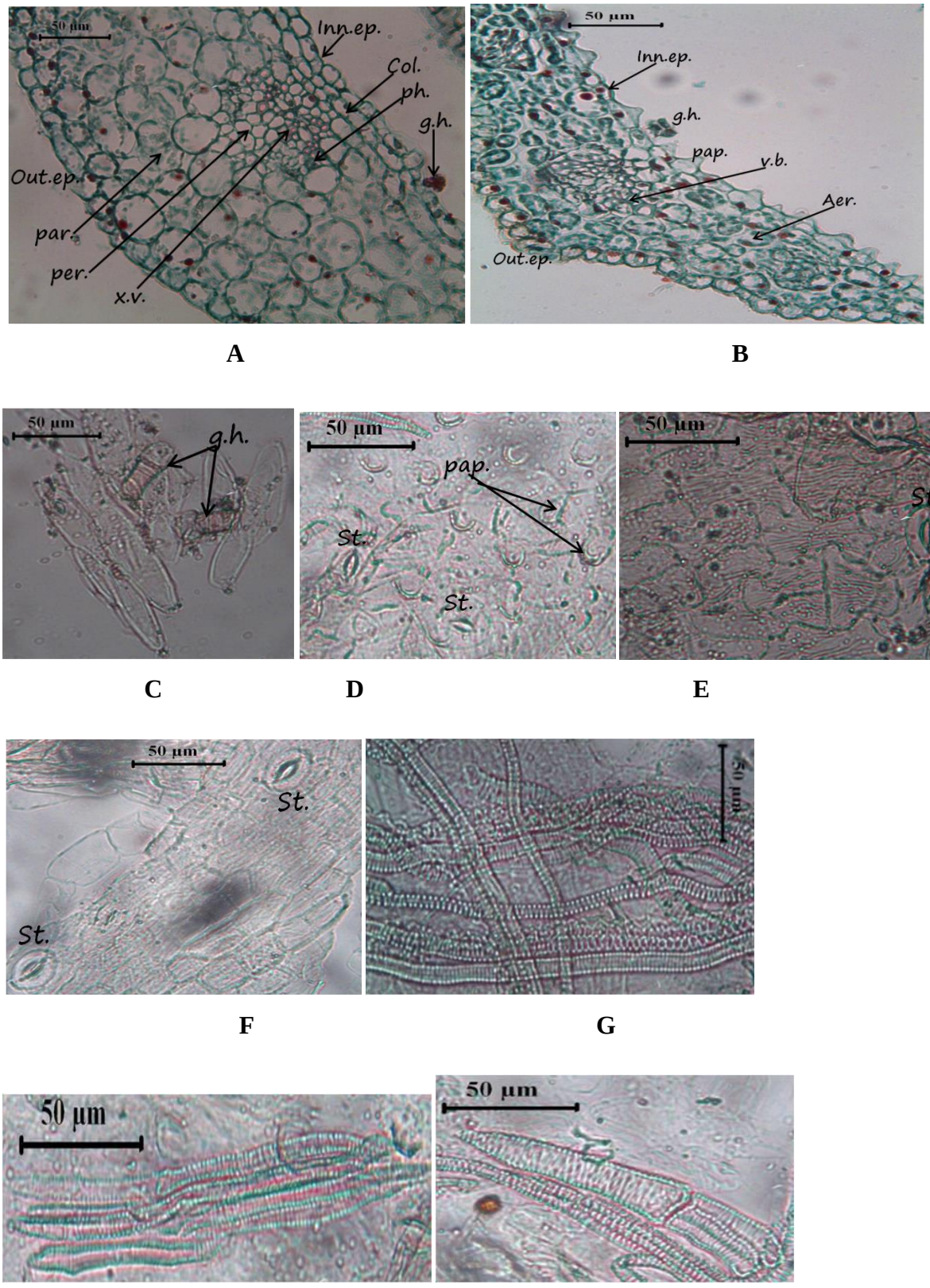


Figure 8 Photographs of the calyx. A, detailed T.S. of the lower epidermis; B, detailed T.S. of the upper epidermis; out.ep., outer epidermis; inn.ep., inner epidermis; col., collenchymas; par., parenchyma; g.h., glandular hair; pap., papillae; aer., aerenchyma; per., pericycle; v.b., vascular bundle; C, lower part of the inner epidermis; D, upper part of the inner epidermis; E, lower part of the outer epidermis; F, upper part of the outer epidermis; G, xylem vessels; H, tracheids; I, wood parenchyma.

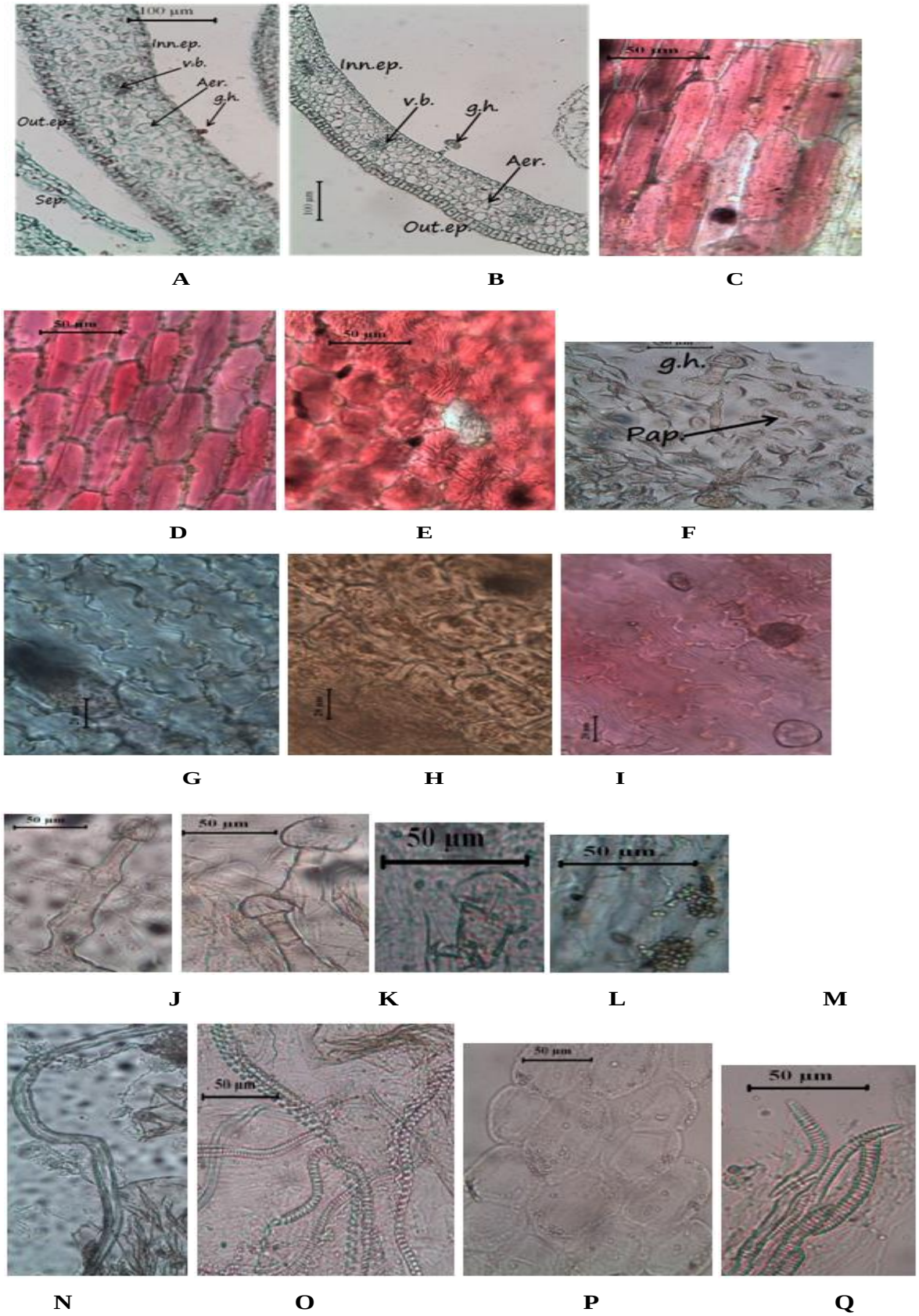


Figure 9 Photographs of the corolla. A, lower part; B, middle part; C, lower inner epidermis; D, middle inner epidermis; E&F, upper inner epidermis; pap., papillae; aer., aerenchyma; sep., sepal; G, lower outer epidermis; H, middle outer epidermis; I, upper outer epidermis; J,K&L, glandular hairs; M, starch granules; N, pericyclic fibers; O, xylem vessels; P, parenchyma of mesophyll; Q, tracheids.

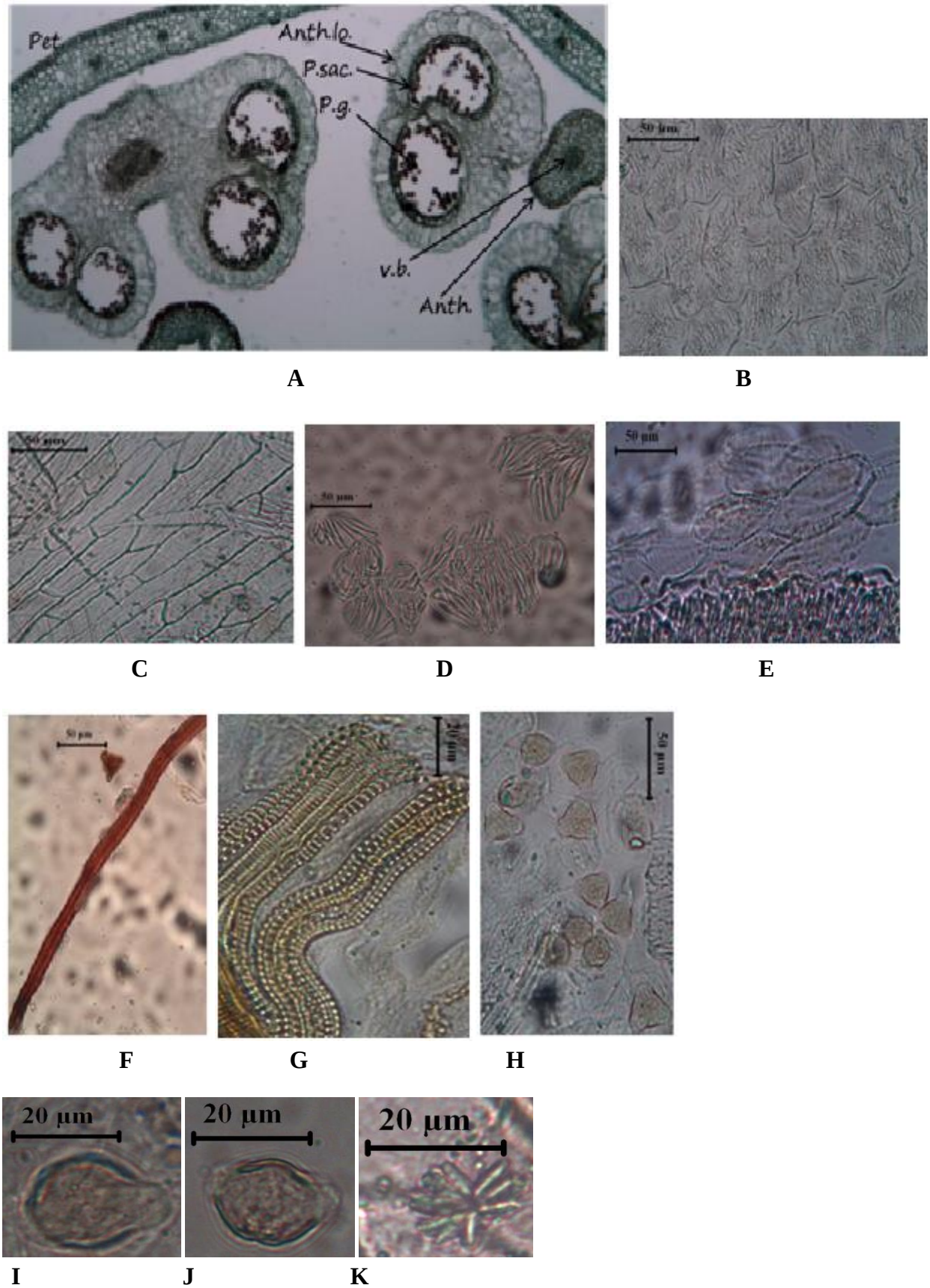


Figure 10 Photographs of the androecium, A, T.S. of the stamen (anther region); B, epidermis of filament; C, epidermis of anther; D&E, fibrous layer of anther; F, pericyclic fibers; G, xylem vessels; H-J, pollen grains; K, protein crystals.

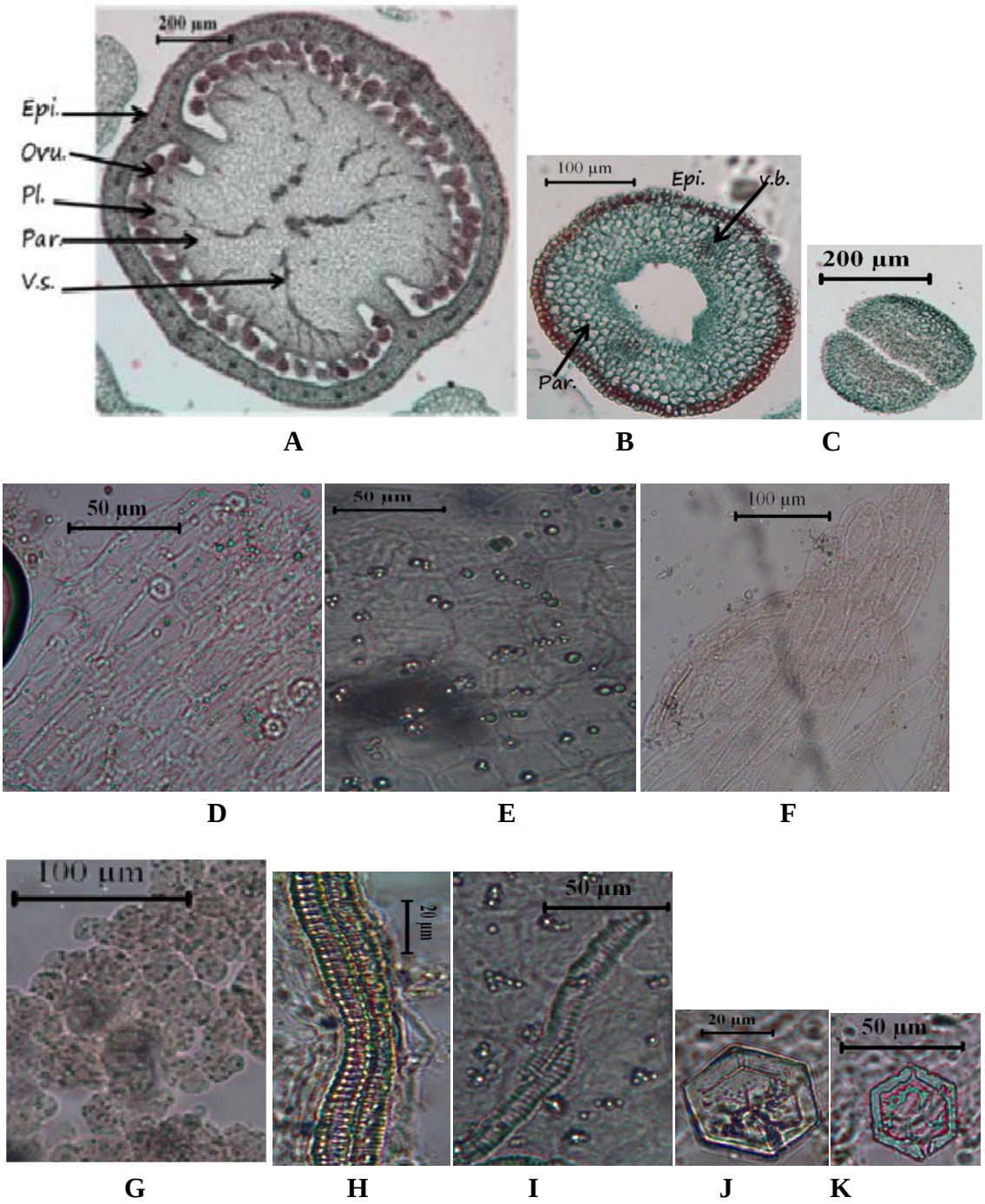


Figure 11 Photographs of the gynaecium, A, T.S. in the ovary; B, T.S. in the style; C, T.S. in the stigma; D, epidermis of ovary; E, epidermis of style; F, epidermis of papillosed stigma; G, parenchyma of ground tissue; H, xylem vessels; I, tracheids; J&K, hexagonal CaOX crystals.

lumen and moderately acute ends with lignified walls and some of them are spindle-shaped. The tracheids are elongated with lignified walls showing simple pits and having blunt ends. The medullary rays are radially elongated sub-rectangular cells with pitted, slightly lignified walls containing starch granules. There is no pith. A transverse section in the **old root** (Fig. 3 C, D) is slightly different. The pericycle zone contains a nearly continuous ring of 4-5 layers of pericyclic fibers and sclerenchyma cells, while medullary rays are wider with a narrow ring of intraxylary phloem present towards the center. Powdered **root**(Fig. 3 E-P) is pale yellow in colour with a faint odour and a slight bitter taste. Elements present were thick-walled parenchyma cells, cork cells, sclerenchyma cells, pericyclic fibers, medullary rays, pitted xylem vessels, fibers, tracheids and wood parenchyma. A transverse section in the **old stem** (Fig. 4A&B) is angular in outline having 7 wave-like prominent ridges. It is formed of an epidermis consisting of one layer of nearly square cells under ridges, and larger, axially elongated and slightly papillosed ones in the areas between ridges, and both types having anomocytic stomata. In some areas, epidermal cells

duplicate to produce a biseriate epidermis (Fig. 4 E&F). In surface view, the cells appear polygonal, isodiametric to slightly elongated, with straight thin cellulosic anticlinal walls, and all of them are covered with a thick, striated and warty cuticle. Epidermal cells contain brown pigments, simple or compound groups of starch granules, protein crystals together with both glandular and non-glandular hairs containing the brown pigments. The glandular hairs are of a short unicellular stalk and a multicellular head of about 6 cells. The non-glandular ones are either unicellular uniseriate with acute or blunt apices, straight slightly curved, or bi- to tri-cellular uniseriate with a long terminal one having blunt apices, both types are covered with thick and warty cuticle. The cortex is formed of an outer collenchymatous zone and inner parenchymatous one, both are heavily filled with chloroplasts. The collenchyma consist of 3-7 layers of small rounded cells, interrupted just below the epidermis by many separated islets of 2-3 layers of sclerenchyma cells which are variable in shape and size and most of them are elongated, possessing thick, lignified, finely pitted walls and narrow lumen. The parenchyma region is formed of 3-7 layers of thin-walled parenchyma cells with many starch granules and some scattered protein crystals. The endodermis is formed of a single layer of tangentially elongated parenchyma cells containing starch granules. The pericycle is formed of a continuous ring of nearly 6-9 layers of small rounded, thin cellulosic-walled parenchymatous cells, interrupted by scattered islets of lignified pericyclic fibers having thick lignified walls with fairly wide lumens and blunt ends. The vascular system forms a continuous ring of vascular tissue. The phloem consists of thin walled parenchymatous cells. The cambium is formed of several layers of, tangentially elongated, cellulosic-walled cambiform cells. The xylem is formed of a continuous narrow ring of lignified vessels, fibers, tracheids, wood parenchyma and traversed by medullary rays. The vessels are mainly annular. The wood fibers are elongated with a narrow lumen and moderately acute ends. Tracheids are elongated with blunt ends, the walls are lignified showing simple pits. The wood parenchyma is rectangular with pitted lignified walls containing numerous starch granules. The medullary rays are formed of radially elongated sub-rectangular cells with pitted and slightly lignified walls. The pith is wide consisting of large, isodiametric, thin-walled parenchyma cells containing numerous starch granules and few crystals of protein.

A transverse section in the **young stem** (Fig. 4 C) is slightly different. It contains few prominent ridges (5).The epidermis shows one layer of epidermal cells with no duplicates, bearing very few hairs. The cortex zone has more chloroplasts. Endodermis is well differentiated, containing starch granules. The pericycle contains very few lignified fibers. The vascular tissue forms a narrow ring with no medullary rays. The pith is wider than that of the older stem.

A transverse section in a **young branch of stem** (Fig. 4 D)is quadrangular in outline having two prominent ridges, and having layers similar to the young stem except in the cortex which is mainly collenchymatic and the vascular tissue is very narrow.

Powdered **stem** (Fig. 4 H-X) is bright green in colour with a faint odour and a slight bitter taste. Elements present are fragments of epidermal cells showing anomocytic stomata and hairs, both glandular and non-glandular hairs with brown pigments, lignified sclerenchyma cells, pericyclic fibers, fragments of parenchyma of pith, lignified annular xylem vessels, fragments of wood parenchyma, tracheids, wood fibers, starch granules simple or muller-shaped, scattered CaOX clusters, and protein crystals either simple or compound.

The leaf (Fig. 5)

The lamina. A transverse section in the leaf blade (Fig. 5 A, B&E) is planoconvex in outline with a slightly raised rounded ridge, consisting of two epidermises enclosing a parenchymatous spongy tissue in between. The upper epidermal cells are polygonal, isodiametric to slightly elongated with sinuous anticlinal walls covered with a thin and faint striated cuticle, having anomocytic stomata and both glandular and non-glandular hairs. The non-glandular hairs are either simple, unicellular with blunt apices and covered with a warty cuticle, or multicellular uniseriate of 2-3 cells, with a short basal cell and a long terminal one that is covered with a smooth cuticle. The glandular hairs are either formed of a short unicellular stalk and a disc-shaped head consisting of about 6 – 8 radiating cells covered with a smooth cuticle, or of the peltate type having a unicellular stalk and a large multicellular head of about (30 – 35 – 40) radiating cells. The lower epidermal cells are similar to the upper ones but are smaller in size, with more sinuous anticlinal walls, fewer hairs and covered with thin and smooth cuticle. The neural epidermis in the midrib region consists of polygonal, isodiametric to slightly elongated cells with straight anticlinal walls, bearing hairs of both types, having rare stomata and covered with a smooth cuticle. Different types of calcium oxalate crystals are present as clusters, rosettes and few prisms, together with few protein crystals and starch granules in the epidermis. The mesophyll is formed of about 6-8 layers of thin-walled, rounded chlorenchymatous cells containing abundant clusters and prisms of CaOX, protein crystals and starch granules. The mesophyll is traversed by separated strands of small vascular bundles with relatively larger ones in the lateral veins, composed mainly of xylem vessels which form together with the CaOX clusters the characteristic crystal layer appearance. The cortical tissue of the midrib shows upper and lower subepidermal collenchymatous masses, where the upper one is formed of 2 – 3 layers, while the lower one is formed of one layer. They are followed by thin-walled rounded parenchyma cells containing CaOX crystals, protein crystals and starch granules. The endodermis is indistinguishable. The vascular tissue is represented by the main collateral vascular bundle of the midrib which is crescent to oval in shape formed of upper xylem, lower phloem and surrounded with parenchymatous pericycle forming arms extending through phloem, and dividing it into compartments. The phloem consists of thin-walled parenchymatous cells. The

xylem is formed of lignified spiral and reticulate vessels, tracheids, fibers and wood parenchyma. The wood fibers appear spindle-shaped.

The petiole (Fig5 C, D&F) A transverse section in the petiole is planoconvex in outline, showing two small wings on both sides. It shows two similar epidermises formed of polygonal, isodiametric with nearly straight, thin, suberized walls, covered with thin and striated cuticles and having few anomocytic stomata. Many non-glandular and few glandular hairs are observed, together with scattered CaOX clusters and prisms. The cortex is formed of an outer collenchymatous layer and an inner parenchymatous one. The collenchyma layer line the whole petiole from inside, occupying the wings, and interrupted just below the upper epidermis with a few islets of lignified sclerenchyma cells. The parenchyma has suberized, thin-walled cells containing CaOX crystals and starch granules. The endodermis is well differentiated containing starch granules. The vascular tissue is nearly similar to that of the leaf, with the exception of presence of pericyclic fibers (sometimes are tortuous) in the pericycle. The pith consists of thin-walled parenchymatous cells.

Table 1: Microscopical measurements of different organs of *Russelia equisetiformis* Sch. & Cham.

Item	L	W	H	D
Moderate root				
Cork cells	30-47-65	10-23-37	11-13-15	
Parenchyma of cortex				20-38-45
Pericyclic fibers				13-20-24
Stone cells	45-60-100	10-18-25		
Tracheids	100-112-125	10-14-25		
Xylem vessels				13-19-25
Wood fibers	250-290-360	10-15-25		
Wood parenchyma	30-55-65	18-22-30		19-20-22
Medullary rays	95-105-140	15-23-40		
Starch				3-5-8
Old stem				
Epidermal cells	15-17-20	10-15-21	15-17-20	
Non glandular hairs	70-91-120	18-25-40		
Glandular hairs				
Head			25-30-35	60-70-75
stalk	18-20-25	15-22-25		
Collenchyma				10-15-18
Stone cells	120-160-180	15-25-37		
Parenchyma of cortex				20-36-50
Pericyclic fibers	700-800	18-23-25		
Tracheids	68-70-85	4-7-8		
Xylem vessels				20-30-35
Wood fibers	270-290-450	10-12-15		
Wood parenchyma	60-65-72	30-35-40		
Clusters of CaOX				8-9-11
Prisms of Caox				7-9-10
Protein crystals	8-10-11	1-2-3		
Starch	7-10-20	5-12-17		
Parenchyma of pith				50-81-95
Leaf				
Upper epidermis	18-43-50	20-26-30	22-24-25	
Lower epidermis	20-36-50	12-17-20	13-15-17	
Neural epidermis	45-48-55	23-26-27	17-19-20	
Glandular hairs				
-head			22-25-26	35-46-60
-stalk	15-19-20	12-16-18		
Peltate hairs				90-107-140
Non glandular hairs	35-67-120	15-19-25		
Stomata	20-23-30	15-17-23		
Collenchyma				10-15-19
Spongy parenchyma(of lamina)				20-23-24
Xylem vessels		12-14-18		

Table 1: Microscopical measurements of different organs of *Russelia equisetiformis* Sch. & Cham.

Item	L	W	H	D
Wood fibers	290-550-600	10-29-30		
Wood parenchyma	200-220-230	20-25-27		
Clusters of CaOX				8-10-12
Prisms of CaOX				7-10-11
Protein crystals	10-11-13	2-3-5		
Starch				4-5-7
Petiole				
Epidermal cells	23-32-40	14-15-18	14-18-20	
Glandular hairs				
head				25-28-35
Non-glandular hairs	25-28-35	8-10-12		
Stomata	20-23-25	15-18-22		
Collenchyma				16-18-19
Stone cells	45-100-125	25-28-30		11-12-16
Parenchyma				25-28-30
Pericyclic fibers		10-15-22		
Xylem vessels				10-12-13
Wood fibers	290-550-600	10-29-30		
Clusters of CaOX				8-10-12
Prisms of CaOX				7-10-11
Protein crystals	10-11-13	2-3-5		
Starch				4-5-7
Flower				
calyx				
Inner (lower) epidermis	50-55-60	20-24-30	9-10-12	
Inner (upper) epidermis	23-25-30	17-20-25	10-13-15	
Outer (lower) epidermis	25-47-50	17-20-25	15-17-18	
Outer (upper) epidermis	25-28-30	18-19-22	10-12-13	
Glandular hairs				
head				20-22-25
stalk	10-20-28	11-12-13		
Collenchyma				8-9-11
Parenchyma				24-30-32
Stomata	18-19-20			16-17-18
Xylem vessels				10-12-14
Tracheids	70-75-85			9-10-12
Wood parenchyma	35-60-75			15-18-20
Corolla				
Inner (lower) epidermis	70-80-90	20-23-25	14-16-18	
Inner (middle) epidermis	50-60-75	25-35-40	14-16-17	
Inner (upper) epidermis	40-45-50	30-35-37	14-16-17	
Outer (lower) epidermis	50-70-80	18-20-21	17-18-22	
Outer (middle) epidermis	45-50-65	20-25-28	14-16-17	
Outer (upper) epidermis	55-60-70	20-25-30	13-15-16	
Glandular hairs				
head				25-30-40
stalk	50-70-120	15-20-28		
parenchyma				40-60-75
Xylem vessels		10-11-12		
Tracheids	48-50-55	8-10-11		
Pericyclic fibers		18-20-23		
Androecium				
Epidermis of filament	50-60-68	25-30-40	25-27-28	
Epidermis of anther	65-70-95	18-20-25	20-22-23	
Fibrous layer of anther	50-55-70	42-48-55	50-60-75	

Table 1: Microscopical measurements of different organs of *Russelia equisetiformis* Sch. & Cham.

Item	L	W	H	D
Xylem vessels		6-8-9		
Pericyclic fibers		20-22-24		
Pollen grains				20-24-25
Gynoecium				
Epidermis of ovary	25-50-55	15-18-20		
Epidermis of style			14-16-18	
Epidermis of stigma	80-100-130	22-25-27		
Parenchyma of pith				19-20-22
Xylem vessels		9-10-11		
Tracheids	60-65-70	10-12-14		

Powdered **leaf** (Fig. 5 G-Y) is dark green in colour with a faint characteristic odour and a bitter taste, having fragments of epidermises showing hairs, stomata, CaOX crystals (clusters, rosettes and prisms), crystal layer from lamina of the leaf, glandular and non-glandular hairs, elongated pericyclic fibers, lignified xylem vessels with reticulate and spiral thickening, wood fibers, tracheids and protein crystals.

The flower. A transverse sections of the flower at different levels **(**Fig. 6)

A- The pedicel (Fig 7 A&B) A transverse section in the pedicel appears circular in outline. It shows an epidermis formed of one row of sub-rectangular cells slightly papillosed, covered with a raised, striated cuticle as seen in transverse section, while in surface view they appear polygonal, isodiametric, with thin cellulosic, straight walls covered with heavily striated cuticle without stomata or hairs but with numerous starch granules. The cortex is formed of an outer collenchymatic zone containing chloroplasts and few sclerenchymatous cells, and an inner parenchymatic one with relatively wide intercellular spaces containing many chloroplasts, and both layers contain numerous starch granules and many CaOX crystals. The vascular tissue exists as a narrow continuous ring. The pericycle consists of a very narrow continuous ring of polygonal small parenchyma cells with no pericyclic fibers. The phloem consists of thin-walled parenchymatous cells. The xylem consists of vessels which are mainly annular, wood fibers, tracheids and wood parenchyma. The pith is parenchymatous consisting of large thin-walled rounded cells with wide intercellular spaces, containing numerous starch granules and many crystals of CaOX (prisms, clusters and rosettes).

Powdered pedicle (Fig. 7 C-J)is Purplish green in colour with a faint odour and a slight bitter taste, containing fragments of epidermal cells, sclerenchyma cells, annular lignified xylem vessels, wood fibers, tracheids, wood parenchyma and starch granules.

B-The calyx (Fig. 8 A&B**)** A transverse section in the calyx region shows outer and inner epidermises enclosing a homogenous mesophyll inbetween, traversed by small collateral vascular bundles. The lower part of the outer epidermis consists of polygonal, isodiametric cells with sinuous anticlinal walls and covered with a striated cuticle while the cells of the upper one are similar but are smaller in size with straight anticlinal walls, and both epidermises contain anomocytic stomata. Both lower and upper parts of the inner epidermis are formed of polygonal, isodiametric cells with straight anticlinal walls, covered with a smooth cuticle, but the upper cells are slightly papillosed and both of them contain anomocytic stomata. Both epidermises contain abundant glandular trichomes consisting of a short uni- or bicellular stalk and a rounded unicellular head. The mesophyll consists of thin-walled parenchyma cells, which are chlorenchymatous and become relatively aerenchymatous towards the upper region. The vascular tissue is formed of parenchymatous phloem and xylem which consists of lignified vessels (mainly annular), lignified wood parenchyma and tracheids.

Powdered **calyx** (Fig. 8 C-I) is dark green in colour with a faint odour and a slight bitter taste, containing fragments of lower and upper parts of inner epidermal cells, fragments of lower and upper parts of outer epidermal cells, lignified xylem vessels with annular thickening, elongated tracheids, and lignified wood parenchyma.

C-The corolla (Fig. 9 A&B) A transverse section in the corolla region shows outer and inner epidermises enclosing inbetween a homogenous mesophyll traversed by small vascular bundles. The inner epidermis shows variations in shape and size. Cells of the basal and apical parts are polygonal, elongated, with thin cellulosic, straight anticlinal walls and covered with a striated cuticle, with the middle ones wider and shorter. Those of the apical part are polygonal, isodiametric, papillosed, with thin, cellulosic, sinuous anticlinal walls and covered with a heavily striated cuticle. Glandular trichomes are widely spread having a short or long uni-or multicellular uniseriate stalk and a uni- or multicellular head. The basal and upper cells of the outer epidermis appear elongated with thin cellulosic sinuous anticlinal walls covered with a thin and striated cuticle, the middle cells are similar but less elongated having less sinuous anticlinal walls, and all cells contain starch granules with no stomata or hairs. The mesophyll consists of thin-walled aerenchymatous cells containing numerous starch granules and few protein crystals, and is traversed lenghthwise by several small vascular bundles. Powdered **corolla** (Fig. 9 C-Q) is bright red in colour with a faint odour and a slight bitter taste containing: fragments of inner epidermis of petal (upper, middle and lower parts), fragments of outer epidermis of petal (upper, middle and lower parts), glandular hairs, pericyclic fibers, parenchyma of mesophyll, xylem vessels, tracheids and starch granules.

D- The androecium (Fig10 A) A transverse section in the filament region is circular to oval in outline. The epidermal cells appear polygonal, papillosed with thin cellulosic, nearly straight anticlinal walls and covered with striated cuticle, and containing starch granules. The ground tissue is formed of polygonal to rounded, loose parenchyma cells in the lower region, which becomes more contact towards the top with numerous starch granules and compound protein crystals. A transverse section in the anther region shows 2 anther lobes attached by the parenchymatous connective through which passes a small vascular strand in the center. Each lobe is formed of two pollen sacs containing pollen grains. The anther wall is formed of an epidermis, fibrous layer and the remains of the tapetium layer. The epidermis of the anther wall appears as polygonal cells with cellulosic, straight walls, covered with a striated cuticle and contain starch granules. The hypodermis of the anther wall is formed of 2 layers: outer fibrous layer and inner parenchymatous one. The fibrous layer is formed of a single row of isodiametric, lignified, thick-walled cells with bar-like thickening as appeared in the side view, and appearing as polygonal cells somewhat elongated with beaded anticlinal walls in the top view. The inner

layer is parenchymatous. The pollen grains are triangular or spherical, yellowish in colour and show a fine warty exine, having three germ pores and furrows.

Powdered **androecium** (Fig. 10 B-K) is yellowish brown in colour with a faint odour and a slight bitter taste, containing fragments of epidermis of filament, epidermis of anther, fibrous layer of anther, xylem vessels (spiral and annular), pericyclic fibers, pollen grains, protein crystals.

E- The gynoecium (Fig.11 A-C)A transverse section in the ovary is circular in outline. The epidermis consist of polygonal cells, with thin cellulosic, straight walls, covered with striated cuticle, containing numerous starch granules and hexagonal CaOX crystals. The ovary encloses a parenchymatous mesophyll with relatively wide intercellular spaces traversed by several small vascular strands, and contains starch granules. A transverse section in the style shows polygonal, isodiametric to slightly elongated cells with straight, thin cellulosic anticlinal walls covered with a smooth cuticle. The stigmatic surface shows papillosed epidermis.

Powdered **gynoecium** (Fig.D-K) is reddish yellow in colour with faint odour and a slight bitter taste containing fragment of epidermis of ovary, style and papillosed stigma, parenchyma of ground tissue, tracheids, annular xylem vessels and hexagonal CaOx crystals.

CONCLUSION

It is concluded that the above pharmacognostic parameters are very useful for the identification of *Russelia equisetiformis* in both entire and powdered form, and its differentiation from other species. These results are also helpful to ascertain the identity, determine the quality and purity together with preparation of a monograph of the plant species in future studies.

REFERENCES

1. M. C. Carlson.Monograph of the Genus Russelia.2nd vol. 4th ed. Chicago Natural History Museum, Fieldiana botany; 1957;P. 244.
2. E. F. Gilman.Russeliaequisetiformis. Environmental Horticultural Department, Cooperative Extension Service,.Fact Sheet FPS-516, Institute of Food and Agricultural sciences, University of Florida; 1999.
3. R. G. Olmstead, C. W. Depamphilis, et al.Disintegration of the Scrophulariaceae. American Journal of Botany2001; **88**(2): 348-361.
4. J. Ryan.Perennial Gardens for Texas.1sted. Austin, China: Texas university press.;1998; P. 180.
5. O. T. Kolawole and S. O. Kolawole. Effects of *Russeliaequisetiformis* Methanol and Aqueous Extracts on Hepatic Function Indices. Biology and Medicine2010; **2**(3): 38-41.
6. E. O. Awe, O. S. Banjoko, et al. Free Radical Scavenging: a Possible Mechanism of Action for the Anti-inflammatory Activity of *Russeliaequisetiformis* Sch. & Cham., Scrophulariacae. Inflammopharmacology 2010;**18**(4): 179-185.
7. H. Gomez-Estrada, F. Diaz-Castillo, et al. Folk Medicine in the Northern Coast of Colombia: An Overview. J Ethnobiol Ethnomed 2011;**7**:7-27.
8. A. Andrade-Cetto and M. Heinrich. Mexican Plants with Hypoglycaemic Effect used in the Treatment of Diabetes. Journal of Ethnopharmacology 2005;**99**(3): 325-348.
9. O. R. Cerecero, H. R. Morales, et al. Use of Medicinal Plants Among Patients with Diabetes mellitus Type 2 in Morelos, Mexico. Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas2009;**8**(5): 380-388.
10. E. O. Awe, J. M. Makinde, et al. Evaluation of the Anti-inflammatory and Analgesic Properties of the Extract of *Russelia equisetiformis* (Schlecht& Cham) Scrophulariaceae.Inflammopharmacology2004;**12**(4): 399–405.
11. E. O. Awe, A. Adeloye, et al. Antinociceptive Effect of *Russelia equisetiformis* Leave Extracts: Identification of Its Active Constituents. Phytomedicine 2008; **15**(4): 301-305.
12. M. Riaz, N. Rasool, et al. Antioxidant, Antimicrobial and Cytotoxicity Studies of *Russelia equisetiformis*. African Journal of Microbiology Research 2012; **6**(27): 5700-5707.
13. O. T. Kolawole, J. M. Makinde, et al.Central Nervous System Depressant Activity of *Russelia equisetiformis*. Niger J Physiol Sci. 2007; **22**(1-2): 59-63.
14. E. O. Awe and J. M. Makinde. The Hair Growth Promoting Effect of *Russelia equisetiformis* (Schclect & Cham). Journal of Natural Products 2009; 2: P. 70-73.
15. E. O. Awe, J.M. Makinde, et al. Membrane Stabilizing Activity: A possible Mechanism of Action for the Anti-inflammatory and Analgesic Properties of *Russeliaequisetiformis*. International Journal of Pharmacology 2006;**2**(4): 447-450.

16. A. I. Vogel.Textbook of Practical Organic Chemistry.3rd ed. London Longman's Green and co. Ltd.; 1966; 133-136.
17. D. F. Cutler, T. Botha, et al. Plant Anatomy: An Applied Approach. UK, Blackwell Publishing Ltd.; 2007; P. 187.
18. Wallis TE. Text Book of Pharmacognosy. 15th ed. London,T.A.churchill; 1985; 575-582.
19. Evans WC. Trease& Evans Pharmacognosy, 15th ed.London, Baillere Tindall; 1983; 538-547.
20. Easu K. Plant Anatomy. New York, John Wiley and Sons;1964; p. 767.
21. Khandelwal KR. Preliminary Phytochemical Screening in Practical Pharmacognosy. Pune, Niralli Parkashan; 2004; 149-56.