P A R T - I

Pharmacognosy, pharmacology and phyto-chemistry

of some

saponin containing plants

C H A P T E R - III

A. General

Some fifteen species of Polygala are available in India, the roots of which can be used as a suitable substitute for Polygala senega roots, known in commerce as senega roots. Watt (1889), Dymock, Warden and Hooper (1890) and Kirtikar and Basu (1933) reported that P. crotalarioides Ham., Willd., P. Chinensis Linn. and P. elongata Klein. could be employed as a suitable substitute for the official senega.

Shortage of senega during the war necessitated search for a substitute in India. The principal indigenous species of Polygala containing saponin-like substance were investigated for commercial utilisation by different workers. The different species of Polygala supplying senega in various parts of the world do not occur in India. As a result of a thorough survey and some experimental work, Polygala angulata DC., P. alba. Watt. and P. boykini Nutt. were utilised for this purpose (Qazilbash, 1949).

Chopra (1933), suggested that Polygala chinensis Linn. and P. crotalarioides Ham. which are plentiful in various parts of the temperate Himalayas, the Nilgiris and the Tipperah hills, could be used as substitute for the B.P. and B.P.C. drugs.

Senega substitutes

Bal and Dutta (1941) made a comparative study in histology and pharmacognosy of the possible substitutes of P. senega. They came to the conclusion that P.chinensis can be used for P.senega as it resembles the latter, both macroscopically and microscopically and is easily available in several parts of India. The other species according to them differ widely in their external as well as internal structures, hence cannot replace senega roots of commerce.

Further, Hosseine, Guha and Mukherji (1943), established that Polygala chinensis like senega contains two types of saponins, polygalic acid (4.5%) and senegin (2.1%). Thus, similarity in macroscopical and microscopical structures (Bal and Dutta, 1941) and chemical constituents (Hosseine, Guha and Mukherji, 1943), proved P.chinensis Linn. as a good substitute for senega. Accordingly, it was included in the first I.P.L. (1946), I.P.C. (1953) and made official in the first Indian Pharmacopea (1955) under the monograph 'chinensis root' or 'Indian senega'.

Gupta and Bal (1952) described Indian senegas. Their botanical source is quite difficult to ascertain, as the collectors maintain strict privacy about botanical source and origin. The varieties sold in the market have been named according to their geographical source as foreign senega (Polygala senega) Delhi senega, Kulu senega, Tuticorin yellow and Tuticorin brown-green.

Senega substitutes

Wallis (1955) mentions three Indian substitutes of senega; roots of Andrachne aspera, roots of Polygala chinensis (Indian senega) and the roots of Mollugo oppositifolia which contain saponin-like substance.

Several authors have described Polygala chinensis as an annual herb (Hooker, 1885; Kirtikar and Basu, 1918; Dutta and Mukherji, 1950). However, Dutta and Mukherji (1950) mention that 'chinensis' should be collected from 3-4 year old plants. 'Chinensis' monograph in the I.P.L. (1946) and I.P. (1955) relates that it should be collected in the autumn from 3-4 year old plants. Qazilbash (1949) describes P.Chinensis as a small herb with thin roots. Roots of P.chinensis available in market show 3-5 growth rings and show distinct secondary growth. They are not thin.

The confusion about correct identity of 'chinensis' roots was cleared by Shah, Vyas and Aghara (1957). They considered chinensis I.P. to be a perennial herb and most probably Andrachne aspera (Euphorbiaceae). According to them, it is not a suitable representative of Polygala senega as it gives a very low froth number and also, a low haemolytic index.

Shah and Khanna (1959) proved that Andrachne aspera is the source of Indian, Pakistan and Delhi

senegas and that it cannot be compared with the true senega obtained from Polygala senega.

Wallis (1955) mention that the roots of Mollugo oppositifolia (Ficoideae) contain a saponin-like substance. Ridgeway and Rowson (1956) as well as Shah and Aghara (1957) have also shown presence of saponin in the roots of M. oppositifolia.

Roots of several species of Primulaceae are also used as a substitute of senega. Roots of Primula elatior and P. viris (officinale) are official in German Pharmacopoeia supplement (Ingo Mazurek, 1951). Kofler (1932) has determined that the roots and rhizomes of both the species are used medicinally and they contain different saponins. He with his co-workers obtained crystalline primulic acid from P. viris but could not obtain it in crystalline form from P. elatior. Margot and Reichstein (1942) succeeded in isolating saponin in crystalline form both the Primula species.

Species of Sapindus (Sapindaceae) are reported to contain saponin. Chopra, Nayer and Chopra (1956) reported presence of saponin in Sapindus mukorossi, S. utilis and S. trifolia.

As previously stated, many species belonging to Liliaceae also contain saponin. Peach and Tracy (1955)

mention that a number of workers has successfully isolated saponin from species belonging to Agave, Yucca, Smilax, Scilla, Trillium, Dracaena, Gloriosa and Lilium.

At present, there is no reliable source for senega in India. The following plants are studied from pharmacognostic point of view to find out a suitable substitute of senega.

(1)	Glinus lotoides Linn.	Ficoideae
(2)	Glinus oppositifolius L.	Ficoideae
(3)	Mollugo nuducaulis Lamk.	Ficoideae
(4)	Mollugo cerviana (L.) Ser.	Ficoideae
(5)	Gisekia pharnaceoides L.	Ficoideae
(6)	Primula denticulata Smith	Primulaceae
(7)	Anagallis arvensis L.	Primulaceae
(8)	Dodonaea viscosa Linn.	Sapindaceae
(9)	Smilax china L.	Liliaceae

All but the last two of the above plants fall under Ficoideae and Primulaceae, which are phyllogenetically related with one another (Bessey, 1915; Hutchinson 1959). These families therefore may give more or less identical results in the phytochemical investigations.

1 - Glinus lotoides Linn.

In different parts of India, the entire plant or the leaf of Glinus lotoides linn. (syn: Mollugo hirta Thumb.) is used as a diuretic, purgative or as an antiseptic. Decoction of the leaves is employed in dropsy. Entire plant or its ash mixed with oil is often applied to boils and ulcers (Thakar, 1952). The dried plant in powder form is employed as a remedy for diarrhoea in Sind. The plant is also used as a purgative for abdominal diseases in the Punjab (Kirtikar and Basu, 1933). In Las Bela, it is prescribed for the cure of boils and bilious attacks while in Pudukotta, the juice is administered internally to weak children (Kirtikar and Basu, 1933). Nadkarni (1954) has referred to its application in itches and skin diseases.

Distribution and description of the plant (Plate II, 1) :

The plant is distributed throghout India. Naturally, it grows wild in Gujarat and Saurashtra where it is commonly observed in November and December. It is usually found in waste places such as roadsides, pits on river banks and surroundings of ponds.

The plant is an annual herb, thickly covered with stellate hair which import it a white tinge. Numerous branches spread from the centre and lie in prostrate or

Glinus lotoides Linn.

rarely ascending manner. Leaves are usually opposite or whorled at a node and pubescent. Flowers are pinkish or white in axillary fascicles of 1 - 6.

M O R P H O L O G Y

Leaf :

The basal leaves are narrow and long petioled while those at the apex are broad and short petioled. The leaf measures 1-2 cm. by 0.8 - 1.3 cm. and is densely villous on both the sides due to stellate hair. A leaf is broadly obovate or suborbicular, obtuse and cuneate at the base with entire margin. The petiole is slender, stellately hairy and measures about 6-10 mm. in length. The lamina is fairly thick.

Stem :

13-15 stems arise from the top of the root to form a crown. They are 15-45 cm. in legnth, directed at right angles to the top and show distinct nodes and internodes. The latter are about 1-3 cm. in length, cylindrical, green and covered with stellate hair. Nodes are swollen. Fracture is smooth and green.

Glinus lotoides Linn.

Root :

The root is woody, straight, mostly unbranched and tapering growing vertically in the soil. It bears a crown at the top (Plate II, 2). A few branch towards the upper end. The root is about 6-16 cm. in length and approximately 3-9 mm. in width, just below the crown. Its outer surface is pale yellow in colour and is marked with irregular longitudinal wrinkles. It also shows faint spiral striations just below the crown. The surface bears a few scattered pits in which the scars of the detached rootlets are seen as faint protrusions. The crown area bears about 10-15 remains of the stem bases. Fracture of the stem-base appears greenish while the root breaks with a short and uneven fracture. The smoothened transverse surface shows alternate concentric rings of vascular tissues forming an anomalous structure. The central cylinder is solid. The xylem vessels are seen as distinct pores. The number of vascular rings varies from 2-6 according to the thickness of the root (Plate II, 8,9 & 10). It is slightly acrid in taste and nonodourous.

H I S T O L O G Y

Leaf :

The dorsiventral lamina has palisade beneath

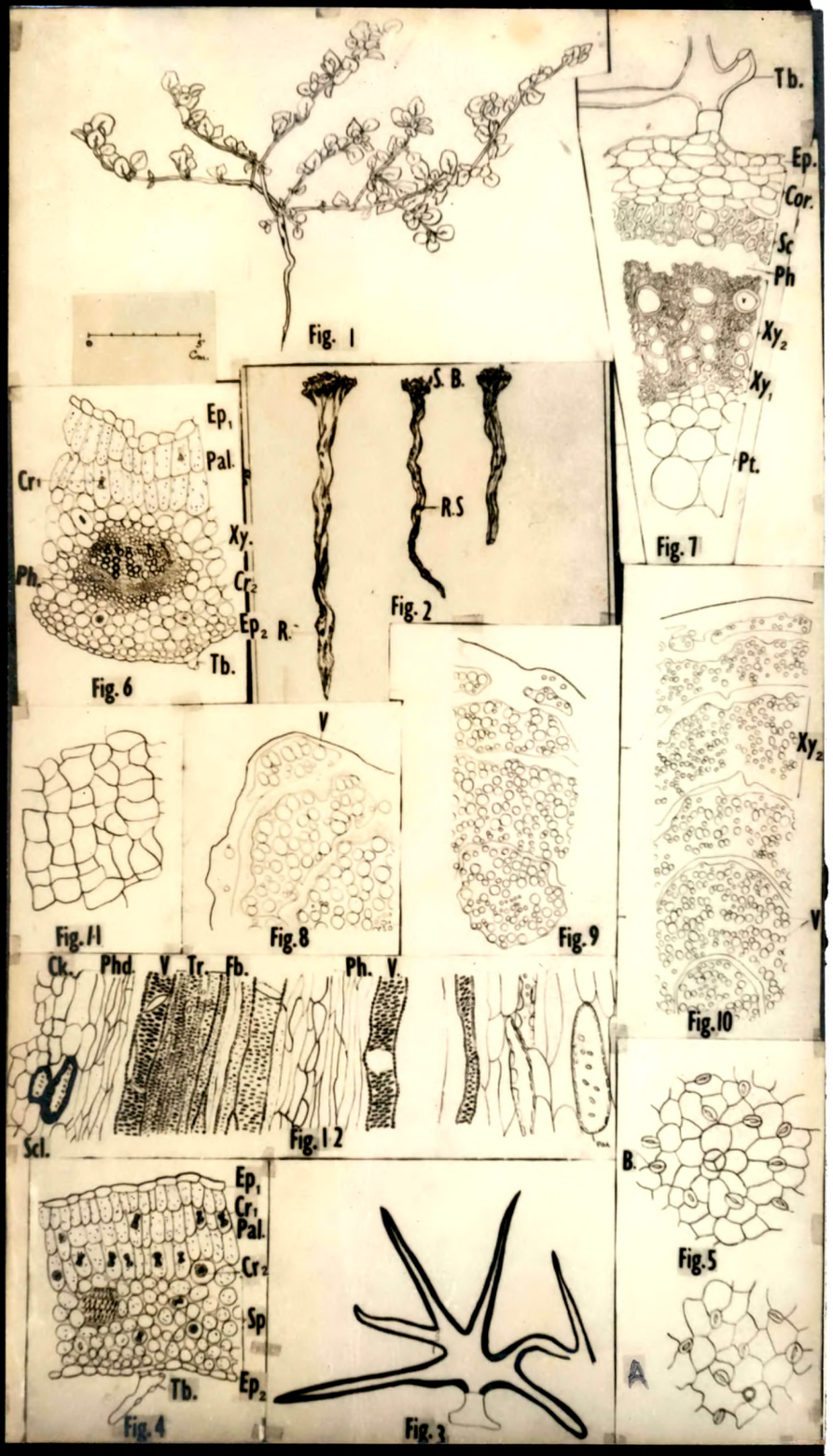
Fig. 1
Tb.
Ep.
Cor.
Sc
Ph
Xy2
Xy1
Pt.
Fig. 7
S. B.
R.S
Fig. 2
Ep1
Pal.
Cr1
Xy.
Cr2
Ep2
R.
Ph.
Tb.
Fig. 6
V
Fig. 11
Fig. 8
Fig. 9
Xy2
V
Fig. 10
Ck.
Phd.
V
Tr.
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V.
Scl.
Fig. 12
B.
Fig. 5
Ep1
Cr1
Pal.
Cr2
Sp
Ep2
Tb.
Fig. 4
Fig. 3
A

P L A T E - II

(Figs. 1 - 12 : *Glinus lotoides* Linn.)

Fig. 1. Entire plant of *Glinus lotoides* Linn. x 1

Fig. 2. Entire roots. x 1.

Fig. 3. A stellate hair. x 320.

Fig. 4. T.s. lamina. x 300

Fig. 5. A - Upper epidermis with stomata. x 320

B - Lower epidermis with stomata. x 320

Fig. 6. T.s. lamina passing through midrib. x 300.

Fig. 7. T.s. young stem. x 300.

Fig. 8. T.s. root from near the apex (diagrammatic). x 60

Fig. 9. T.s. root, middle region (diagrammatic). x 60

Fig.10. T.s. root, near the crown (diagrammatic). x 60

Fig.11. Cork of root in surface view. x 350.

Fig.12. L.s. root, near the crown. x 350

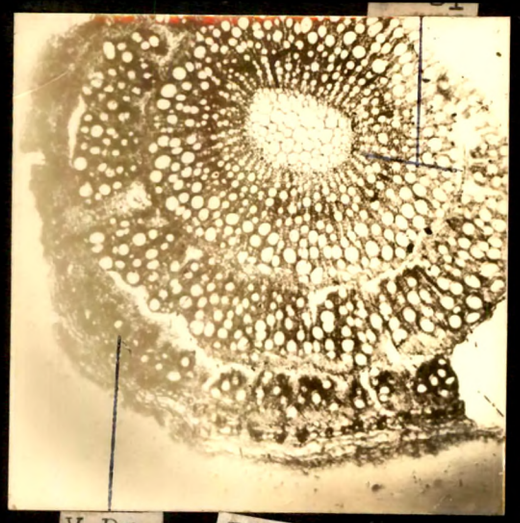
Ck - cork; Cor. - cortex; Cr_1 - boe-shaped crystal;
Cr_2 - rosette ctystal; Ep. - epidermis; Ep_1 - upper epidermis;
Ep_2 - lower epidermis; Fb. - fibre; Pal. - palisade;
Ph. - phloem; Phd - phelloderm; Pt. - pith; R. - root;
R.S. - root scar; Sc. - sclerenchyma; Scl. - sclereid;
Sp. - spongy; S.B. - stem base; Tb. - broken trichome;
Tr. - tracheid; V - vessel; Xy. - xylem; Xy_1 - primary xylem;
Xy_2 - secondary xylem.

the upper epidermis only. The epidermis consists of tabular cells having straight anticlinal walls. Some of the cells bear unicellular stellate trichomes (Plate II, 3). Stomata are more abundant on the lower epidermis than on the upper one, and belong to the ranunculaceous and the cruciferous types(Plate II, 5A & 5B). Palisade consists of three layers of elongated columnar cells (Plate II, 4). Spongy tissue consists of 3-4 layers of rounded or oval cells. The cells of the mesophyll tissue contain calcium oxalate crystals of various shapes - cubical, prismatic, boe-shaped, sphaeraphides and rosettes. Besides, obliquely and longitudinally cut veinlets are also present in the mesophyll.

The midrib slightly projects on the abaxial side and has a shallow groove on the adaxial side (Plate II, 6). The cross-section shows two continuous layers of palisade over the vascular bundle. The vascular bundle consists of radiating xylem and phloem. The cortical tissue of the midrib is parenchymatous. The cells of the palisade and cortical parenchyma also contain calcium oxalate crystals of various shapes.

Stem :

Epidermis is covered by cuticle and at places bears unicellular stellate trichomes (Plate II, 3 & 7).



V.Rg$_3$ Fig.1

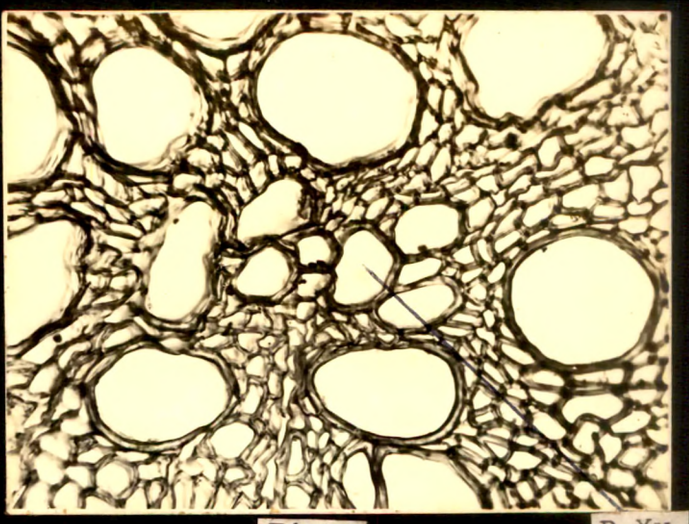
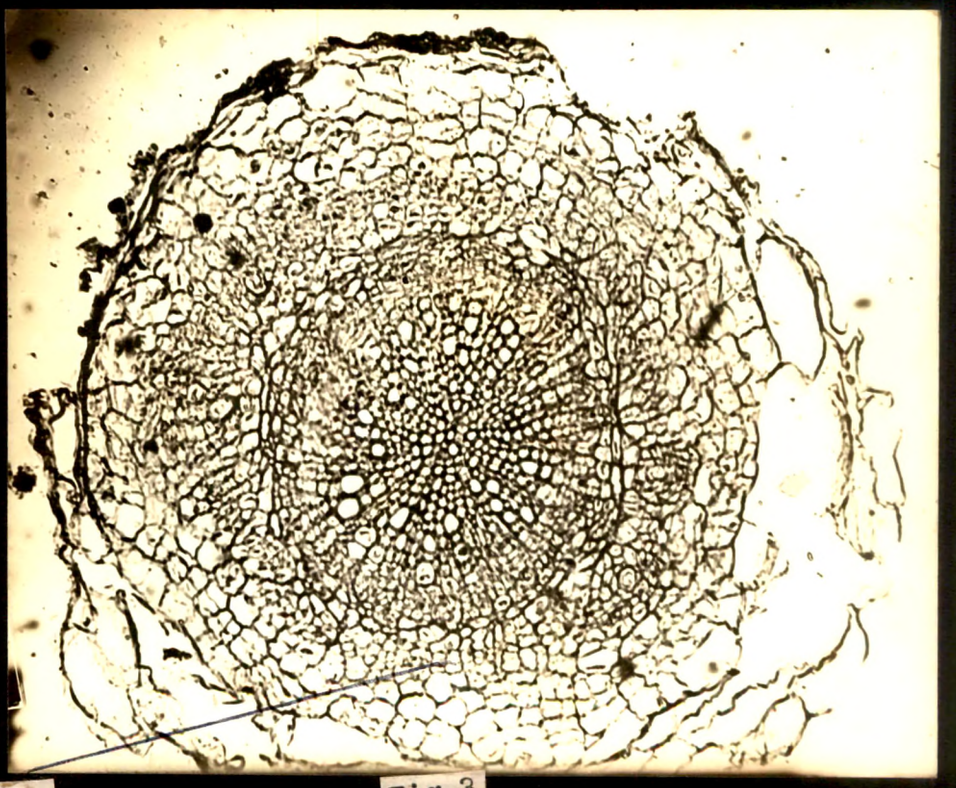
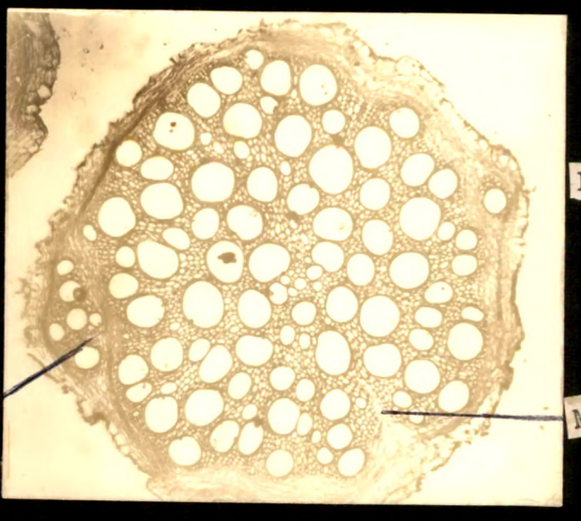


Fig.2 P.Xy.



Cb$_2$ Fig.3



V.Rg$_2$ Fig.4 M.R.

P L A T E - III

(Figs. 1 - 4 : Photomicrographs of *Glinus lotoides* Linn.)

Fig. 1. T.s. stem at its base showing three anomalous rings. x 32.

Fig. 2. T.s. root showing the central portion exhibiting diarch xylem. x 380

Fig. 3. T.s. young root showing the formation of second cambium ring. x 110.

Fig. 4. T.s. secondary root showing second anomalous ring under formation. x 54.

x-x-x-x-x-x

Cb_2 - cambium No. 2; M.R. - Secondary medullary ray; P.Xy. - primary xylem; $V.Rg_1$, $V.Rg_2$ & $V.Rg_3$ - anomalous vascular ring number one, two and three respectively.

Glinus lotoides Linn.

Cortex consists of 3-5 layers of chlorenchymatous thin walled cells. Stem base develops 2-3 layers of thin-walled lignified cork cells. The pericyclic region is sclerenchymatous. Here, the lignified cells are oriented in a ring (Plate II, 7; Plate III, 1) In old stem, isolated sclereids are present in the pericycle and in the cortex. The stem shows 2-3 anomalous rings of vascular tissues at the base (Plate III, 1). Secondary phloem given out by successive cambium rings, consists of a few layers of parenchyma followed by phloem proper. Xylem development is normal. Activity of the first cambium ring is of a short duration. Later on, a second cambium ring arises from the outer phloem parenchyma. Secondary medullary rays establish interconnections with the successive anomalous vascular rings.

Root (old) :

In old roots, only two or three layers of radially arranged cork cells are visible as the outermost layers are peeled off (Plate II, 12). They are deposited with lignin and suberin. Phelloderm consists of 8-13 layers of compact parenchymatous cells arranged more or less in radial rows. In its outermost region sometimes a few sclereids are present (Plate II, 12). The outermost anomalous vascular tissue is in the form of an incomplete or a complete ring below the secondary cortex (Plate II, 10; Plate VI, 10). There are about six complete and concentric rings of anomalous

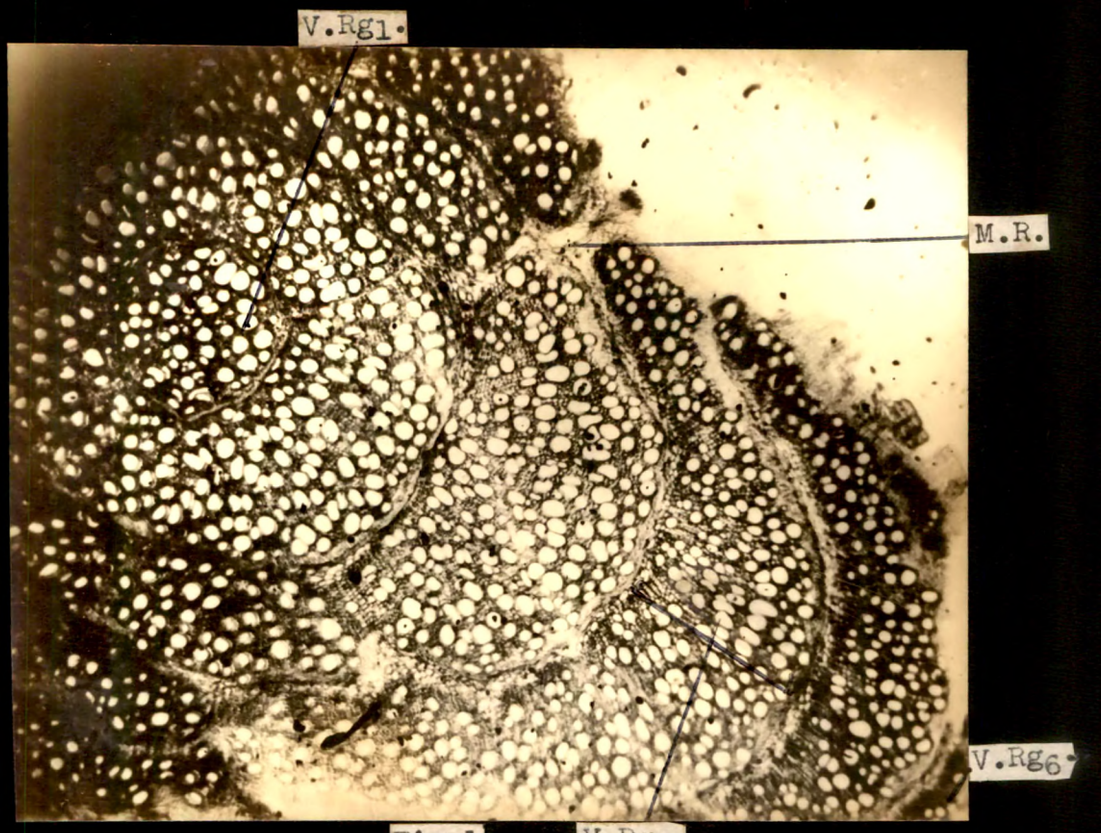


Fig.1

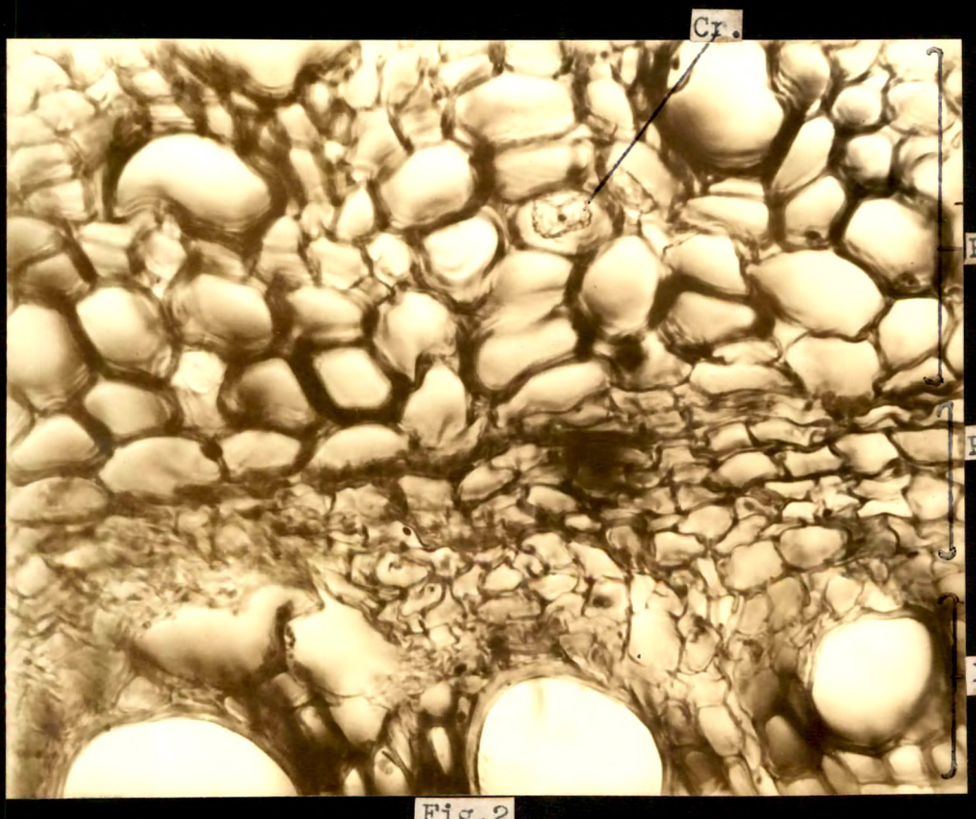


Fig.2

P L A T E - IV

(Figs. 1 & 2 : Photomicrographs of *Glinus lotoides* Linn.)

Fig. 1. T.s. of root taken from crown portion showing six rings of anomalous secondary growth. x 50.

Fig. 2. T.s. root showing the middle portion of an anomalous vascular ring. A portion of secondary xylem, secondary phloem and secondary parenchyma with calcium oxalate crystal is seen. x 380.

x-x-x-x-x-x

Cr. - crystal; Par. - parenchyma; Ph.- phloem; M.R. - secondary medullary ray; $V.Rg_1$, $V.Rg_4$ & $V.Rg_6$ - anomalous vascular ring No. one, four and six respectively; Xy. - xylem.

Glinus lotoides Linn.

vascular tissue.

Each vascular ring shows a small phloem zone always outside the xylem. Phloem consists of sieve tubes, companion cells and phloem parenchyma. Xylem consists of vessels, tracheids, xylem parenchyma and a few fibres (Plate II, 12). Vessels occur singly or in groups of 2-3. A vessel shows bordered pits and pointed ends in macerated material. Tracheids are scattered or aggregated in groups and show bordered pits (Plate II, 12). Fibres are relatively few, lignified and show a few pits. The successive vascular rings are interconnected by secondary medullary rays (Plate IV,1).

Outside each zone of anomalous vascular tissue, there is a mass of parenchymatous tissue (Plate IV, 1 & 2). Cells of this tissue show presence of saponin (Johansen, 1940) besides calcium oxalate crystals (Plate IV, 2) and starch. Calcium oxalate crystals may be cubical, rectangular or rosette. Starch grains are of both simple and compound types . Simple grains measure 4.7 μ - 11.4 μ in diameter. Some cells show large oval pits (Plate II, 12). The parenchymatous bands alternate with zones of vascular tissues. The successive vascular zones are similar in character excepting the central zone where cells of primary xylem show diarch condition (Plate III, 2)

Glinus lotoides Linn

T A B L E - 1

Measurements of Root elements

Elements	Length	Width
Vessel	95-147-218-320-375 μ	19-30-46-75-79 μ
Tracheid	130-153-242-330-420 μ	9-11-15-20-22 μ
Fibre	131-182-261-334-375 μ	7-10-16-22-28 μ
Sclereid	49-79-125-173-199 μ	19-36-67-114-131 μ

Root (young) :

In young root, about 6-7 layers of radially arranged cork cells are present. They are both lignified and suberised. Sclereids are absent.

Anomaly in the root :

Cambium in young root arises normally as a wavy ring and gives rise to secondary vascular tissues. The activity of the first formed cambium is of a short duration. Soon, arcs of new cambium develop externally in the Phelloderm (Plate III, 3). These arcs at first give out collateral patches of vascular tissues (Plate VI, 10) but later on, an almost complete cambium ring

is formed as the intervening cells between the collateral patches show meristematic activity. The cambium ring on its outer side initially differentiates into a few layers of parenchyma before giving rise to secondary phloem (Plate IV, 2). The parenchyma serves as a storage tissue.

A few more arcs of cambium arise and behave as the first ones. Thus, the crown portion of the old root shows about 5-6 concentric rings of vascular tissues accompanied with parenchyma zones (Plate IV, 1).

Secondary roots are mostly filiform. A few slightly thick ones show presence of 1-3 anomalous rings (Plate III, 4). The central xylem core is surrounded either by a single ring of cambium, phloem and parenchyma or in a few cases, as many as three concentric rings of anomalous vascular tissue are developed in the same fashion as in the main root. Vessels of secondary roots are numerous, and bigger than those of the main root. The secondary medullary rays are also present (Plate III, 4).

D I S C U S S I O N

As observed here, Subnis (1921-24) reports a dense covering of stellate ~~trichomes~~ hairs over the leaf. A hair possesses a unicellular stalk which bears a unicellular

stellate head. Metcalfe and Chalk (1950) describe presence of either ranunculaceous or rubiaceous stomata in Ficoideae. Here, both types are observed together. Cluster crystals of calcium oxalate in the leaf were also reported by Solereder and cited by Metcalfe and Chalk (1950).

Metcalfe and Chalk (1950) mention three modes of anomalous secondary thickening in the Ficoideae. They are as follows : (a) numerous secondary bundles arranged in more or less complete rings in a concentric manner, (b) more or less a complete ring of xylem alternating with that of phloem (c) a transition between a and b, may also occur. Matcalfe and Chalk (1950) mention that in Glinus the second type of anomalous growth takes place. The same is confirmed here. According to them, cambium develops either in phloem or pericycle. The cambium in the present study of Glinus stem arises in the phloem region.

In case of the root, origin of the first cambium ring is normal. But subsequent cambial rings which vary from 2-6, originate from the phelloderm. They give out initially a few layers of parenchyma prior to the development of secondary phloem cells on the outer side. Metcalfe and Chalk (1950) have not touched this point.

The woody root stores saponin, starch and

calcium oxalate crystals which is also reported here for the first time.

Presence of unicellular stellate trichomes on both the leaves and the stem, palisade layers, large number of chloroplasts and large epidermal cells of the leaf prove xerophytic nature of the plant.

S U M M A R Y

Lamina of the leaf possesses three layers of palisade below the upper epidermis. Cruciferous and ranunculaceous stomata as well as unicellular stellate trichomes are present on both the surfaces. Cells of the mesophyll and the midrib cortex contain calcium oxalate crystals.

Stem epidermis is covered by thick cuticle. It bears unicellular stellate trichomes. Cortex is chlorenchymatous. Pericyclic fibres are arranged in a ring. In the old stem, sclereids appear in the stem cortex. Old stem also shows 2-3 anomalous vascular rings. Combium originates in the phloem region. Starch is present in the stem.

Young root is diarch. Normal cambium ring

Clinus lotoides Linn.

remains active for a short time. Successive cambial rings are produced in phelloderm. Each cambial ring on its outer side gives off a few layers of parenchyma before giving rise to the cells of the secondary phloem; it forms secondary xylem on the inner side. In old root, maximum six complete concentric rings of anomalous tissues are present. Phellogen develops 2-3 layers of cork and 8-13 layers of phelloderm; the latter, at a later stage may develop a few sclereids. Vessels and tracheids show bordered pits while fibres show few simple pits. The outer parenchyma layers developed by each cambium ring contain besides saponin, calcium oxalate crystals and starch. Starch is also present in phelloderm and cells of the medullary rays. Secondary roots show 2-3 complete or incomplete rings of anomalous vascular tissue.

2. Glinus oppositifolius Linn.

Glinus oppositifolius Linn. (syn: Mollugo oppositifolia Linn.) grows in moist places. It grows especially in vicinity of ponds and river banks in Gujarat.

Entire plant has been described by Kirtikar and Basu (1933), as stomachic, aperient and antiseptic. It is also used in skin diseases.

Pharmacognosy of the root of G.oppositifolius has been reported by Ridgway and Rowson (1956) and Shah and Aghara (1957).

Description of the plant :

It is a diffuse, prostrate or ascending herb. 6-8 stems originate from the top of the root and make the latter knotty. Leaves, unequal in size, arise in whorls of 4-5. Flowers are white in axillary fascicles of 2 - ∞. Pedicels are long and filiform. A sepal is oblong and has membranous margins. Stamens are three. Ovary has three very short styles and spreading stigmas. The seeds are numerous, subreniform, dark-brown and covered with raised tubercular points. A small white scale at the hilum extends into a bristle, which runs around the seed.

G. oppositifolius

M O R P H O L O G Y

Leaf :

A leaf is light green, simple, entire, obovate or spathulate, acute at the apex and much tapering to the base. Taste is bitter.

Stem :

Stem and branches reach a height of 25 cm. above soil. They are glabrous and pale green. Internodes, 1-3 cm. long are separated by prominent nodes. Taste is slightly bitter.

H I S T O L O G Y

Leaf :

Leaf is dorsiventral. 2-3 layers of elongated and compact cells of the palisade lie below the upper epidermis. The tabular cells of the epidermis are protected on their outer walls by thin cuticle (Plate VIII, B 11). Dermal cells on both the sides possess ranunculaceous stomata (Plate V, 2A & 2B); those of the lower epidermis have comparatively more wavy walls and possess more stomata. Oval or spherical cells of the

G. oppositifolius

cells of the spongy tissue are arranged in 4-5 layers (Plate VIII, B 11). A few veins and veinlets present, are mostly cut transversely. Cells of the mesophyll contain not only chloroplasts but many of them also possess calcium oxalate rosettes of 14 - 19 μ diameter (Plate VIII, B 11).

Two layers of palisade continue over the midrib (Plate V, 1). The midrib cortex is mostly composed of rounded parenchymatous cells. Some of them also contain calcium oxalate rosettes. Vascular bundle of the midrib is conjoint and collateral. The xylem points towards the adaxial and the phloem towards the abaxial side (Plate V, 1). Xylem is composed of 6-7 radial rows of vessels and intervening xylem parenchyma cells. Cambium is absent. Phloem is composed of the usual elements.

Leaf constants :

Stomatal index for the upper epidermis is 11.4 - 17.7, while the same for the lower epidermis is 15 - 18.3. Palisade ratio is 2.6 - 3.5. The vein islet number comes to 6 - 10.

Stem :

Transection of a young stem of 208 μ diameter shows rectangular cells of the outer epidermis. A thin layer of cuticle and multicellular trichomes afford protection

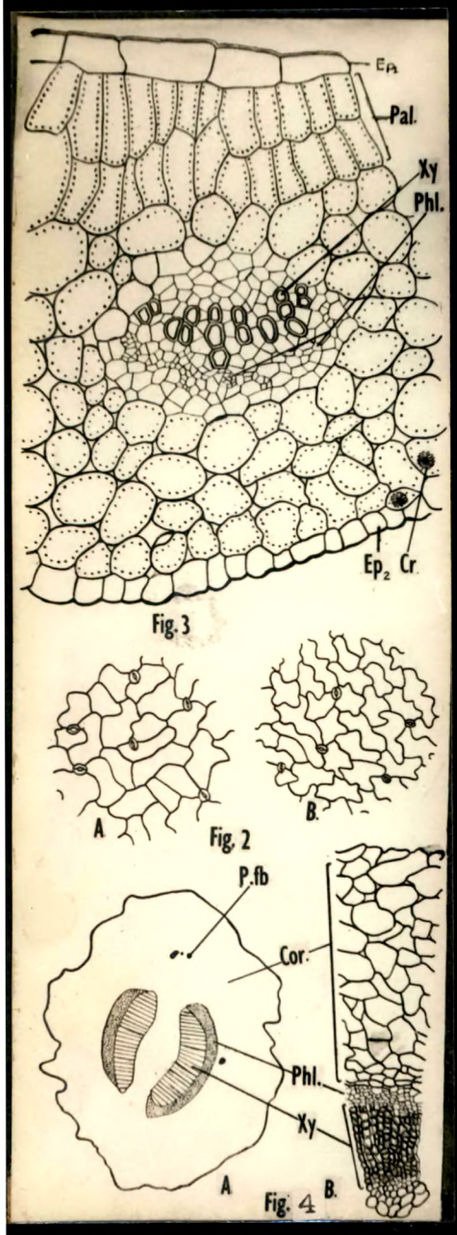


Fig. 3

Fig. 2

Fig. 4

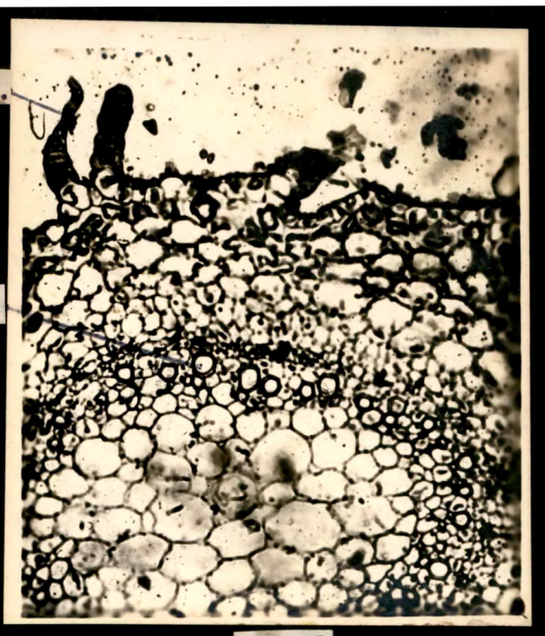


Fig.3

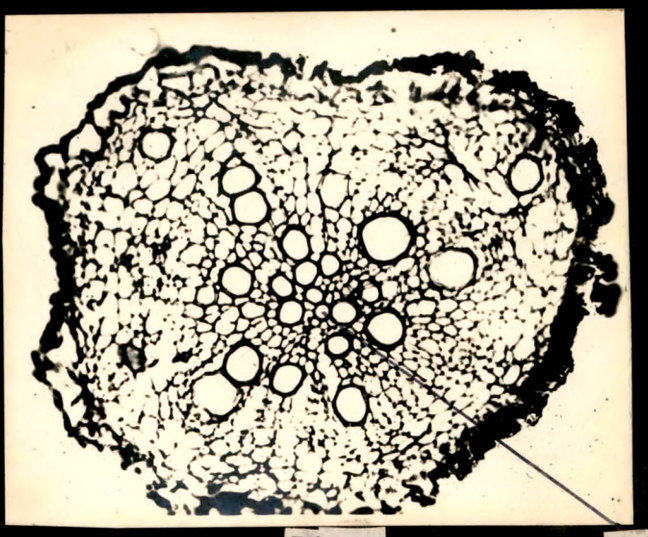


Fig.5

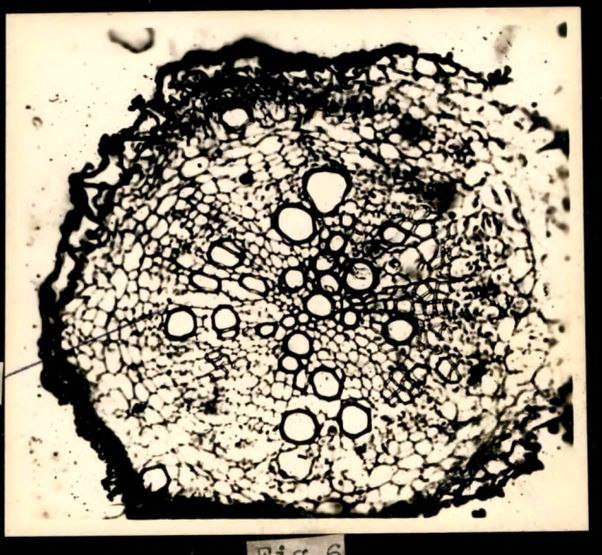


Fig.6

P L A T E - V

(Figs. 1 - 6 : Glinus oppositifolius Linn.
Figs. 3, 5 & 6 are photomicrographs.)

Fig. 1. T.s. lamina passing through midrib. x 780

Fig. 2. A - upper epidermis with stomata. x 250.
B - lower epidermis with stomata. x 250.

Fig. 3. T.s. of young stem showing trichomes and vascular bundles. x 194.

Fig. 4. A - T.s. old stem, near a node (diagrammatic). x 7.
B - T.s. old stem magnified. x 250

Fig. 5. T.s. young root, showing diarch condition. x 86.

Fig. 6. T.s. young root, showing the formation of second vascular ring. x 34.

x-x-x-x-x-x-x

Cb_1 - cambium No.1; Cor. - cortex; Cr. - rosette crystal; Ep_1 - upper epidermis; Ep_2 - lower epidermis; Pal. - palisade; Phl. - phloem; P.fb. - pericyclif fibre; P.Xy. - primary xylem; Tr. - trichome; V.B - vascular bundle; Pt. - pith; Xy. - xylem.

G. oppositifolius

externally (Plate V, 3). A trichome is 4-6 celled and 611-893 μ long; each trichome cell exhibits fine longitudinal striations externally. Cortex is composed of 5-6 layers of oval or rounded cells. Chloroplasts are present in a few of the outer cells. Endodermis and pericycle are obscure. Stele shows numerous small, conjoint, collateral and open vascular bundles. Xylem is composed of a single row of 1-3 vessels arranged radially (Plate X, 3). Phloem occurs as a small group outside the xylem. Ray cells are polygonal . The spherical or oval parenchyma in the centre constitutes a wide pith.

An old stem of 1360 μ diameter shows secondary growth (Plate V, 4, A & B, 4). Lignified pericyclic fibres possess wide lumen; they are arranged in an interrupted ring around the vascular tissues (Plate VIII B, 12). Cork development has not started. Section near the node shows two opposite leaf gaps in the vascular cylinder. (Plate V, 4A). Secondary phloem is separated from the secondary xylem by 1-2 layers of cambium. Xylem consists of vessels, tracheids and fibres. Secondary medullary rays are uniseriate (Plate V, 4B). Pith is small and parenchymatous.

The stem shows 2-3 anomalous concentric, complete or incomplete rings of vascular tissue at the base. The development of anomalous rings is similar to that of

G. oppositifolius

G.lotoides. Externally, three layers of lignified cork cells and two layers of phelloderm replace the epidermis. Parenchymatous tissues in general contain only spherical, concentric and simple or compound starch grains.

T A B L E - 2

Measurements of stem elements

Elements	Length	Width
Vessel	148.7-225-333.7-404-587.5 μ	20-28-38.5 μ
Tracheid	172-226.5-278-321.5-349 μ	14-19-28 μ
Fibre	263-569-966-1147-1476 μ	14-29-41 μ

Root : Anomalous secondary growth (Plate V, 5 & 6) :

Young root is diarch (Fig. 5). Secondary growth is found to be similar to that of G.lotoides. Both roots differ in occurrence of xylem parenchyma, secondary medullary rays and presence or absence of starch and calcium oxalate crystals. G.oppositifolius has comparatively more xylem parenchyma, secondary rays and starch grains but no calcium oxalate crystals in the root.

G. oppositifolius

D I S C U S S I O N

Stem bases of old stem exhibits anomalous secondary growth of the same type as reported by Metcalfe and Chalk (1950) for the genus Glinus. The anomaly in this case is the same as discussed in G. litoides.

Root also exhibits the same type of anomalous secondary growth as discussed in case of G. lotoides.

Less amount of chloroplasts in palisade and glabrous leaf and stem prove that this is less xerophytic than G. lotoides.

S U M M A R Y

Leaf is dorsiventral as 2-3 layers of palisade and 4-5 layers of spongy tissue fill the mesophyll. Ranunculaceous stomata are present on both the surfaces. Cells of the mesophyll and midrib cortex contain calcium oxalate crystals.

Cuticle and multicellular trichomes protect the stem in young condition. Stele of a young stem shows numerous vascular bundles and a parenchymatous pith. Old stem exhibits secondary growth. Lignified pericyclic fibres form an interrupted ring around the vascular tissues. At

its base, the stem shows 2-3 concentric, complete or incomplete rings of anomalous vascular tissue. Successive cambium rings originate in phloem. Three layers of cork and 2 layers of phelloderm replace the epidermis in an old stem. Starch is present in the cells of the phelloderm, cortex, medullary rays and pith.

Young root is diarch. Secondary growth is similar to that found in Glinus lotoides Linn. Xylem parenchyma, medullary rays and starch are relatively more abundant here. Oxalate crystals are absent.

3 - Mollugo nudicaulis Lamk.

Mollugo nudicaulis Lamk. grows in hotter parts of India. The entire plant is bitter, pectoral and used in Madagaskar as atherepy and on whooping cough. Leaves applied to boils draw out pus (Kirtikar and Basu, 1933).

M.nudicaulis Lamk. is an erect, annual herb which grows to 15-20 cm. height. Several obscurely angled glabrous and diffuse flowering stems arise from the tuft of radical leaves. The white flowers are arranged on filiform peduncles in loose, trichotomous terminal cymes. Fruit is nearly a globular capsule containing many dull-black, reticulate seeds.

M O R P H O L O G Y

Leaf :

Leaf is thin, glabrous and pale green in colour. It is obscurely petioled, elliptic, acute or obtuse at the apex or apiculate and tapering to the base. A leaf measures 1.5-4 cm. by 0.4-1 cm.

Stem :

Alike the flowering ones, the stems are erect, slender and green. They are glabrous, leafless and trichotomous. Flowering stems are 7.5-15 cm. long.

Mollugo nudicaulis Lamk.

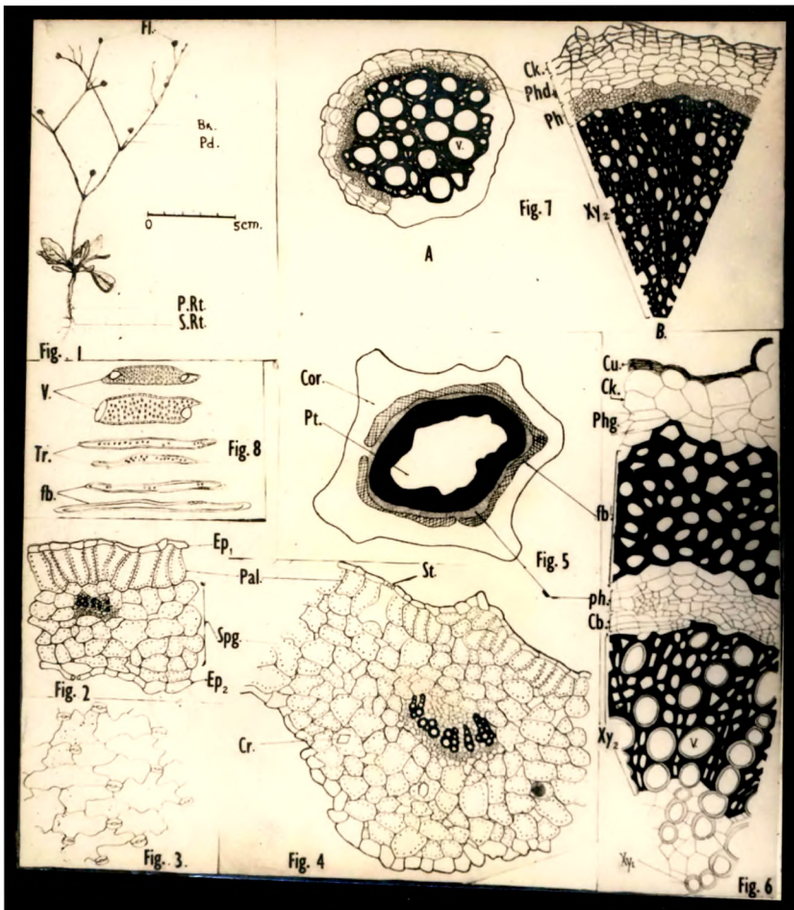
Root :

Root is straight, almost unbranched, tapering below and crowned at the top. It is 1-5 cm. in length and maximum 102.5 μ across. Outer surface below the crown is greyish in colour and has irregular longitudinal wrinkles. This part bears a few filiform secondary rootlets which measure 22.5 μacross. The small crown shows the remains of the stem bases. The root breaks with granular white fracture. It is odourless and bitter in taste.

H I S T O L O G Y

Leaf :

The lamina is dorsiventral as it has a single layer of palisade cells towards the upper side (Plate VI, 2); these cells possess less chloroplasts. The epidermis is non-hairy and consists of tabular cells having wavy anticlinal walls. A dermal cell in surface view has generally wavy outline. A thin layer of protective cuticle is also present on both the ~~epiderl~~ dermal surfaces. The stomata are of ranunculaceous type and are comparatively more abundant on the lower epidermis (Plate VI, 3). Spongy tissue consists of 4-5 layers of rounded cells with large intercellular spaces. In a cross section, a number of veins are cut transversely while a few longitudinally or obliquely.



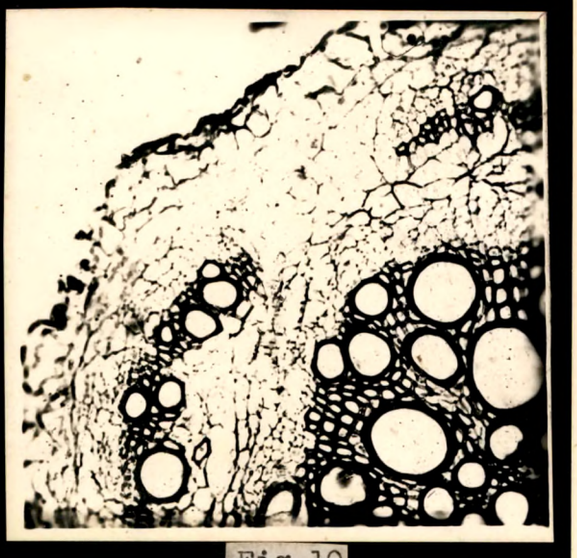


Fig.10

Pal.

P.fb.

Xy.

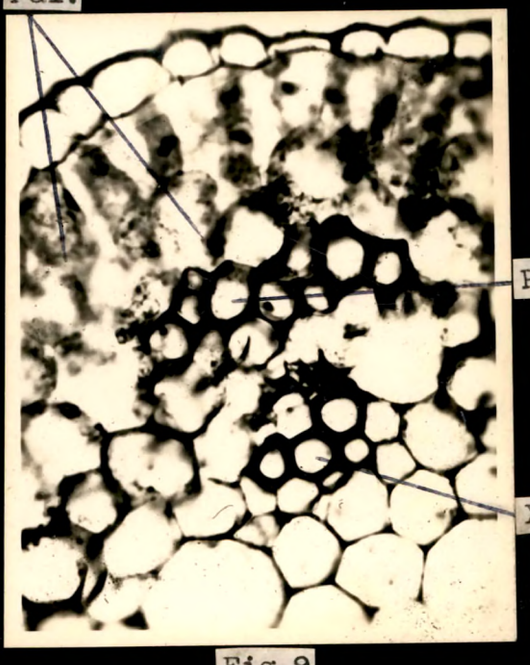


Fig.9

P L A T E - VI

(Figs. 1 - 9 : Mollugo nudicaulis Lamk.
Fig. 10 : Glinus lotoides Linn.)

(Figs. 9 & 10 are photomicrographs)

Fig. 1. Entire plant. x 1

Fig. 2. T.s. lamina. x 320

Fig. 3. Lower epidermis with stomata. x 350

Fig. 4. T.s. leaf midrib. x 330.

Fig. 5. T.S. old stem (diagrammatic). x 75.

Fig. 6. T.s. old stem magnified. x 750

Fig. 7. A - T.s. secondary root. x 450.
B - T.s. tap root. x 350

Fig. 8. Some vascular cell elements. x 380.

Fig. 9. T.s. flowering stalk; note outer photosynthetic tissue. x 120.

Fig. 10. T.s. root showing collateral patches of vascular tissues of an anomalous growth. x 94.

x-x-x-x-x-x-x

Br. - branch; Cb. - cambium; Ck. - cork; Cor. - cortex;
Cu. - cuticle; Ep_1 - upper epidermis; Ep_2 - lower epidermis;
fb. - fibre; fl. - flower; Pal. - palisade; Pd. - pedical;
Ph.- phloem; Phd. - phelloderm; Phg. - phellogen; Pt. - pith;
P.fb. - pericyclic fibres; P.Rt. - primary root; Spg. - spongy;
St. - stomata; S.Rt. - secondary root; Tr. - trichome;
V - vessel; Xy - sylem; Xy_2 - secondary xylem.

Mullugo nudicaulis Lamk.

Isolated cells of the spongy tissue contain a few cubical, rectangular or red-shaped crystals of calcium oxalate (Plate VI, 2).

Palisade is continuous over the midrib, which slightly projects towards the abaxial side and is more or less in line with the lamina on the adaxial side (Plate VI, 4). The cortical tissue of the midrib is parenchymatous; some of its cells also contain calcium oxalate crystals. The midrib bundle consists of radiating xylem above and phloem below. Xylem parenchyma is present in between the radiating rows of xylem vessels.

Leaf constants:

Stomatal index for the upper epidermis is 27-28 and the same for the lower one is 32-33.5. Palisade ratio is 1.4 - 2 while the vein-islets are 5-9. Vein-islet number works out to be 5-9.

Stem :

Transection of the stem appears angled, as the corners project to form wing-like projections (Plate VI, 5). Epidermis possesses a few stomata and is protected on its outer side with much striated thick cuticle (Plate VI, 6). Cortex consists of 4-5 layers of parenchymatous cells containing chloroplasts. Stem base at each of the corners

Mullugo nudicaulis Lamk.

develops about two layers of thin-walled but lignified cork cells (Plate VI, 6). Pericyclic region becomes sclerenchymatous. It consists of lignified fibres which mostly form a complete but rarely an incomplete ring (Plate VI, 5). The pericyclic ring is 2-3 cells thick at the sides while it appears cap-like and seven layers thick at the corners. A few sclereids are also present in this region.

Young stem shows 6-8 or occasionally as many as 10 conjoint, collateral and open vascular bundles. Some of these, occupy the corners and are usually bigger than the rest that occupy the sides.

Old stem shows xylem consisting of vessels, tracheids and fibres (Plate VI, 5). Vessels and tracheids are bordered pitted. Spiral vessels are not altogether ruled out.

Flowering stems are circular and measure 320 μ in diameter. Epidermis is well protected with cuticle and bears a few stomata. Hypodermis consists of 2-3 layers of slightly elongate palisade cells (Plate VI, 9). Inner part of the cortex is parenchymatous. Endodermis is obscure. Groups of pericyclic fibres protect each of the conjoint, collateral and open vascular bundles. Parenchymatous pith and medullary rays are present. Secondary growth is absent.

Mullugo nudicaulis Lamk.

T A B L E - 3

Measurements of stem elements

Elements	Length	Width
Vessel	118-155-195-229-270 μ	13-25-31 μ
Trachied	182-274-420-525-637 μ	14-21-32 μ
Fibre	532-701-900-990-1200 μ	11-17-22.5 μ

Root :

The outer cork layers in old roots get peeled off, hence only 2-4 layers of comparatively thin-walled, lignified and suberised cork cells are observed (Plate VI, 7A & 7B). Phelloderm consists of 7-8 layers of compact parenchymatous cells which are arranged in more or less radial rows. Endodermis and pericycle are obscure.

Vascular tissues lie immediately below the phelloderm. Phloem is a small zone outside the xylem. It consists of sieve tubes, companion cells and phloem parenchyma. Cambium consists of 2-3 distinct cell layers. Xylem is comparatively a broader zone, made up of vessels, tracheids, xylem parenchyma and a few fibres. Vessels occuring singly or in groups of two or three. They show

ellipsoid bordered pits (Plate VI, 8). Tracheids also show ellipsoid bordered pits placed obliquely. Starch and calcium oxalate crystals are absent in the root.

T A B L E - 4

Measurements of root elements

Elements	Length	Width
Vessel	90-123-173-253-269 μ	11-19-27 μ
Tracheid	153.5-173-226-273-296 μ	8-12-15 μ

D I S C U S S I O N

Bakshi and Kapil (1952) report large cells intercalated among the epidermal cells of ordinary dimensions. This holds good in the present case also. The glabrous nature of the leaf and occurrence of ranunculaceous stomata therein were reported previously by Metcalfe and Chalk (1950) as well as Bakshi and Kapil (1952).

Anomalous secondary growth as has been reported in the root of Mollugo radiata Raiz. (Metcalfe and Chalk, 1950) is absent in the root of M.nudicaulis.

Mullugo nudicaulis Lamk.

Glabrous nature of the plant, palisade in leaf, thick cuticle on stem, chlorenchymatous cells of cortex as also of flowering stem show that the plant is a xerophyte leaning towards mesophitism.

S U M M A R Y

Dorsiventral lamina possesses a single palisade layer on the upper side and 4-5 layers of spongy tissue below. In contrast with the observation of Subnis (1921-24) leaf is glabrous. The epidermis possesses large as well as small cells. It bears ranunculaceous stomata. Palisade is continuous over the midrib. Cells of the mesophyll in the lamina and in the midrib cortex contain calcium oxalate crystals.

Stem epidermis possesses a few stomata and cuticle outside. Superficial cork develops at the stem angles. Pericycle is sclerenchymatous; it becomes many layered opposite the angles. Secondary xylem consists of vessels and tracheids with bordered pits; fibres have a few simple pits. Secondary growth is normal. Hypodermis of flowering stem has 1-2 layers of palisade cells. Endodermis is obscure while pericycle develops a few sclerenchyma. Secondary growth is absent in the flowering stem.

Mullugo nudicaulis Lamk.

Root exhibits normal secondary growth. Two layers of lignified and suberised cork cells and 7-8 layers of phelloderm are present. Xylem consists of vessels and tracheids with bordered pits and fibres.

4 - Mollugo cerviana (L.) Ser.

Mollugo cerviana (L.) Ser. is a berb generally found in hotter parts of India. In Gujarat, it appears after the first rains in July-August and persists upto February.

It is reported by Nadkarni (1954) to contain a bitter principle, resin, gum and 68% ash having alkaline nitrates. The plant believed to be stomachic, aperient, uterine stimulant, antiseptic and febrifuge is widely used for promoting the flow or lochial discharge, for gouty and rheumatic complaints and also in fevers (Watt, 1890; Kirtikar and Basu, 1933; Nadkarni, 1954). Infusion or decoction of flowers and tender shoots is said to possess diaphoretic effect (Nadkarni, 1954).

Description of the plant (Plate VII, 1)

The plant is an annual, erect, slender and glabrous herb about 7.5-20 cm. high. 3-7 filiform branches arise from the top of 8 cm. long tap root giving out umbellate and filamentous sub-branches. Radical and cauline leaves are morphologically alike. Peduncles are elongate, filiform and pendulous. Numerous flowers are borne on umbellately arranged stiff but filiform pedicels. Elliptic-oblong and obtuse sepals are having white membranous margins. Corolla is absent. The flower possesses three stamens and

Mollugo cerviana (L.) Ser.

a tricarpellate ovary with three very short styles. Fruit is a subglobose capsule as long as the sepals. Numerous, yellow-brown and smooth seeds are without tubercular points.

M O R P H O L O G Y

Leaf:

Leaves are arranged in a rosette at the base. The nodal leaves are whorled. Both types of leaves are alike - dark-green, glabrous and obscurely petioled with the only difference that the basal leaves are linear-spathulate; they measure 0.75 - 1.25 cm. in length and 0.2 - 0.4 cm. in width. The nodal leaves are linear, narrow and apiculate and measure 0.75 cm. in length and 0.2 - 0.5 cm. in width.

Stem :

It is smooth, slender and erect. It is having prominent nodes and filiform internodes. The latter measure about 1-4 cm. in length and 0.1 - 0.5 cm. in diameter. The lower part of the stem is pinkish-purple while the upper part is yellowish-green in colour.

Root :

The short, light yellow or brown tap root

Mullugo cerviana (L.) Ser.

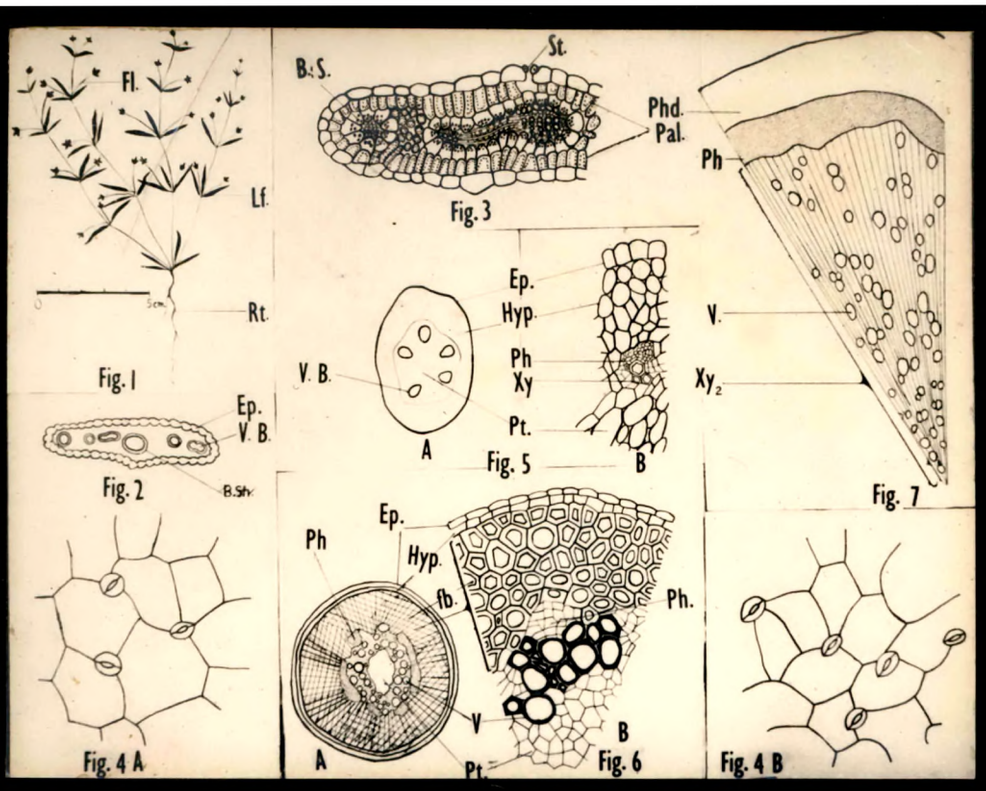
measures about 1-4 cm. in length and 0.2 -0.5 cm. in diameter. It bears a few secondary rootlets. The root is somewhat knotty at the base due to the origin of numerous branches. Its smoothened fractured transverse surface appears white, while taste is slightly bitter.

H I S T O L O G Y.

Leaf:

The transverse section of the leaf shows presence of a large midrib bundle in the centre (Plate VII, 2). 5-6 small bundles are arranged in the lamina more or less symmetrically on each side of the midrib. Vascular bundles in the lamina region are generally cut transversely; occasionally however, one or two of them are cut obliquely. A vascular bundle is ensheathed by a layer of big, pear-shaped cells containing a few but large chloroplasts. The vascular bundle is conjoint and collateral (Plate VII, 3 & 8). The xylem consists of 2-6 radial rows of vessels on the outside. Phloem is composed of sieve tubes, companion cells and phloem parenchyma. Some of the cells of phloem parenchyma, especially those adjacent to the bundle sheath on the abaxial side are usually big (Plate VII, 3).

Lamina is isobilateral as palisade tissue is present under the upper as well as the lower epidermis


Fl.
Lf.
Rt.
Fig. 1
Ep.
V. B.
B.Sh.
Fig. 2
Fig. 4 A
B.S.
St.
Phd.
Pal.
Fig. 3
Ep.
Hyp.
Ph
Xy
Pt.
V. B.
A
Fig. 5
B
Ep.
Hyp.
Ph
fb.
Ph.
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Pt.
A
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Fig. 6
Ph
V.
Xy2
Fig. 7
Fig. 4 B

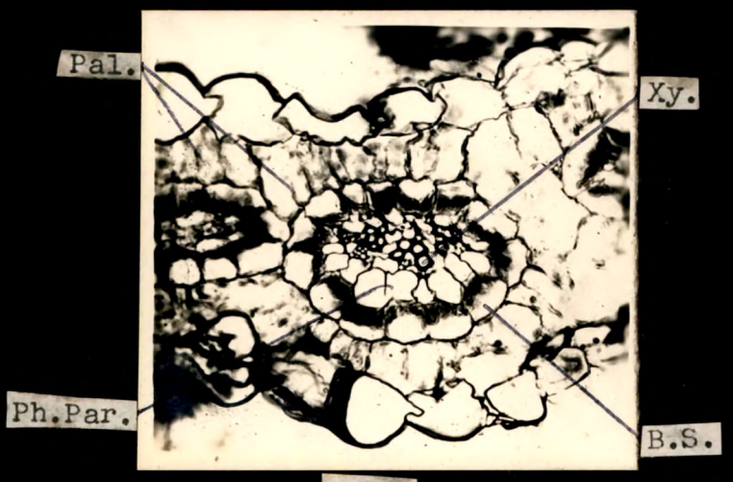

Pal.
Xy.
Ph.Par.
B.S.

Fig.8

P L A T E - VII

(Figs. 1 - 8 : Mollugo cerviana (L) Ser.
Fig. 8 : photomicrograph)

Fig. 1. Entire plant. x 1.

Fig. 2. T.s. leaf (diagrammatic). x 70.

Fig. 3. T.s. leaf showing isobilateral condition. x 280.

Fig. 4. A - upper epidermis with stomata. x 440.
B - Lower epidermis with stomata. x 440.

Fig. 5. A - T.s. young stem (diagrammatic). x 70.
B - T.s. young stem magnified. x 780

Fig. 6. A - T.s. old stem (diagrammatic). x 250.
B - T.s. old stem magnified. x 250.

Fig. 7. T.S. old root (diagrammatic). x 250.

Fig. 8. Vascular bundle of leaf magnified; note phloem parenchyma and chlorophillous bundle sheath. x 310.

x-x-x-x- x-x

B.S. & S.Sh. - bundle sheath; Ep.- epidermis; fb. - fibre; Hyp. - hypodermis; Lf. - leaf; Pal. - palisade; Ph. - phloem; Phd. - phelloderm; Pt. - pith; Ph.Par. - phloem parenchyma; Rt. - root; St. - stomata; V - vessel; V.B. - vascular bundle; Xy. - xylem; Xy_2 - secondary xylem.

Mollugo cerviana (L.) Ser.

(Plate VII, 3). The enlarged tabular epidermal cells are having straight anticlinal walls. They probably constitute a water storage tissue. A thin layer of protective cuticle is present on the outer walls. In surface view, the polygonal cells of the epidermis are interrupted by ranunculaceous and cruciferous stomata (Plate VII, 4A & 4B). Stomatal indices for the upper and lower epidermises are 20-23.3 and 25.5-28.6 respectively. The palisade cells are arranged compactly; they contain chloroplasts. Spongy tissue consists of rounded or oval cells (Plate VII, 3). It is situated in the middle of the lamina in between the vascular bundles. Isolated cells of the palisade and spongy tissues contain calcium oxalate cubes, rectangles and clusters.

Stem :

Young stem appears circular or oblong in transverse section (Plate VII, 5A & 5B). Outer epidermis consists of a layer of cubicle cells covered by a thin protective cuticle outside. The parenchymatous hypodermis consists of rounded or oval cells containing a few chloroplasts. They show intercellular spaces. Next, 2-3 layers of compact and comparatively thick-walled parenchymatous cells make up the rest of the cortex. Endodermis is indistinct. Stelar region consists of 5-6 vascular bundles, medullary rays and pith. Each vascular bundle is conjoint, collateral and

open. Its poorly developed xylem consists of 3-4 vessels only. The phloem cells are small and polygonal. A distinct cambial layer separates xylem from phloem. Medullary rays, as many as the vascular bundles, consist of radially elongated cells. Pith is small and parenchymatous.

Old stems exhibit moderate secondary growth (Plate VII, 6A & 6B). Beneath the epidermis, there is a single layer of tangentially elongated compactly arranged parenchymatous cells. This is the hypodermis. The rest of the cortex is sclerenchymatous. Thus, a hollow cylinder made up of sclerenchyma offers mechanical strength to the filiform stems. Secondary xylem forms a closed ring while phloem forms 5-6 discontinuous bands. Xylem consists mostly of vessels. They show scalariform as well as bordered pits on their walls. Spiral vessels are also present; these are comparatively longer.

T A B L E - 5

Measurements of stem elements

Elements	Length	Width
Vessel	133-188-221-270-321.5 μ	14-18.8-23.5 μ
Fibre	560-752-1040-1280-1488 μ	48-64-80 μ

Mollugo cerviana (L.) Ser.

Root :

Old root possesses 2-3 layers of thin walled radially elongated and lignified cork cells (Plate VII, 7). Phelloderm consists of about 9-12 layers of tangentially elongated and compact cells. As usual, phloem consists of sieve tubes, companion cells and phloem parenchyma; however, the cells of the phloem tissue are very small. One or two layers of small brick-shaped cells constitute the cambium. Xylem consists not only of vessels, but also of tracheids and fibres. Primary xylem in the centre is indistinct. Vessels occur singly or in groups of two; they mostly possess bordered pits. Tracheids have also bordered pits on their wall, while the lignified fibres show a few simple pits.

T A B L E - 6

Measurements of root elements

Element	Length	Width
Vessel	68-93-122-140-169 μ	15.4-22-31 μ
Tracheid	100-130.5-161-192-222 μ	11.5-16.5-23 μ
Fibre	135.5-163-179-200-221 μ	10-14-21 μ

Mollugo cerviana (L.) Ser.

D I S C U S S I O N

Subnis (1921-24) reports stellate hair on the leaf epidermis. He also states that large cells are intercalated among cells of ordinary diameter in the leaf epidermis. Bakshi and Kapil (1954) categorically state that they have found neither stellate hair nor difference in cell size in the epidermis. In the present study, the leaf is found to be glabrous. The other observation of Subnis (1921-24) holds good here. Presence of ranunculaceous stomata has also been reported by Metcalfe and Chalk (1950) and Bakshi and Kapil (1954). According to the latter pericyclic cells are thin walled. In the present study both ranunculaceous and cruciferous stomata are found. They probably refer to phloem parenchyma present on the abaxial side of the vascular bundle. The vascular bundles in the leaf are 3-7 and not 'the usual three' as reported by them. Cluster crystals reported by Bakshi and Kapil (1954) are found in the leaf of M. cerviana. Moreover, cubes and rectangular ones are also observed.

Kapil and Bakshi (1954) denied presence of stomata and hair on the stem as reported by Subnis (1919). The former observed a 2-3 layered cortex containing cluster crystals and a pericyclic ring of fibres around the inner tissues. The present work confirms the findings of Bakshi

Mollugo cerviana (L.) Ser.

and Kapil (1954) about the absence of hair and stomata. The inner cortex however, is modified to form a closed and wide ring of lignified cells around the inner tissues. This ring was interpreted by Bakshi and Kapil (1954) as belonging to the pericyclic region.

Anomalous secondary growth has been reported in the root of Mollugo radiata Raiz. (Metcalfe and Chalk, 1950). However, as confirmed here, Bakshi and Kapil (1954) have reported its absence in the root of M. cerviana.

Semicentric leaf, large epidermal cells, stomata somewhat deep seated, presence of palisade below both the surfaces, chlorophyllous bundle sheath and abundant chloroplasts prove xerophytic nature of the plant.

S U M M A R Y

The leaf which is somewhat centric has 5-7 symmetrically arranged vascular bundles, the central one being the biggest. Each vascular bundle is surrounded by a layer of large thin walled cells of the bundle sheath. Vascular bundle is conjoint and collateral. A few large thin walled phloem parenchyma are present on the abaxial side. The epidermis as in Mollugo nudicaulis Lamk. contains large and small cells. Stomata are both of ranunculaceous and

Mollugo cervians (L.) Ser.

cruciferous types. A single cell layer of palisade, lies below each surface. Calcium oxalate cubes and rectangles are present in the mesophyll tissue.

Young stem possesses a 2-4 celled parenchymatous cortex and a central stelar region with 5-6, conjoint, collateral and open vascular bundles. Old stem exhibits normal secondary growth. The stem is characterised by a single layered parenchymatous hypodermis, a sclerenchymatous ring around the vascular cylinder and a small parenchymatous pith.

Root exhibits normal secondary growth. In the periderm, there are 2-3 layers of lignified cork cells and 9-12 layers of phelloderm. Xylem consists of vessels, tracheids and fibres. The former two show bordered pits while the latter shows a few simple pits.

5 - Gisekia pharnaceoides L.

Gisekia pharnaceoides L. grows throughout India, especially in the Punjab, Baluchistan, Rajputana desert, Sind, Gujarat, Konkan, S. Maharastra, Deccan and E.Mysore State (Chopra, Nayer and Chopra, 1956).

The plant is described as digestive, alexiteric, anthelmintic and vulnerary. In Ayurveda, it is used for the cures of scabies, thirst, rhinitis and bronchitis as also for the loss of ~~apitite~~ appetite, heart troubles, leprosy, leucoderma and urinary diseases (Kirtikar and Basu, 1933). Entire plant is a powerful anthelmintic (Watt, 1890; Kirtikar and Basu, 1933). The plant being strongly anthelmintic is a specific for tapeworms, if properly administered, preferably in fresh condition. Strangely, no medicinal evidence in favour of virtues alleged by Lowther (Watt, 1890) is available.

Seeds do possess anthelmintic properties and they contain tannin-like principles provisionally named as α -Gisekia and β -Gisekia (Nadkarni, 1954).

Description of the Plant (Plate VIII - A, 1) :

The plant is a rather diffuse, succulent and glabrous herb, 24-35 cm. in height. It grows wild around Ahmedabad during December-January. The cylindrical stem bears a number of prostrate or ascending branches and subopposite leaves. Flowers with slender pedicels are

Gisekia pharnaceoides L.

arranged in sessile umbellate cymes. Sepals are elliptic-oblong, sub-acute and membranous at the margins. Each of the five stamens possesses a filament dilated at the base. The fruit surrounded by calyx, is as long as a sepal. The black seed surface is provided with scattered white glandular prominences.

M O R P H O L O G Y

Leaf :

Leaf is subfleshy, cauline, glabrous and dull green in colour. It is elliptic-lanceolate, cuneate at the base, entire, obtuse or subacute and reticulate. It measures 2.5-4 cm. by 0.3-0.6 cm. Petioles are approximately 0.6 cm. in length.

Stem :

About 3-6 branches with opposite sub-branches arise from the top of the root. A branch is 15-30 cm. long; nodes are prominent and internodes are 1-6 cm. long. A sub-branch is yellowish-green in colour and shows clear longitudinal striations; also white vertically elongated tubercles are scattered irregularly.

Root :

Root is about 10 cm. long and straight in

growth. It is knotty at the top. Colour is yellow or light-brown or sometimes even purple. Smoothened transverse surface which is white, shows a big central porous region.

H I S T O L O G Y

Leaf:

A leaf is dorsiventral; palisade being present below the upper epidermis only (Plate VIII A, 2). Large bladder-like epidermal cells are intercalated with small cells. They are well protected by thick cuticle externally. They act as a water storage tissue. In surface proparation, the cells of the lower epidermis show wavy cell walls and prominent cuticular striations in the form of concentric wavy rings (Plate VIII A, 3A & 3B). Stomata are of ranunculaceous type; they are more abundant on the lower epidermis than the upper one.

Mesophyll is differentiated into palisade and spongy tissues (Plate VIII A, 2). Palisade consists of 1-2 rows of elongated and closely packed cells which are studded with chloroplasts. Round or oval cells make up the spongy tissue, which has prominent intercellular spaces. A few cells of the mesophyll tissue contain calcium oxalate raphide sac measuring 98.7-211.5-291.4 μ in length. Almost all of the 16-19 vascular bundles, are

cut transversely (Plate VIII B, 7); rarely one of them may be cut obliquely. Each vascular bundle is ensheathed by its own bundle sheath. Large, pear-shaped cells of the sheath are studded with a few big chloroplasts. Cells of the bundle sheath too may constitute a water storage tissue.

Palisade is discontinuous over the midrib (Plate VIII, A. 4). Over the midrib, the upper and the lower epidermises run in depressions, which result in the formation of shallow channels on both the surfaces. At the midrib, the leaf measures 320 μ while at the sides, it measures 400 μ in thickness. Cells of the midrib cortex are parenchymatous. Isolated cells contain calcium oxalate raphide sac or occasionally sandy crystals of calcium oxalate. The single vascular bundle of the midrib is large and arc-shaped; it has xylem towards the adaxial side and phloem towards the abaxial one. (Plate VIII, A, 4). Xylem consists of about seven radiating rows of vessels and xylem parenchyma in between. Phloem is represented as several small groups, one below each of the vessel row and separated by the rays. Small strips of inactive cambium are present between xylem and phloem of each row.

Leaf constants :

Stomatal indices for the upper and lower epidermis are 23-26 and 15-20 respectively. Vein-islet

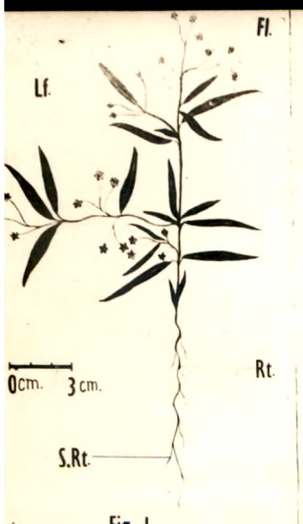


Fig. 1

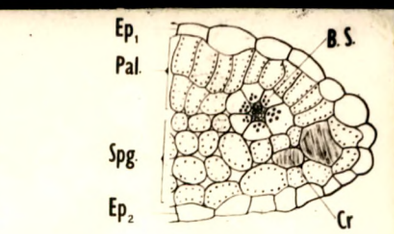


Fig. 2

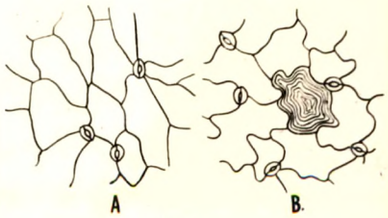


Fig. 3

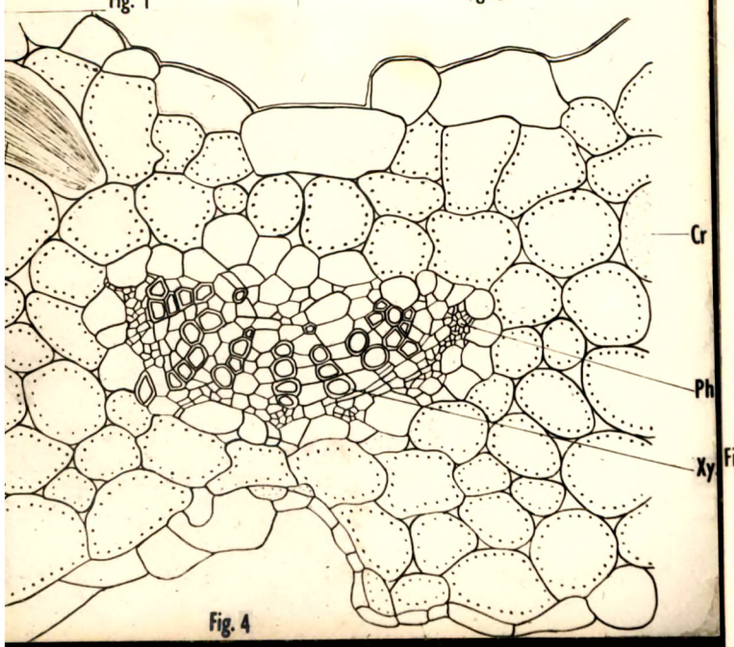


Fig. 4

A

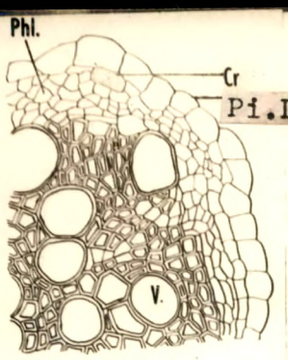


Fig. 10

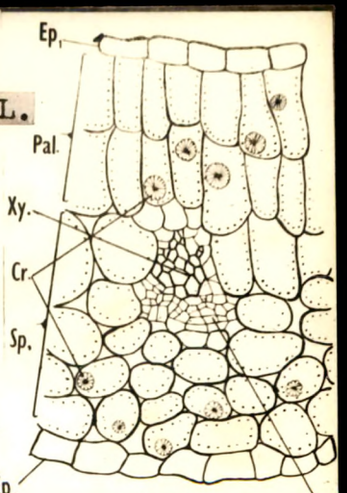


Fig. 11

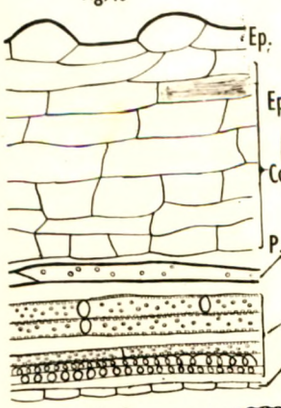


Fig. 9

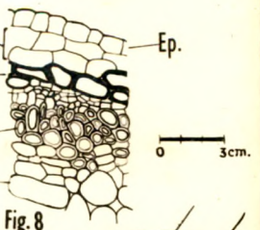


Fig. 8

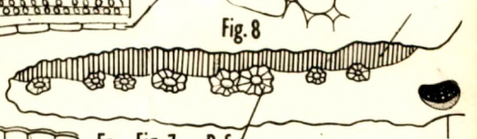


Fig. 7

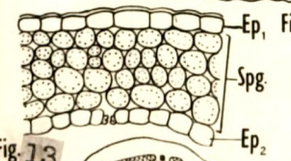


Fig. 13

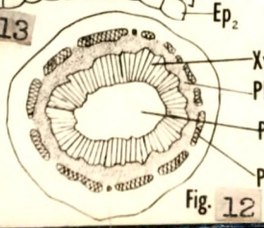


Fig. 12

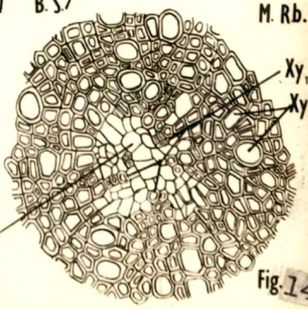


Fig. 14

B

P L A T E - VIII

(Figs. 1 - 4 & 7 - 10 : Gisekia pharnaceoides L.;

Figs. 11 & 12: Glinus oppositifolius Linn. ;

Figs. 13 & 14 : Anagallis arvensis Linn.)

P L A T E - VIII-A

Fig. 1. Entire plant. x 1

Fig. 2. T.s. lamina showing bladder-like epidermal cells. x 250.

Fig. 3. A - Upper epidermis showing stomata x 440.

B - Lower epidermis showing stomata.x 440.

Fig. 4. T.s. lamina passing through midrib. x 780.

P L A T E - VIII-B

Fig. 7. T.s. lamina (diagrammatic). x 250.

Fig. 8. T.s. young stem. x 440.

Fig. 9. L.s. old stem. x 440.

Fig. 10. T.s. root. x 780.

Fig. 11. T.s. lamina. x 780

Fig. 12. T.s. stem showing pericyclic fibres and vascular tissues. x 70.

Fig. 13. T.s. lamina showing isobilateral condition. x 250.

Fig. 14. T.s. old stem; note the protoxylem groups in the centre. x 440.

x.x.x.x.x

B.S. - bundle sheath; Cor. - cortex; Cr. - crystal; Ep.- epidermis; Ep_1 - upper epidermis; Ep_2 - lower epidermis; Fl. - flower; Lf. - leaf; Pal. - palisade; Ph. or Phl. - phloem; Pt. - pith; Pi.L. - piliferous layer; P.fb. - pericyclic fibres; Rt. - root; Sp. or Spg. - spongy; S.Rt. - secondary root; V - vessel; Xy. - xylem; Xy_1 - primary xylem; Xy_2 - secondary xylem.

number comes to 3-6. Palisade ratio works out as 5-9.

Stem :

The stem which appears circular in transverse section starts secondary growth at an early stage. Cells of the epidermis become bladder-like at irregular intervals; they probably correspond to white, vertically elongated, tubercle-like projections observed on the surface of the stem (Plate VIII B, 9). Cortex is parenchymatous and 2-7 layered (Plate VIII B, 8 & 9). Isolated cells in the cortex act as raphide sacs or possess sandy crystals. Endodermis is obscure. Lignified pericyclic fibres arrange in a complete or incomplete ring around the vascular tissues (Plate VIII B, 8). Phloem constitutes a very narrow zone. Cambium is distinct and single layered. Scondary xylem is composed of vessels which show bordered pits on their walls. Primary xylem consists of annular and spiral vessels (Plate VIII B, 9). It faces the centre of the stem.

Gisekia pharnaceoides L.

T A B L E - 7

Measurements of stem elements

Elements	Length	Width
Vessel	288-409-587.5-728.5-876.5 μ	19-26-33 μ
Tracheid	160-263-334-437-517 μ	13-20-28 μ
Fibre	1600-1760-1952-2160-2240 μ	19-42.4-33 μ

Root :

Secondary growth starts in the root at a very early stage so that, even in a young root primary xylem becomes obscure. Root pieces of different diameters as 192 μ; 272 μ; 400 μ; and 800 μ show gradual advance of secondary development.

In old roots, a layer of large, thick-walled cells remains as the external protective layer. Isolated cells of a 4-5 layered parenchymatous cortex, are filled either with raphides or sandy crystals of calcium oxalate (Plate VIII B, 10).

The narrow phloem zone is followed by 1-2 layers of cambium cells. Xylem forms a central big, woody region; it consists of vessels, tracheids, xylem parenchyma

and a few fibres. Vessels are large occuring singly or in groups. They show bordered pits on their walls. Tracheids show branched ends and bear comparatively a few pits of the same type as in vessels.

T A B L E - 8

Measurements of root elements

Elements	Length	Width
Vessel	119-177-225.5-258.5-329 μ	19-23.5-37.6 μ
Tracheid	179-235.5-272.6-333.7-339 μ	9.5-14-19 μ

D I S C U S S I O N

Metcalfe and Chalk (1950) and Joshi and Kambhoj (1959) rightly mention that large cells are intercalated with small cells in the epidermis of the leaf, which is glabrous. They have noted presence of ranunculaceous stomata but failed to report the presence of prominent cuticular striations on the cells of the upper epidermis. In the present study, occasionally two layered palisade tissue is also noticed, in contrast with a single layer reported by Joshi and Kambhoj (1959). Nineteen as the average number

of veins, and common occurrence of raphides reported by Joshi and Kambhoj (1959) hold good here.

Presence of bladder-like cells at irregular intervals in the stem epidermis has not been mentioned either by Metcalfe and Chalk (1950) or Joshi and Kambhoj (1959). The latter find trichomes on the ridges of stem and a 3-4 celled deep cortex. In the present work, trichomes are not noticed; while cortex is 2-7 celled deep.

Sandy crystals of calcium oxalate and raphides are observed in the root cortex which is said to contain only raphides in a few of its cells by Joshi and Kambhoj (1959).

Thick layer of cuticle on leaf, presence of palisade, numerous chloroplasts, bladder-like epidermal cells and big cells of bundle sheath probably storing water are characters pointing towards xeromorphy of this species.

S U M M A R Y

Leaf is dorsiventral. Epidermis possesses both small as well as large bladder-like cells; ranunculaceous stomata are found on both the surfaces. Leaf mesophyll is traversed by 16-19 identical vascular bundles which are mostly cut transversely. Each vascular

bundle is surrounded by a chlorophyllous bundle sheath. Calcium oxalate raphide sacs are of common occurrence in the lamina.

Cells of the stem epidermis show presence of a few bladder-like cells along with cells of normal size. A complete ring of pericyclic fibres encircles the vascular tissue. Calcium oxalate raphide sacs are also found in the stem cortex. Vessels with bordered pits as well as with annular and spiral thickenings are present.

Root exhibits normal secondary growth. 2-3 layers of cork and 4-5 layers of phelloderm replace the piliferous layer in the root. Vessels, as in the stem show bordered pits.

6 - Primula denticulata Smith

Primula denticulata Smith is primarily selected for its saponin contents. No literature is available to show its usefulness. According to Watt (1892) and Chopra, Nayer and Chopra (1956), entire plant of P.reticulate Watt. is poisonous to cattle and is used externally as an anodyne.

Description of the plant (Plate IX - A, 1) :

It is a perennial herb, which measures 15-25 cm. above soil. Leaves are radical. They attain maximum growth during the flowering season. The inner leaves are surrounded by a number of thick, fleshy and ovate leaf bases, which are about 3-4 cm. long and broad. Flowers are crowded to form heads on a 18-23 cm. long scape. Bracts are short, unequal and sometimes connate. Corolla is pale purple and salver-shaped.

M O R P H O L O G Y

Leaf (Plate IX-A, 1C) :

The plant produces about 12 leaves, each of which measures 7-15 cm. x 1-3 cm. A leaf is simple, dark green, ovate-spathulate, sheathing or decurrent at the base and obtuse. Margin is minutely toothed. It is slightly pubescent on the veins which are reticulate and prominent

on the lower surface. The side veins leaving the broad grey midrib go obliquely upwards and towards the margin. Veinlet enters each one of the small dentations of the margin to end there. Lowermost veins run down to supply the short and winged petiole. Texture is papery and brittle.

Rhizome :

The short, stunted rhizome is bent and tortuous. It gives out 10-12 roots from the ventral side. Growth is horizontal. Colour is dark-brown.

Root (Plate IX-A, 1A & 1B)

Each root is approximately 25 cm. long, straight and buff coloured. Outer surface shows prominent, straight and longitudinal wrinkles which form ridges and furrows nearer the rhizone. The wrinkles become gradually faint towards the tip. The upper part shows a few thin secondary rootlets, the remains of which are sometimes seen as scars. The lower part shows many such rootlets (Plate IX-A, 1A). A root measures 2.6-3.2 mm. across in the upper part. The middle and the end parts measure 1.5-1.7 mm. and 0.6-0.9 mm. respectively. Secondary rootlets measure 0.4-0.5 mm. across. A root breaks with a short and horny fracture when dry. The fractured surface is white, but has a buff coloured stelar region. In some cases a small pith is

Primula denticulata Smith

is present in the centre. Taste is acrid.

H I S T O L O G Y

Leaf :

Lamina is isobilateral (Plate IX - B,1). The mesophyll is entirely composed of rounded or oval cells of the spongy tissue. Epidermal cells are big and rectangular with straight anticlinal walls. They bear glandular as well as smiple trichomes (Plate IX-B,3). The glandular trichomes are numerous and scattered all over the surface. The latter are found around the veins and veinlets on the lower surface. The glandular trichome possesses a unicellular stalk which bears a large spherical one celled and 14-30.5 μ diameter body.

In surface preparation, epidermis shows ranunculaceous stomata (Plate IX-B, 2A & 2B). Cells of the upper epidermis are large, possess fewer stomata and show small beads on their straight walls.

The mesophyll consists of homogeneous small cells with intercellular spaces (Plate IX-B, 1). The cells of the mesophyll are generally studded with chloroplasts but a few isolated ones may possess granular contents.

Primula denticulata Smith

The midrib projects much on the ~~dorsal~~ abaxial side (Plate XI,1). The projection, composed of large parenchymatous cells, works as a water storage tissue. Vascular bundle is lunar-shaped; xylem facing the adaxial and phloem the abaxial side. Vessels are arranged in 8-10 radial rows and xylem parenchyma in between. Cambium present between xylem and phloem remains inactive. A few isolated cells of phloem also show presence of granular cell contents.

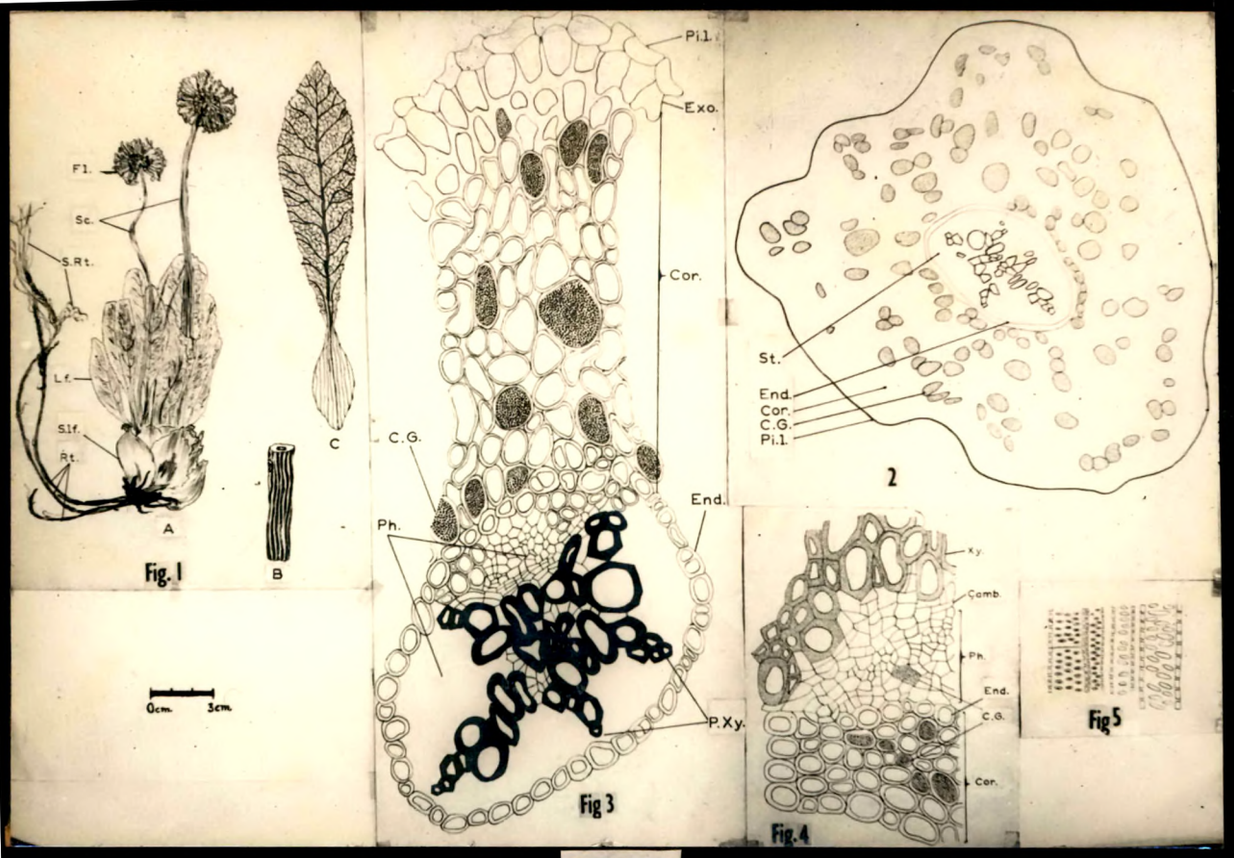
Leaf constants :

Stomatal index for the upper epidermis is 9.5-14.5 while the same for the lower epidermis is 8-12. Vein-islet number is 4-6.

Rhizome :

The structure of rhizome is complex as a number of leaf and root traces emerge out from the central vascular cylinder (Plate IX - B, 4). It also shows 1-2 branch traces.

On the outer side, the epidermis has large and thin walled cells. Cortex is wide and parenchymatous. A leaf trace appears as a crescent in the rhizome cortex. Its protoxylem points towards the centre. Root traces have exarch protoxylem and they appear circular in cross


Fl.
Sc.
S.Rt.
Lf.
S.lf.
Rt.
A
B
C
Fig. 1
0cm. 3cm.
Pi.l.
Exo.
Cor.
C.G.
Ph.
End.
P.Xy.
Fig 3
St.
End.
Cor.
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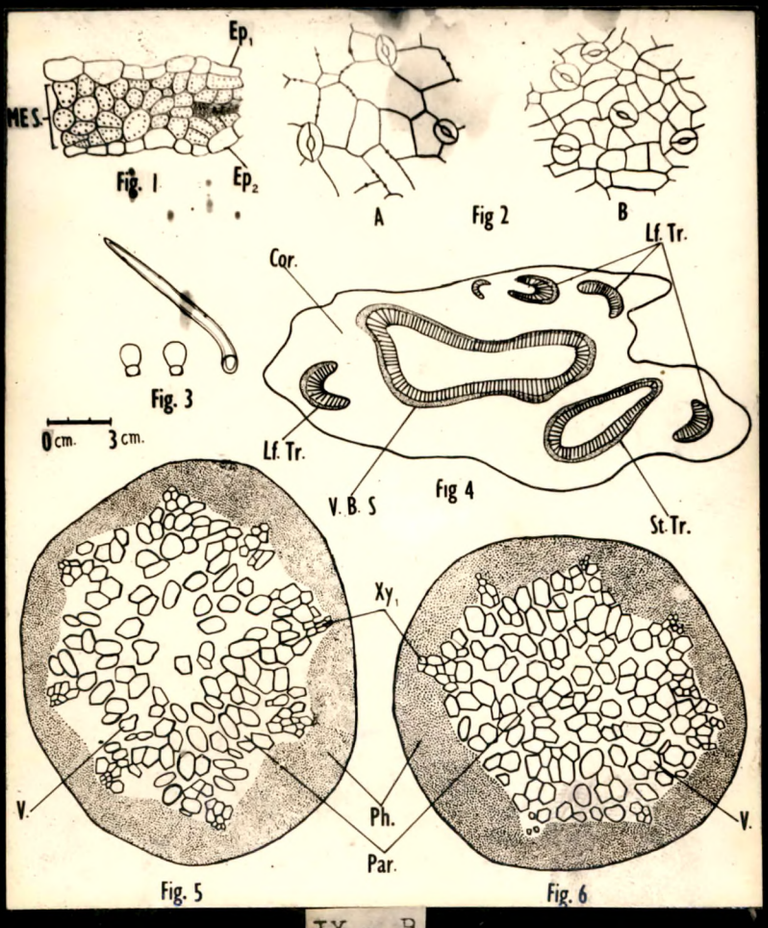
2
Xy.
Comb.
Ph.
End.
C.G.
Cor.
Fig.4
Fig 5

IX - A


Ep1
MES.
Ep2
Fig. 1
A
Fig 2
B
Lf. Tr.
Cor.
Fig. 3
0cm. 3cm.
Lf. Tr.
V. B. S
Fig 4
St. Tr.
Xy1
V.
Ph.
Par.
V.
Fig. 5
Fig. 6

IX - B

P L A T E - IX - A

Plate: IX-A (Figs. 1 - 5 : Primula denticulata Smith)

Fig. 1. A - Entire plant. x 1.

B - A piece of root. x 6.

C - A leaf. x 2.5

Fig. 2. T.s. root (diagrammatic). x 320.

Fig. 3. T.s. root magnified. x 750

Fig. 4. T.s. root showing a portion of xylem, phloem and cortex. x 750.

Fig. 5. L.s. root showing pitting on the vessels. x 750.

Plate: IX-B (Figs. 1 - 6 : Primula denticulata Smith)

Fig. 1. T.s. Lamina showing isobilateral condition. x 440.

Fig. 2. A - Upper epidermis showing stomata and beaded cell wall. x 250.

B - Lower epidermis showing stomata. x 250.

Fig. 3. Covering and glandular trichomes. x 440.

Fig. 4. T.s. rhizome showing leaf and branch traces (diagrammatic). x 250.

Fig. 5. T.s. root showing octarch stele (diagrammatic). x 250.

Fig. 6. T.s. root showing heptarch stele (diagrammatic).x 250.

x-x-x-x-x-x

Camb. - cambium; Cor. - cortex; C.G. - cell with granular contents; End. - endodermis; Exo. - exodermis; Fl. - flower; Lf. - leaf; Ph. - phloem; Pi.L. - piliferous layer; P.Xy. - primary xylem; Rt. - root; Sc. - scape; St. - stele; S.Rt. - secondary root; S. lf. - leaf base.

Primula denticulata Smith

section. The branch traces resemble the vascular bundles of the rhizome. A distinct endodermis having thick radial walls delimits the cortex from the stelar region.

Secondary growth starts at a very early stage and shows a single ring of closed vascular cylinder. The cells of the parenchymatous pith are pitted.

Root :

The transverse section of the root shows an uneven outline in conformation with the ridges and furrows (Plate IX-A, 2). The outermost piliferous layer consists of thin-walled cells which are elongated tangentially (Plate IX-A, 3). Some of these cells show peg-like projections, which probably increase the absorbing region and function like root hairs. In old root, this layer gets crushed and in that condition persists as a lignified protective layer over the exodermis. Exodermis consists of a single layer of large cells, which persists even in old roots.

The broad cortex is parenchymatous (Plate IX-A, 3). It has big rounded cells with intercellular spaces which are clearly seen when treated with chloral hydrate. In old roots, 2-3 outermost layers of the cortical parenchyma thicken much (Plate IX-A,3). Endodermis consists of a single layer of thick-walled rounded or oval

Primula denticulata Smith

and sometimes septate cells. Pericycle is indistinct. The central exarch stele varies from triarch to octarch though pentarch condition is dominent (Plate IX-A, 2 & 3); Plate IX-B, 5 & 6). In a pentarch stele, five radiating xylem groups alternate with the same number of phloem groups. Small parenchymatous pith which is present in the young root gradually reduced and replaced by xylem in the old root. Xylem consists of only vessels which show elongated bordered pits as well as reticulate type of wall thickening (Plate IX-A, 5). Cambium is distinct and two layered. Phloem consists of sieve tubes, companion cells and phloem parenchyma.

T A B L E - 9

Measurements of root elements

Elements	Lenth	Width
Vessel	97-135-176-206-255 μ	21-37-52 μ
Parenchyma	150-229-289-334-480 μ	30-43-56-71-90 μ

Granular contents :

Grannular contents are present in isolated cells of the lamina, midrib, rhizome and root. The contents of the phloem cells of the root are stained orange red

with 10% iodine solution, while those of the cortical and phloem cells in the root are stained brown with ferric chloride and iodine solutions; with sudan III, they are stained orange red.

Starch :

Simple as well as compound starch grains of 3 - ∞ components occur in the parenchymatous cells of the rhizome and root. Simple grains of the root are mostly ellipsoidal; and often fissured; they measure 9-23 μ in diameter.

D I S C U S S I O N

Metcalfe and Chalk (1950) report confinement of ranunculaceous stomata either to lower or to both the upper and the lower epidermises in Primula. In the present work, they are found on both the dermal surfaces. Beads on dermal walls of upper epidermis are observed here for the first time. Lamina of P.nivalis consists of homogenous small cells with intercellular spaces; midrib has cresentric or circular vascular bundle (Metcalfe and Chalk, 1950). Lamina of P. denticulata studied here consists of homogenous rounded or polygonal cells; the midrib possesses a large cresent-shaped vascular bundle.

Cells of the piliferous layer in root of

Primula denticulata Smith

Primula viris Linn. and P.vulgaris Huds. according to Metcalfe and Chalk (1950) are prolonged to form short hairs. In members of the sections Amethystina, Muscarioides and Candelabra they are absent. Only peg-like projections are observed in P.denticulata. This may be attributed to environmental conditions. The species of Primula having divided endodermal cells also show development of secondary tissues in the vascular cylinder (Metcalfe and Chalk, 1950). In the present work, though divided endodermal cells are present, development of secondary tissues is not observed. Vascular bundles are also reported to possess 2-11 xylem poles and a broad zone of parenchymatous pith (Metcalfe and Chalk, 1950). Here, the stele shows 3-8 exarch xylem poles while only a small parenchymatous pith present in young root is gradually replaced by xylem in the old root.

Thin cuticle on epidermis of leaf, homogenous small parenchymatous cells of the lamina and less chloroplasts show that the plant is a mesophyte.

S U M M A R Y

Leaf is isobilateral. It is entirely composed of rounded or oval cells. Epidermis bears covering as well as glandular trichomes. In surface view, cells of the upper epidermis show small beads on their walls.

Primula denticulata Smith

Ranunculaceous stomata are present on both the surfaces. Midrib, which is prominent on the ~~dorsal~~ abaxial side, possesses a big arc-shaped vascular bundle. Isolated cells in the lamina and also around the midrib vascular bundle contain some granular contents.

The wide parenchymatous cortex of the rhizome shows a few leaf traces as well as root traces. The endodermis has cells with thick radial walls. Rhizome shows secondary growth.

Piliferous layer in a young root, consists of peg-like projections. Exodermis persists in old roots as well. Cortex is wide and parenchymatous. Endodermis has a few septate cells. Xylem is generally pentarch. Rarely there may be 3-8 protoxylem groups. Young root has a small parenchymatous pith in the centre which is replaced by xylem at a later stage. Xylem of root consists only of vessels which show elongated bordered pits. Reticulate thickening is also met with. Starch is present in form of simple as well as compound grains.

7 - Anagallis arvensis Linn.

Anagallis arvensis Linn. is a herb common over the greater part of India. It ascends to an altitude of 8,000 ft. in the Himalayan region (Chopra, Bhadwar and Ghosh, 1949). It grows wild in Gujarat during November to April.

The plant is used as a bitter tonic in rheumatism, scurvy and pulmonary complaints. It is also reported by Thakar (1952) to promote growth of foetus in arrested uterus. According to Kirtikar and Basu (1933) and Chopra, Bhadwar and Ghosh (1949), it was once used in epilepsy, mania, hysteria and derillium in the European countries. Not only was it reputed for the enlargement of liver and spleen but was also applied on dropsy, emaciation, stone, plague and bites of serpents etc. In the indigenous medicine as reported by Chopra, Bhadwar and Ghosh (1949), this plant has the reputation of being useful in gout and dropsy and as a remedy for snake bite; it is used in India to intoxicate fish and to expel leeches from the nostrils of livestock. Bitterish and somewhat acrid to taste, it has poisonous effects producing gastro-enteritis in dogs and horses.

Chopra, Bhadwar and Ghosh (1949) report that a pungent, acrid volatile oil isolated from this plant by

Anagallis arvensis L.

Heintzelman when administered orally produces intense headache and nauses accompanied by pains throughout the body lasting for 24 hours. It has also been reported by Chopra, Bhadwar and Ghosh (1949) to contain two glucosidic saponins; a third saponin called as cyclamine, was found in the root.

Description of the plant (Plate X, 1) :

The plant is an erect or procumbent annual, usually ~~usually~~ branched from the base. It measures 13-47 cm. in length. The vegetative organs show opposite and decussate arrangement. Axillary and solitary flowers are born on slender and erect peduncle 12-40 mm. long. Calyx is 6.5 mm. long. It is divided right upto its base into narrow, lanceolate and acuminate lobes. The blue rotate corolla is 9-13 mm. in diameter. Each of the five stamens is provided with a villous filament. The capsule raised on a decurved stalk bears a persistent style at the top. Many minute and trigonous seeds are liberated from the capsule when the operculum is detached by a transverse split in the middle of the capsule.

M O R P H O L O G Y

Leaf :

Leaf is sessile, exstipulate, ovate,

Anagallis arvensis L.

acute and entire. It is papery and pubescent in texture. It measures 1-2.6 c.m. by 0.7-1.2 cm. Glands in the form of small rounded swellings are scattered all over the pale green lamina. Lower surface has numerous black markings. 3-7 anastomosing veins compose the vascular supply of the lamina.

Stem :

Stem and branches are four angled. The base of the main stem may be circular. The main stem or its branch is green in colour, soft, straight and 10.5-39 cm. long. Nodes are slighly prominent and the internodes measure 2-5.5 cm. Stem and branches show fine lognitudinal striations. The former at four points gives out wing-like outgrowths which form four shallow channels. Internodes of old stem at times become hollow but the nodal parts remain solid.

Root :

The thin, wiry and often undulated tap root is 9-11 cm. long and yellowish or light brown in colour. It exhibits longitudinal striations and also shows a number of raised protuberances which are the scars of the detached secondary rootlets.

Anagallis arvensis L.

M I C R O S C O P Y

Leaf :

Lamina is generally isobilateral but rarely dorsiventral and about 94 μ thick (Plate VIII-B, 13; Plate X, 2). It is very soft and delicate. Cells of the upper epidermis are comparatively bigger and possess less wavy cell walls than those of the lower epidermis (Plate X, 3A & 3B). Both the upper and lower epidermis are interrupted by ranunculaceous stomata, which immediately lead to the respiratory cavities. A thick layer of cuticle covers the upper epidermis, the cells of which are having straight anticlinal walls. Mesophyll is differentiated into palisade and spongy tissues or latter alone, with 3-7 vascular bundles embedded in it. A small veinlet or two are often cut obliquely. In a dorsiventral leaf, palisade consists of elongated compact cells studded with chloroplasts (Plate X, 2). At places, this layer is interrupted by the respiratory cavities. Spongy tissue consists of rounded or oval cells separated by conspicuous intercellular spaces. When the leaf is isobilateral, the spongy tissue consists of about four cell layers (Plate VIII-B, 13).

Midrib is weakly developed. The epidermis above the midrib runs through a slight depression (Plate X, 4). Xylem consists of three or four radiating rows of

Fig. 1

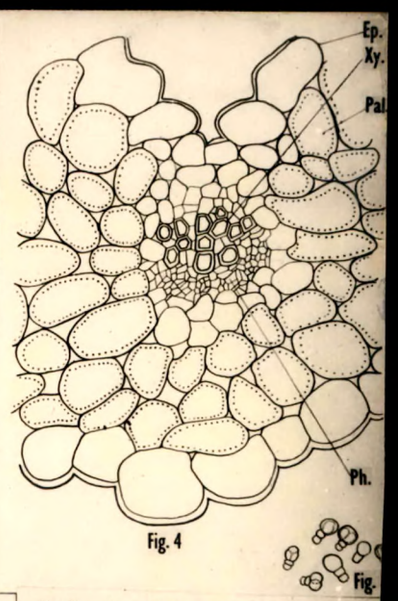


Fig. 4

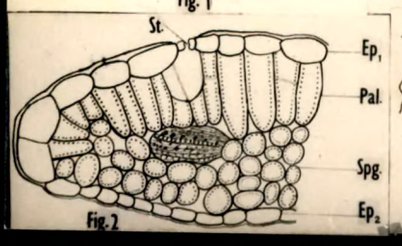


Fig. 2

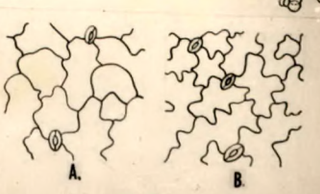


Fig. 3

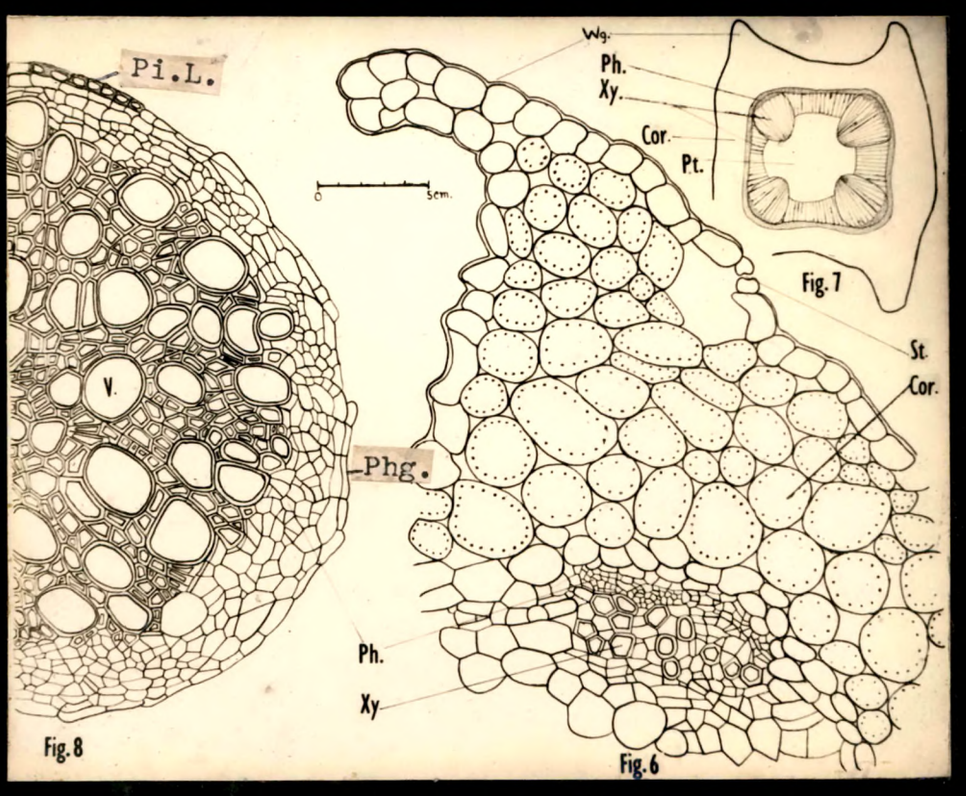


Fig. 8

Fig. 6

Fig. 7

P L A T E - X

(Figs. 1 - 8 : Anagallis arvensis Linn.)

Fig. 1. Entire plant. x 1½.

Fig. 2. T.s. lamina. x 440.

Fig. 3. A - Upper epidermis with stomata. x 260.

B - Lower epidermis with stomata. x 260.

Fig. 4. T.s. midrib. x 780.

Fig. 5. Glandular trichomes. x 260.

Fig. 6. T.s. young stem. x 780.

Fig. 7. T.s. old stem (diagrammatic). x 70.

Fig. 8. T.s. old root. x 440.

x-x-x- x -x-x

Cor. - cortex; Ep. - epidermis; Ep_1 - upper epidermis;

Ep_2 - lower epidermis; Fl. - flower; Ft. - fruit;

Pal. - palisade; Ph. - phloem; Phg. - phellogen;

Pt. - pith; Pi.L. - piliferous layer; Rt. - root;

Spg. - spongy; St. - stomata; Wg. - wing; Xy. - xylem.

Anagallis arvensis L.

vessels and xylem parenchyma in between ~~rows~~. Phloem, situated below the xylem, consists of all the usual elements. Typical cambial cells in a layer or two are situated between the xylem and the phloem. 3-5 layers of parenchymatous cells intervene between the epidermis and the vascular bundle. Vascular bundles that are present in the lamina are structurally identical to the midrib bundle.

Leaf constants:

Stomatal index for the upper epidermis is 19-22.25 and that for the lower one is 23.7-26.6. The average number of palisade cells below each epidermal cell is 3-4.5 while the vein islet number comes at 0-1-2.

Stem :

The transverse section of a young stem measures 188 μ x 185 μ . Epidermal cells are enlarged, cubical or tangentially elongated with straight anticlinal walls (Plate X, 6); they are well protected by a thick cuticle externally. At each of the four corners, the epidermis forms a thin outgrowth, due to which, the stem appears winged (Plate X, 6 & 7). Stomata with guard cells are quite frequent on the stem, so also the trichomes. As observed in hand sections, glandular trichomes with uni- or bicellular stalk and uni- to quadricellular head measure 188-197.5 μ (Plate X, 5). Parenchymatous cortex shows prominent intercellular spaces. It consists of two or three

layers of cells containing chloroplasts. It is more massive at the corners where it is about eight cells thick. Endodermis is inconspicuous as its tangentially elongated cells are quite small in size.

The stele consists of four vascular bundles, one in each of the four corners (Plate X, 6 &7). Besides, there are four broad medullary rays made up of rounded or polygonal cells and a large central pith, the inner side of which comprises of pitted parenchyma. Weakly developed endarch xylem consists of 5-6 radiating rows of vessels with intervening medullary rays. Phloem possesses sieve tubes, companion cells and phloem parenchyma. Only a single layer of cambium is present in between xylem and phloem. As branching is opposite and decussate, the opposite pairs of branch ~~traces~~ primordia originate alternately from the pericycle (Plate XI, 2).

Old stem is also four angled (Plate X, 7). A typical sample measures 446.5 μ in width. Its epidermis shows only a few glandular trichomes. Chloroplasts also persist in the cortical parenchyma of the mature stem. Cells of the endodermis show much periclinal stretching and lignin is deposited on their anticlinal walls. Pericyclic fibres are absent. Cambium strips of the vascular bundles extend on lateral sides to form a cambium ring which produces secondary vascular tissues in the usual way.

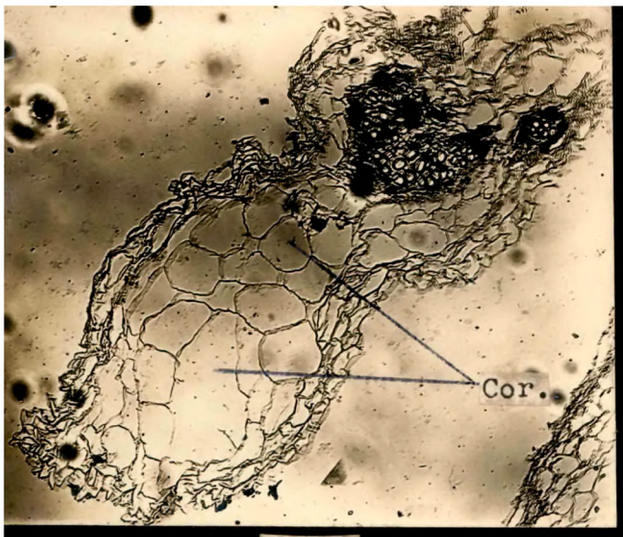


Fig.1

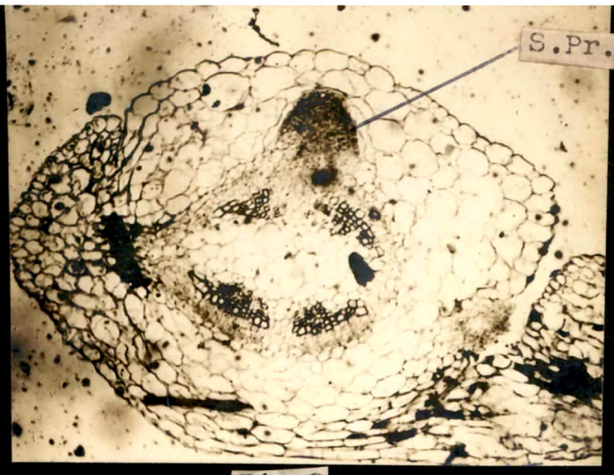


Fig.2

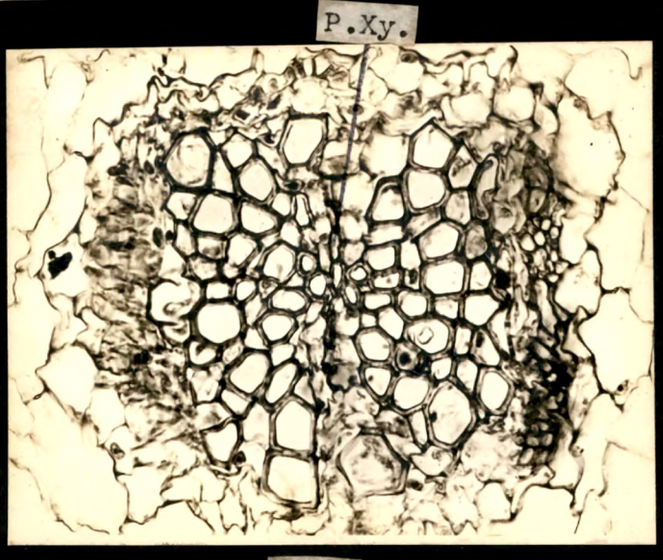


Fig.3

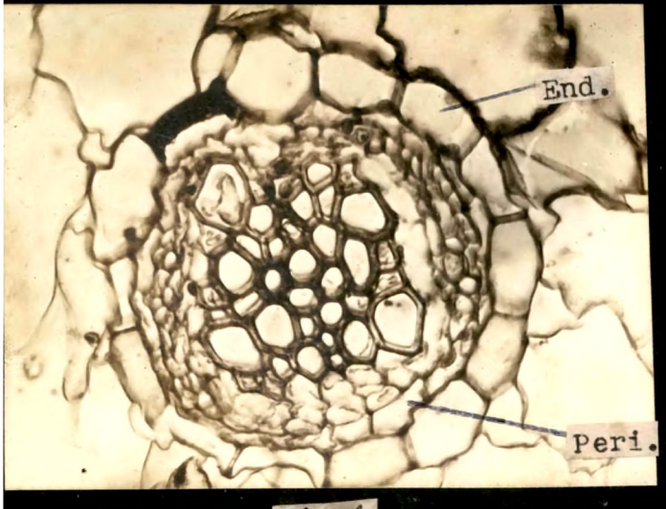


Fig.4

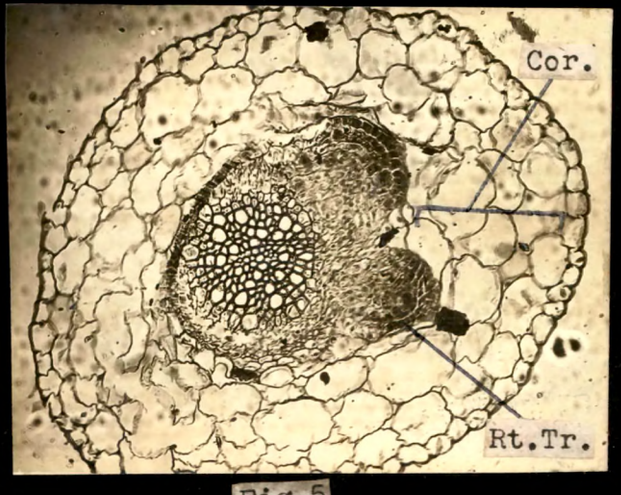


Fig.5

P L A T E - XI

(Fig. 1 : photomicrograph of Primula denticulata smith;
Figs. 2 - 5 : Photomicrographs of Anagallis arvensis Linn.)

Fig. 1. T.s. midrib; note the prominent projection on the abaxial side. x 120.

Fig. 2. T.s. young stem showing ~~Stem~~ branch primordia. x 66.

Fig. 3. T.s. young root, showing diarch condition x 430.

Fig. 4. T.s. root; note distinct endodermis and pericyclic cells. x 430.

Fig. 5. T.s. root, showing the emergence of lateral root primordia. x 110.

x-x-x-x-x-x

Cor. - Cortex ; End. - endodermis ;

S.Pr. - ~~Stem Primordia~~ branch ; Peri. - pericycle ;

P.Xy. - proto xylem; Rt. Tr. - root trace.

Anagallis arvensis L.

Due to the addition of secondary tissues, the pith diminishes in size. Thus, at the stem base, pith is hardly 4-6 celled and shows four opposing groups of primary xylem (Plate VIII-B, 14).

Xylem in old stem consists of vessels and tracheids only. Vessels mostly occur singly and show bordered pits on their walls. Tracheids also show pits of the same type. Phloem consists of the usual components. Secondary medullary rays are indistinct.

T A B L E - 10

Measurements of stem elements

Elements	Length	Width
Vessel	141-202-261.4-315-423 μ	18-30-39.5 μ
Tracheid	150.5-230-304-363-437 μ	17-23.5-37.6 μ

Root :

Young root is diarch and is softer than the stem (Plate XI, 3). Initially, it develops a cambium ring. The cambium strips on the underside of the two phloem groups become active earlier than those on the upper sides of the

Anagallis arvensis L.

xylem groups. This activity results into a circular cambium ring. Opposite the primary xylem, the cambium produces parenchyma to initiate formation of two opposite secondary medullary rays (Plate XI, 3). Cortex is parenchymatous and 3-4 cells wide (Plate XI, 5). Single layer of pericycle initiates development of secondary roots (Plate XI, 4 & 5). Endodermis is also distinct.

Old root lacks turgidity of the young root (Plate X, 8). The observed maximum diameter of a root is 131.6 μ. Primary xylem is not distinguishable, while secondary xylem consists of vessels, tracheids and xylem parenchyma. The vessels are having bordered pits on their walls. Tracheids also show pits of the same type. Secondary medullary rays are inconspicuous. Cambium is distinct while phloem which constitutes a small zone, consists of all the components. Phelloderm development has not yet commenced. Phellogen is observed only at places where it is single layered. Thick-walled cells of the piliferous layer are observed at places (Plate X, 8).

Anagallis arvensis L.

T A B L E - 11

Measurements of root elements

Elements	Length	Width
Vessel	174-201-268-310-367 μ	40-47-59 μ
Tracheid	230-282-332-390-451 μ	14-20.5-28 μ

D I S C U S S I O N

Both one celled glandular trichomes and ranunculaceous stomata as reported in Anagallis (Metcalfe and Chalk, 1950) are found in the present study also. It may also be stated that dorsiventral as well as isobilateral conditions of the lamina have not been reported previously.

Winged stem with four vascular bundles one against each of the four angles of the stem and absence of pericyclic fibres as observed here, have been reported by Metcalfe and Chalk (1950). They however have failed to mention glandular trichomes on stem.

Glabrous leaf, isobilateral or rarely dorsiventral lamina and thin cuticle on epidermis show that the plant lives in mesophytic habitat.

Anagallis arvensis L.

S U M M A R Y

Both isobilateral as well as dorsiventral conditions are prevalent in the leaf. Stomata are ranunculaceous. Vein islet number is quite low (0-1-2).

Young stem is green and four angled. Stem epidermis bears trichomes with heads consisting of 1-4 cells. Each of the four angles of a stem is occupied by a vascular bundle. Secondary growth is of normal type.

Young root is diarch. Secondary growth is of normal type.

8 - Dodonaca viscosa Linn.

Dodonaea viscosa Linn. is a shrub or a small tree growing in warm countries. It is reported throughout India, Ceylon and Malacca by Nadkarni (1954). In Gujarat, it finds its place in garden fencing.

Leaves of D.viscosa according to Nadkarni (1954) are used as alterative, laxative and in rheumatism. They are used as febrifuge in Madagaskar and chewed as a stimulant in Peru. Their infusion is considered as sudorific in La Reunion. Kirtikar and Basu (1933) report the use of the decoction of the wood for astringent bath in Madagaskar, and the employment of the entire plant for stomachic disorders in South Africa. They have also reported the use of powdered leaves for wounds, burns and scalds. The juice of the leaves is used as a wash on swellings and also used as a poultice (Kirtikar and Basu, 1933).

According to Nadkarni (1954), leaves contain gums, albumen and tannin besides two acrid-resins; an alkaloid saponin has also been reported from the leaves.

Description of the plant (Plate XII) :

Dodonaea viscosa Linn. has twiggy branches, mostly angled and softly pubescent. Leaves are simple, alternate and tristichous. They contain a yellow resinous exudation. Small greenish-yellow, unisexual flowers occur

Dodonaea viscosa Linn.

in short few flowered cymes. Each of the 8 stamens bears an oblong-linear anther as long as the sepal. Ovary is 2-3 angled, hairy externally and possesses a long style. Capsule is membranous. It is notched at the base and the apex and has 2-3 wide marginal wings.

M O R P H O L O G Y

Leaf: (Plate VII, 1) :

A leaf is simple, entire, subsessible, oblanceolate with a subacute or shortly apiculate apex and a much tapering base. Its viscid, glabrous, shining surface possesses dark green colour. It measures 4-10 cm. x 0.5-1.5 cm. and has reticulate venation. Marginal veins anastomose. Taste is mucilagenous and slighly bitter.

Stem :

Stem and branches are woody. Each is many angled or cylindrical. Nodes are prominent and internodes are 2-3 cm. long. Uppermost part of a young branch is greenish and prominently angled. This part develops thin, brown bark as it grows old. An old branch shows

longitudinal striations, some of which are so prominent that the branch appears a little angled. Besides, it bears numerous small, amorphous yellowish masses which can be removed easily. The brownish outer part of a branch usually splits longitudinally into lenticular areas exposing the inner cortex. Wood is dark-brown, hard and heavy.

Root (Plate XII, 1) :

Roots are long spreading and dark-brown in colour. Young root shows minute tubercle-like swellings which commonly develop into big knot-like structures at a later stage. Occassionally, rootlets may emerge from the tubercles in addition to the nontubercular parts. They give a clay-like consistency to the root powder.

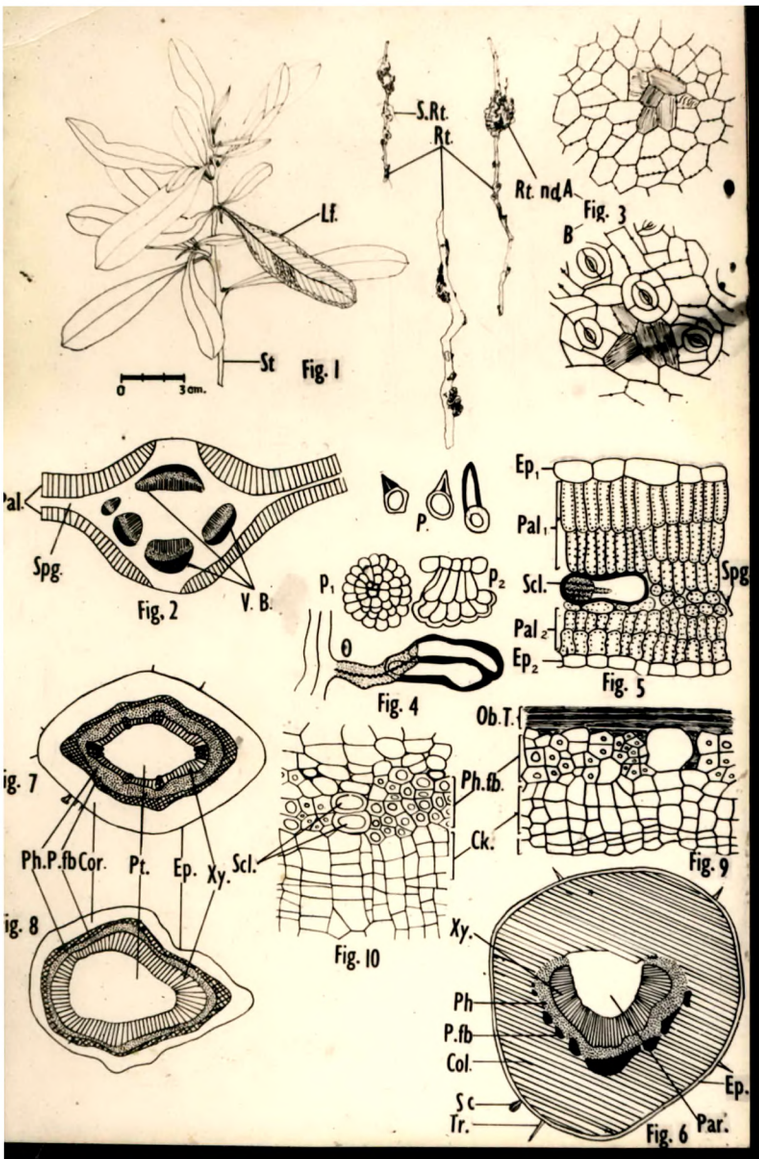
H I S T O L O G Y

Leaf (Plate XII) :

Transverse section of the leaf shows isobilateral lamina, as palisade is present under both the upper and the lower epidermis (Figs. 2 & 5). The enlarged cells of the upper epidermis are tabular in shape; they possess straight anticlinal walls (Fig. 5). Thick layer of cuticle protects both the dermal surfaces. In surface view, the polygonal cells of both the epidermises show

Dodonaea viscosa Linn.

beads on their walls and exhibit straight, wavy or interruptedly wavy cuticular striations (Fig. 3A & 3B). Cells of the upper epidermis are however, relatively straight walled and show more beads; cuticular striations are also more prominent here. Cells of the lower epidermis and the cells around the veins on the upper epidermis are interrupted with numerous small rubiaceous stomata. Unicellular trichomes as well as multicellular peltate scales are present on both the surfaces; the former mostly appear on the veins or on the margin while the latter are scattered throughout the lamina (Fig. 4 p, p_1 & p_2). Trichomes found around the veins are longer, measure 70.5-188 μ in length and are abundant on the upper surface; those of the margin are shorter and measure 66-90 μ in length. Peltate scales measure 88-120 μ in diameter and are found scattered on both the surfaces. A vein termination is well protected by a group of sclereids (Fig. 4 o.). 2-3 layers of elongated cells of the palisade are present below the upper epidermis. The two layers of palisade cells below the lower epidermis are relatively shorter and possess more wavy anticlinal walls. 2-3 layers of rounded or oval cells in the centre and in between the upper and lower palisade layers, constitute the spongy tissue.(Fig. 5). Veins and veinlets are cut transversely or commonly obliquely in the laminar region. They are surrounded by a bundle sheath which can be observed only after clearing the sections with chloral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3cm.
Fig. 1
S.Rt.
Rt.
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A
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Fig. 6

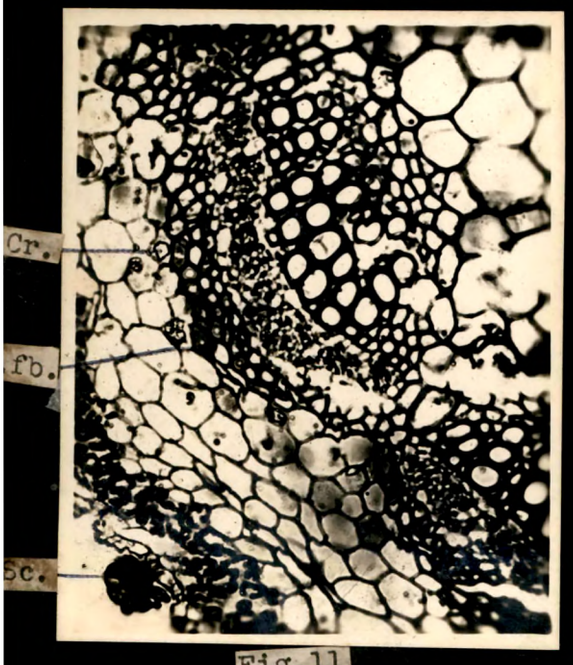
Cr.
fb.
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Fig.11

P L A T E - XII

(Figs. 1 - 11 : Dodonaea viscosa Linn; Fig. 11 : photomicrograph)

Fig. 1. Twig of Dodonaea viscosa Linn. showing leaves, stem and root. x 1.

Fig. 2. T.s. leaf passing through midrib (diagrammatic). x 70

Fig. 3. A - upper epidermis with prominent cuticular striations. x 250.

B - Lower epidermis showing stomata and cuticular striations. x 440.

Fig. 4. P - trichomes. x 440.

P_1 - peltate scale. x 440.

P_2 - L.S. peltate scale. x 780.

O - Vein ending surrounded by sclereids. x 440.

Fig. 5. T.s. lamina. x 440.

Fig. 6. T.s. petiole (diagrammatic). x 250.

Fig. 7. T.s. young stem (diagrammatic). x 70.

Fig. 8. T.s. young stem (diagrammatic). x 70.

Fig. 9. T.s. stem, showing phellogen development in the phloem region. x 440.

Fig.10. T.s. old stem, showing development of sclereids among phloem fibres. x 440.

Fig.11. T.s. midrib, showing a vascular bundle; note peltate scale and calcium oxalate crystal. x 120.

x-x-x-x-x-x-x

Ck - cork; Col. - collenchyma; Cr. - crystal; Ep. - epidermis; Ep_1 - upper epidermis; Ep_2 - lower epidermis; Lf. - leaf; Ob. T. - obliterated tissue; Pal - palisade; Pal_1 - palisade below upper epiermis; Pal_2 - palisade below lower epidermis; Par. - parenchyma; Ph - phloem; Pt. - pith; P.fb. - percyclic fibre; Ph.fb. - phloem fibre; P.Sc. - peltate scale; Rt. - root; Rt. nd. - root nodule; Scl. - sclereid; spg - spongy; St. - stem; S. Rt. - secondary root; Tr. - trichome; V.B. - vascular bundle; Xy. - xylem.

hydrate as the cells of the mesophyll are studded with chloroplasts.

Midrib slightly projects on the adaxial side but more so on the abaxial one (Fig. 2). In transection, palisade is discontinuous over and under the vascular ring. It reaches half way on both sides in the midrib (Fig. 2). The vascular ring is dissected into 4-6 conjoint, collateral and open vascular bundles. 3-5 of these form an arc on the abaxial side while the remaining one occupies the adaxial side. A group of pericyclic fibres form a protective arch towards the outer side of each vascular bundle (Figs. 2 & 11). Xylem of the bundle faces the inner side and consists of radiating rows of vessels and xylem parenchyma in between. Phloem faces the outer side and consists of sieve tubes, companion cells and phloem parenchyma. Cortex and pith of midrib are parenchymatous. However, cells in 2-3 layers below the upper and the lower epidermises in the midrib may turn collenchymatous.

Leaf Constants :

Dodonaea viscosa Linn.

T A B L E 12

Stomatal Index

Leaf surface	Location*			Range of variation	Mean value
	Base	Middle	Apex		
Upper	0	0.95	0	0-1.29	0.32
Lower	6.7	7.2	5.6	5.3-8.2	6.5

T A B L E 13

Palisade Ratio

Upper	8.8	8.75	7.2	5-12.5	8.25
Lower	3.7	4.5	4.65	2.25-7	4.28

T A B L E 14

Vein Islet Number

Location*			Range of variation	Variation
Base	Middle	Apex		
14	9.8	12.5	8-18	15.4

* values are mean of 12 readings for each of the leaf parts.

Dodonaea viscosa Linn.

T A B L E - 15

Peltate scales per sq. millimeter

Location*			Range of Variation	Variation
Base	Middle	Apex		
9	6.4	14.6	3-19	10

Petiole (Plate XII) :

Transection of petiole is sub-spherical in shape (Fig. 6). Its epidermis bears peltate scales as well as trichomes, as in the leaf. Cortex is collenchymatous. Xylem of the stele takes the form of a strongly developed arc. Xylem and phloem of the stele as usual face adaxial and abaxial sides respectively. Groups of lignified fibres arrange into a discontinuous arc on the abaxial side of the stele (Fig.6). The channel on the adaxial side, formed by the ends of the xylem is parenchymatous (Fig. 6).

Stem (Plate XII) :

Transverse section of young stem appears irregularly angled (Figs. 7 & 8). Secondary growth starts early, as a young stem of 968 μ x 660 μ or 935 μ x 715 μ ,

Dodonaea viscosa Linn.

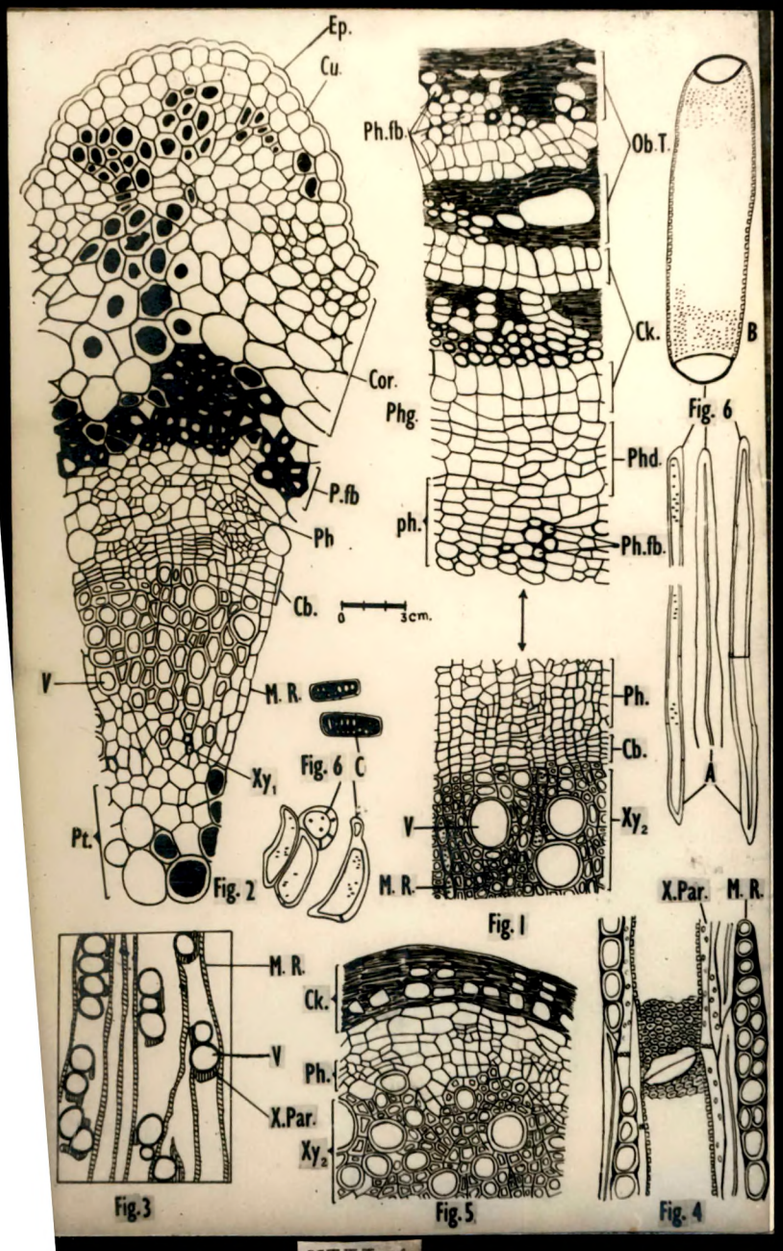
shows secondary growth. To initiate with, about six primary xylem groups are visible. The young stem is protected from outside by a thick cuticle. Its epidermis bears trichomes and multicellular peltate scales. Cortex is parenchymatous; occasionally however, two hypodermal layers of small spherical cells may develop cellulose thickening at the corners. Inner cortex is composed of large parenchyma cells with distinct intercellular spaces. Pericyclic fibres form a complete ring encircling the vascular tissues. Secondary phloem zone is as large as xylem. Cambium is 2-6 layered. Pith is parenchymatous.

Trichomes and peltate scales are also present in the portion of the stem very close to the apex where the primary xylem groups become obscute.

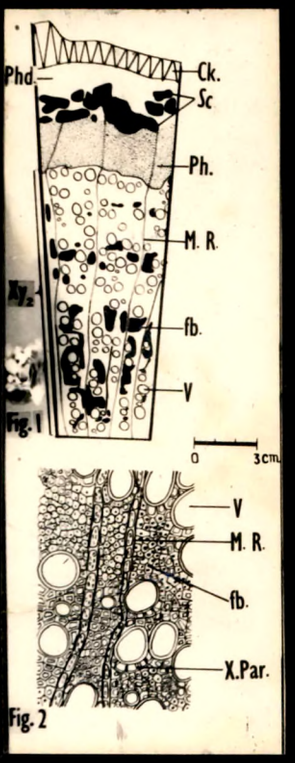
Two layers of phellogen originate from the inner side of the pericyclic fibres (Plate XII, 9 & 10). The first phellogen so originating remains active for a short time, during which it gives out 3-5 layers of cork cells towards its outer side and 2-3 layers of phelloderm towards the inner side. Cork cells are thin-walled, lignified and suberised and almost isodiametric. Tissues external to the cork, usually get crumpled to form an obliterated mass. This mass is rhytidoma, as it consists of cork, phloem, phloem fibres and phelloderm (Plate XIII-A, 1). While the activity of the first phellogem is going on, isolated cells of phloem starts depositing lignin (Plate XIII - A, 1). Thus, groups of phloem

cells modify into fibres which later on form a ring. The cells of the phloem rays here, occasionally transform to form sclereids (Plate XII, 10). When the activity of the first phellogen ceases, a new one starts into origin within the ring of phloem fibres and sclereids. Thus, in an old stem rhytidoma consists of not more than three alternate layers of cork, and obliterated mass (Plate XIII-A, 1).

Phloem is a wide zone which is composed of all the usual elements. Cambium is distinct and 2-5 layered (Plate XIII-A, 1 & 2). Xylem forms the wood of the stem. It consists of vessels, tracheids, xylem parenchyma, secondary medullary rays and fibres. Vessels mostly occur in radial groups of 2-5 (Plate XIII-A, 1 & 3). Often a large vessel may show tylosis. Their lignified walls may show hexagonal bordered pits with slit-like openings or more commonly scattered slit-like bordered pits (Plate XIII-A, 4). A few tracheids present are mostly fibro-tracheids. Fibres are numerous and appear in masses. They are mostly septate and hardly show a few pits. Some of the fibres also show branched ends. Xylem parenchyma are mostly of vesicentric type and possess many big oval pits. Secondary medullary rays are generally uniseriate, though biseriate ones are not uncommon (Plate (Plate XIII-A, 4). A ray is 2-44 cells long or occasionally even more so. Cells of the ray are radially elongated, and show spherical pits on their wall. In an old stem these cells become much lignified.

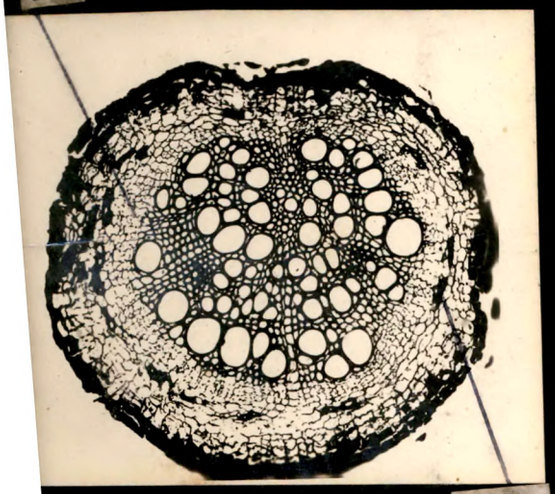


XIII-A



XIII-B

Ph.



XIII-B, 3

P.fb.

Par.

XIII-B, 4

P L A T E - XIII - A

(Fig. 1 - 6 : Dodonaea viscosa Linn.)

Fig.1 - T.s. outer part of an old stem. x 440.

Fig.2 - T.s. young stem; note cell contents. x 780.

Fig.3 - T.s. old stem showing the central wood (diagrammatic). x 250.

Fig.4 - T.l.s. wood, old stem. x 440

Fig.5 - T.s. old root. x 780.

Fig.6 - Maceration of root piece : A-tracheid and septate and unseptate fibre. x 440; B - a vessel element; C - sclereids and pitted parenchyma. x 440.

P L A T E - XIII B

(Figs. 1 - 4 : Dodonaea viscosa Linn; 3 & 4 : Photomicrographs)

Fig. 1 - T.s. old root (diagrammatic). x 250.

Fig. 2 - A portion of vascular tissue of root magnified. x 440.

Fig. 3 - T.s. root showing eccentric growth; note pericyclic fibres. x 86.

Fig. 4 - T.s. root, from a nodule region showing parenchyma invading xylem portion. x 50.

x-x-x-x-x-x

Cb - cambium; Ck. - cork; Cu - cuticle; Cor - cortex; Ep. - epidermis; fb. - fibre; Ob.T. - obliterated tissue; Par. - parenchyma; Ph. - phloem; Phd. - phelloderm; Phg. - phellogen; Pt. - pith; P.fb. - pericyclic fibre; Ph.fb. - phloem fibre; M.R. - medullary ray; Sc. - sclerenchyma; V - vessel; Xy_1 - primary xylem; Xy_2 - secondary xylem; X. Par. - xylem parenchyma.

Dodonaea viscosa Linn.

T A B L E - 16

Measurements of stem elements

Elements	Length	Width
Vessel	183-230-303.5-381-426 μ	34-54.5-80 μ
Tracheid	188-250-324-357-428 μ	14-21.5-28 μ
Fibre	42-68.6-80-141-164.5 μ	20-31-42 μ
Pitted Parenchyma	34-59-76 μ	16.5-25-34 μ
Cork	17.8-26.8 μ	17-28 μ

Root (Plate XIII, A & B)

A young root of 167 μ diameter exhibits secondary growth (Plate XIII-A, 5). Phellogen throws off the primary cortex and develops 5-6 layers of thin-walled radially elongate cork cells on its outer side. Transverse section of a root at a nodule shows development and multiplication of parenchyma towards the infected side; this parenchyma may invade xylem. Small groups of pericyclic fibres are also present (Plate XII-B, 4).

Secondary growth in an old root may be eccentric (Plate XIII, 3 & 4). In a 825 μ diameter old root,

Dodonaea viscosa Linn.

3-4 layers of cork cells are observed (Plate XIII, 3 & 4). Cells of the cork are thin-walled, lignified and are arranged radially; usually, they are filled with black to brown cell contents. Phelloderm is 2-3 layered. Groups of fibres associated at times with a few sclereids, delimit the phloem from the phelloderm region (Plate XIII, 3 & 4). At a later stage cells of the phelloderm also get modified into sclereids. These fibres or sclereids are surrounded by small parenchyma cells each containing a crystal of calcium oxalate. Cambium is distinct and is 2-4 cell layered. Phloem consists of the usual elements. Xylem forms the central solid core which is composed of vessels, tracheids, fibres, xylem parenchyma and secondary medullary rays. Vessels mostly occur in irregular groups of 2-4 (Plate XIII-B, 1,2,3 & 4). They show slit-like bordered pits on their wall. As in stem, most of them show pointed ends. A few big vessels may show tylosis. Tracheids are comparatively few and exhibit a few bordered pits. Fibres are numerous, mostly septate and show a few pits. As in stem, fibre form wide zones in root too (Plate XIII-B,1,2,3 & 4). Secondary medullary rays are mostly uniseriate.

Dodonaea viscosa Linn.

T A B L E - 17

Measurements of root elements.

Elements	Length	Width
Vessesl	181-229-285-343-398 μ	35-64-89 μ
Tracheid	195.5-274-329-376-470 μ	15.5-23.5-33 μ
Fibre	464-554-683-810-944 μ	11-20.5-33 μ
Sclereid	70-136-169 μ	28-35-42 μ
Pitted Parenchyma	47-94-128 μ	12-22-28 μ

Microchemical tests :

Calcium oxalate crystals :

Parenchyma and phloem of the midrib cortex and midrib vascular bundles respectively, parenchyma around the laminar vascular bundles, cortex of petiole and phloem of stem contain rosettes, cubes and diamond-shaped crystals of calcium oxalate. Rosettes of the midrib cortex and around the laminar vascular bundles are bigger in diameter (10.4-15.6-18 μ) than those present in the phloem of midrib vascular bundles, cortex of petiole and phloem of stem (5.2-7.8-10 μ).

Dodonaea viscosa Linn.

Tannin :

With ferric chloride, cell contents of cortex, phloem parenchyma, phloem ray and peripheral cells of pith in case of stem (Plate XIII-A, 1) and a few outermost cells of petiole as well as those around the pericyclic fibres turn bluish black, indicating the presence of tannin.

Mucilage:

Peresence of mucilage in leaf was tested according to Youngken (1951). It was found to be present in the cells of both the epidermises as well as cells of the bundle sheath.

Resin :

Presence of resin in leaf was also tested according to Youngken (1951). Cells of the second palisade layer below the upper as well as the lower epidermis chiefly show emerald green colour indicating its presence.

D I S C U S S I O N

Observations taken here on Dodonaea viscosa Linn. differ considerably from those taken on other species of Dodonaea. In the following table some observations of D.viscosa are compared with those cited by Metcalfe and Chalk (1950) and are presented here for the first time.

Dodonaea viscosa Linn.

T A B L E - 18

Dodonaea species (cited by Metcalfe & Chalk, 1950)	Dodonaea viscosa Linn. (studied here)
1. Dorsiventral or partly centric. Palisade on the upper surface only or all around.	Isobilateral, palisade present on both the surface.
2. Multicellular peltate scales present over the leaf surface.	Both multicellular peltate scales and unicellular covering trichomes present.
3. Ranunculaceous or rubiaceous stomata in different species of Dodonaea. No beaded thickening and cuticular striations reported in the epidermis.	Stomata are rubiaceous mostly confined to lower epidermis; beaded thickening on epidermal cell walls; prominent cuticular striations on the outer walls.
4. Calcium oxalate crystals not reported.	Calcium oxalate crystals are present.
5. Bundles many, separate, arranged in a ring.	A single, large, arc-shaped bundle.
6. Cork originates within pericyclic sclerenchyma in Dodonaea.	Cork originates on the inner side of pericyclic sclerenchyma in D. viscosa.

Dodonaea viscosa Linn.

Dodonaea species (cited by Metcalfe & Chalk,1950)	Dodonaea viscosa Linn. (studied here)
7. A second sclerenchymatous ring is formed in the phelloderm due to the activity of a phellogen strip originating there.	Second sclerenchymatous ring is formed in the secondary phloem; the phellogen originating on its inner side.
8. Repeated phellogen strips produce 2-4 layers of cork and sclerenchyma but no phelloderm layers.	Repeated phellogen strips form a rhytidoma which consists of 2-4 layers of cork, sclerenchyma and a few collapsed phelloderm layers in between.

Isobilateral leaf with palisade under both the surfaces, presence of covering trichomes and multicellular peltate scales and numerous chloroplasts in the palisades shows that the plant is a xerophyte.

S U M M A R Y

Leaves are isobilateral, there being palisade cells under both the surfaces. Epidermal cells show prominent

Dodonaea viscosa Linn.

cuticular striations. Leaves possess covering as well as multicellular peltate scales. Sclereids protect vein terminations. Midrib possesses a number of vascular bundles arranged in a ring.

Stem shows rhytidoma which consists of 2-3 alternate layers of cork, crushed phelloderm and sclerenchyma of phloem origin. Phellogen originates in secondary phloem. Vessels and tracheids bear bordered pits. Wide zones of fibres occur in the wood. There are 1-2 seriate long medullary rays.

Root at a nodule, shows much parenchyma development; this may invade the xylem. Growth of xylem is eccentric. Pericyclic fibres and calcium oxalate crystals are present in the stem and the root.

Leaf, petiole and stem contain calcium oxalate crystals. Tannin is present in young stem and petiole while resin and mucilage is found in the leaf.

9 - Smilax china L.

Smilax china L. according to Chopra (1956) is indigenous to Japan, China and Indo-China. According to Nadkarni (1954), it contains a fat, sugar, glucoside, colouring matter, 'saponin', gum and starch. The drug is used to some extent as a substitute for sarsaparilla in India. Its decoction is depurative, diaphoretic, stimulant, antisyphilitic, sudorific, demulcent, tonic and aphrodisiac. Fat soluble portion is taken internally in rheumatism, gout, epilepsy, chronic nervous diseases, cachexia, seminal weakness and constitutional syphilis. Though widely used in Ayurvedic and Unani systems of medicine (Nadkarni,1954), no work on the pharmacognosy of this drug is reported.

M O R P H O L O G Y

The drug mostly consists of entire thick tuberous rhizomes measuring about 7-15 cm. in length and 8-15 mm. in diameter or broken pieces of various dimensions. A rhizome is straight or slightly curved and monopodial in growth. It may occasionally branch. Lateral buds may occur as small protrusions from the main rhizome (Plate XIV, 1). Entire drug is irregular, cylindrical, more or less knotty and occasionally tapering to the end. Upper broad portion bears a central depression of the detached

Smilax china L.

aerial shoot. Outer surface is rugged and smooth intermittantly. The protruberances are the cut ends of the roots. Nodes and internodes are generally not easily distinguishable. Internodes are about 1-2.5 cm. long and most of them are usually covered with brownish scale leaves arising from the nodes. Colour of the drug, after the removal of the scale leaves, is light buff to pinkish. Fracture is starchy and granular. Odour is not characteristic; taste is mucilagenous and slighly irritating.

Smoothened transverse surface shows a brownish periphery with no sharp limit between the cortex and the central core. It shows scattered vascular bundles in light buff or pink background. The vascular bundles in the central core are very close while towards outside, they are rather apart (Plate XIV, 2).

H I S T O L O G Y

Transection of the rhizome, on its outer side shows several layers of large, tangentially elongate thick-walled cells which at times are filled with brown contents (Plate XIV, 3). These are first followed by large cells, which often contain bundles of raphides and then by 2-3 layers of brick-shaped cells (Plate XIV, 3). There are also a few layers of thin-walled and closely

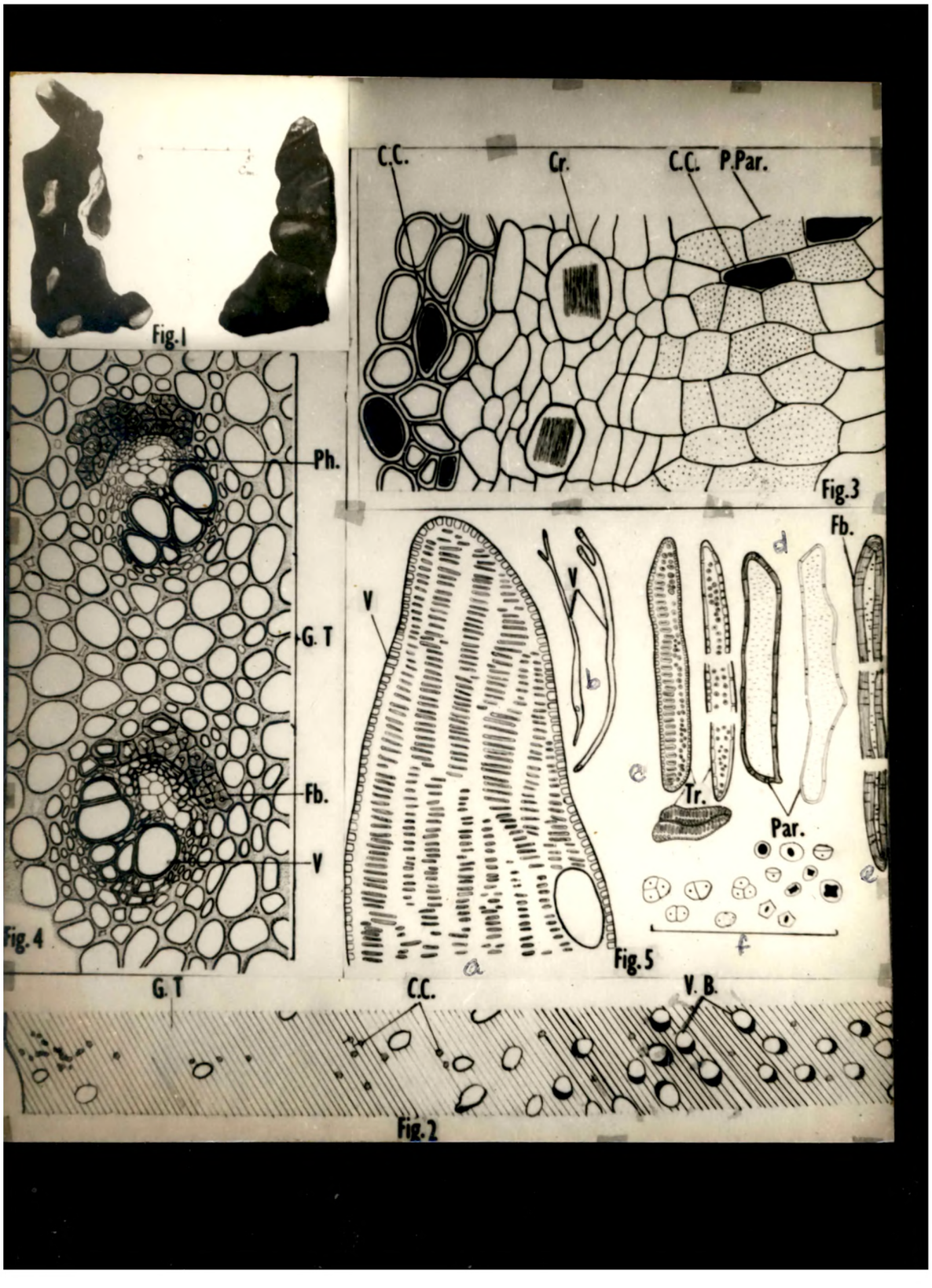


Fig.1
C.C.
Cr.
C.C.
P.Par.
Fig.3
Ph.
G. T
Fb.
V
Fig. 4
V
V
b
a
Fig.5
Fb.
d
c
Tr.
Par.
e
f
G. T
C.C.
V. B.
Fig.2

P L A T E - XIV

(Figs. 1 - 5 : *Smilax china* L.)

Fig. 1. - Entire rhizome. x 1.

Fig. 2. - T.s. rhizome showing arrangement of vascular bundles (diagrammatic). x 250.

Fig. 3. - T.s. rhizome showing outer portion. x 250.

Fig. 4. - T.s. middle region of the rhizome. x 250.

Fig. 5. - Rhizome maceration : a - upper portion of a vessel, x 440; b - branched vessel, x 30; c - tracheids, x 440; d - parenchyma, x 440; e - fibre, x 440; f - starch grains, x 440.

x-x-x-x-x-x

C.C. - cell with cell contents ; Cr. - crystal ;

Fb. - fibre; G.T. - ground tissue; Par. - parenchyma;

Ph. - phloem; P. Par. - phloem parenchyma;

Tr. - tracheid; V - vessel; V.B. - vascular bundle.

Smilax china L.

pitted cells on the inner side of the latter.

A wide zone of large, thick-walled and finely pitted parenchymatous cells forms the ground tissue. It is traversed by a few obliquely cut vascular bundles. The central core has numerous, closely arranged, conjoint, collateral and closely arranged fibro-vascular bundles which are variously oriented (Plate XIV, 2). There is no distinct endodermis delimiting the outer ground tissue from the inner one.

A vascular bundle contains 3-7 vessels, tracheids, sieve tubes and companion cells (Plate XIV, 4), Vessels mostly show reticulate thickening. A few are unusually long forked and measure 3840 μ or 5600 μ. Some vessels show elongated slit-like bordered pits; the longer vessels at times give a scalariform appearance (Plate XIV, 5a). Rarely, some elongated pits fork to join the neighbouring pits above or below. Tracheids show slit-like or oval bordered pits (Plate XIV, 5c). Phloem consists of sieve tubes and companion cells. Encircling the phloem are groups of thick-walled, stratified and closely pitted fibres which have big lumen. Some of these fibres are septate (Plate XIV, 5e).

A few isolated parenchymatous cells of the ground tissue contain red granular contents (Plate XIV, 2 & 3) and all the parenchymatous cells contain

Smilax china L.

simple and compound starch grains. A grain is spherical, cup-shaped, biconvex or polygonal with a central hilum which may be a point, slit or radiating fissure (Plate XIV, 5f). They measure 19-33-46 μ in diameter. 2-50 or more grains contact at flat surfaces and form the compound grains.

T A B L E - 19

Measurements of rhizome elements

Elements	Length	Width
Vessel	816-2000-3200 μ	51-125-199 μ
Tracheid	245-408-680 μ	72-112-153 μ
Fibre	747-1088-1448-1760-2179 μ	35.5-46-60 μ
Large parenchyma	557-813-976 μ	208-272-700 μ
Small parenchyma	211-277-360 μ	69-112-144 μ
Isodiametric parenchyma	168-200 μ	144-160 μ

S U M M A R Y

Rhizome is straight or slightly curved, irregular, cylindrical and more or less knotty. Nodes and

internodes are not easily distinguishable. Smoothened fractured surface shows scattered vascular bundles in a light buff or pink background.

In transection, the rhizome shows externally a zone of thick-walled cells followed by large cells which may contain calcium oxalate raphides. 2-3 layers of brick-shaped cells follow the large cells. Each fibrovascular bundle is conjoint, collateral and closed. Vessels show reticulate thickening. Some also show elongated slit-like or oval bordered pits. Starch is present in form of simple or compound grains.