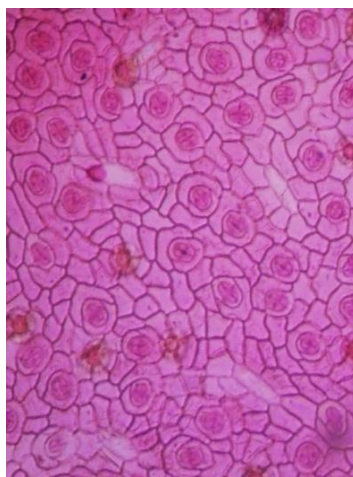


The Republic of the Union of Myanmar
Ministry of Natural Resources and Environmental Conservation
Forest Department



**Morphological and Anatomical Characters of Two Medicinal Plants,
Justicia decussate Roxb. and *Rhinacanthus nasutus* (L.) Kurz. of the Family
Acanthaceae**



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**Morphological and Anatomical Characters of Two Medicinal Plants,
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Acanthaceae**

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Abstract

Nowadays, traditional medicines are widely used in Myanmar. The specimens of *Justicia decussata* Roxb.(Nat-pan) and *Rhinacanthus nasutus* (L.)Kurz (Htaw-la-batt), belonging to the family Acanthaceae were collected from Amarapura Township, Mandalay Region from December 2017 to July 2018. The morphological characters of both vegetative and reproductive parts and the anatomical characters of leaf, stem and root were studied and described with relevant photographs and photomicrographs. Both of the species were perennial herbs. The inflorescences were terminal and axillary, but spikes in *Justicia decussata* Roxb. and paniculate cymes in *Rhinacanthus nasutus* (L.) Kurz. The diacytic type of stomata was found in the lamina of both species. Palisade parenchyma were 1 – 3 layered in the lamina of *Justicia decussata* Roxb. and one layered in that of *Rhinacanthus nasutus* (L.) Kurz. In transverse section of midribs and petioles, a large vascular bundle was accompanied by two small accessory bundles in both species. The transverse section of stem was circular in outline in *Justicia decussata* Roxb. whereas that was hexangular with ridge and furrow in *Rhinacanthus nasutus* (L.) Kurz. Cystoliths and non-glandular trichomes were found in both species. Secondary growth was found in the stem and root of both of two species studied, but no periderm formation occurs except in the case of the root of *Justicia decussata* Roxb. The findings in this research work provide the information on morphology and anatomy of the two species studied. Their morphological characters were useful in identification of the medicinal plants and anatomical characters can also support identification.

Keywords: cystoliths, diacytic type, inflorescence, medicinal plant, palisade parenchyma, periderm, vascular bundles

**ဆေးဖက်ဝင်သော Acanthaceae မျိုးရင်းဝင် မယားသိမ်နှင့် ထောလပတ်ပင် နှစ်ပင်၏
ပြင်ပရုပ်သွင်နှင့် အပင်ခန္ဓာဗေဒလက္ခဏာများကိုလေ့လာခြင်း**

ဒေါ်အေးငြိမ်းချမ်း၊ သုတေသနလက်ထောက်(၃)

သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

မြန်မာနိုင်ငံတွင် တိုင်းရင်းဆေးဝါးများကို ယနေ့အခါ၌ တွင်ကျယ်စွာသုံးစွဲလျက်ရှိသည်။ ထို့ကြောင့် ဆေးဖက်ဝင်အပင်မျိုးစိတ်များကို သိပ္ပံနည်းကျသုတေသနဆောင်ရွက်ရန် လိုအပ်ပါသည်။ ယခုစာတမ်းတွင် မန္တလေးတိုင်းဒေသကြီး၊ အမရပူရမြို့နယ်မှ Acanthaceae မျိုးရင်းဝင် မယားသိမ်ပင်(နတ်ပန်း)နှင့် ထောလပတ်ပင်တို့ကိုစုဆောင်းပြီး ပြင်ပရုပ်သွင်နှင့် အပင်ခန္ဓာဗေဒလက္ခဏာများကိုလေ့လာ၍ မျိုးမည်ဖော်ထုတ်ထားပါသည်။ ၎င်းနှစ်ပင်၏ အပင်ပိုင်းနှင့် မျိုးပွားပိုင်းတို့၏ ပြင်ပရုပ်သွင်လက္ခဏာများ၊ အရွက်၊ ပင်စည်နှင့် အမြစ်တို့၏ ခန္ဓာဗေဒလက္ခဏာများကိုလေ့လာ၍ ပုံများနှင့်တကွ ဆွေးနွေးတင်ပြထားပါသည်။ ၎င်းမျိုးစိတ်(၂)မျိုးစလုံးသည် နှစ်ရှည်ခံပင်ပျော့များဖြစ်ကြသည်။ မယားသိမ်ပင်၏ ပန်းခိုင်သည် ပွင့်ညှာမဲ့ (spike) ပန်းခိုင်အမျိုးအစားဖြစ်ပြီး ထောလပတ်ပင်သည် အဆုံးရှိပန်းခိုင် (cymose) အမျိုးအစားဖြစ်သည်။ ထိုအပင်များ၏ အရွက်များတွင်တွေ့ရသော လေပေါက်များသည် diacytic type ဖြစ်သည်။ မယားသိမ်ပင်၏ ရွက်တွင်းသားဆဲလ်(mesophyll cell) တွင်တွေ့ရသော palisade parenchyma များသည် ဘလွှာမှဘလွှာအထိရှိပြီး ထောလပတ်ပင်တွင် ဘလွှာထဲသာတွေ့ရသည်။ ၎င်းအပင်များ၏ ရွက်လယ်ကြော(midrib) နှင့် ရွက်ညှာ(petiole)များ၏ ကန့်လန့်ဖြတ်ပိုင်း (Transverse section)တွင် ကြီးမားသောအစာရေကြောစည်းတစ်ခု(vascular bundle)နှင့် သေးငယ်သောအစာရေကြောစည်း (accessory bundle) နှစ်ခုကိုတွေ့ရသည်။ မယားသိမ်ပင်၏ ပင်စည်ကန့်လန့်ဖြတ်ပိုင်းသည် စက်ဝိုင်းပုံသဏ္ဌာန်ရှိပြီး ထောလပတ်ပင်၏ပင်စည်သည် ခြောက်ထောင့်ပုံသဏ္ဌာန်ရှိ၍ အစင်းမြောင်းများပါသည်။ စစ်စတိုးလစ်များ(cystoliths)နှင့် အဆီဂလင်းမပါသော (trichomes) များကို တွေ့ရသည်။ ၎င်းအပင်(၂)ပင်၏ ပင်စည်နှင့် အမြစ်များတွင် vascular cambium ၊ ထပ်ပွားအစာကြောနှင့် ထပ်ပွားရေကြောတို့ကိုတွေ့ရသည်။ Periderm ဖြစ်ပေါ်ခြင်းကိုမူ မယားသိမ်ပင်၏ အမြစ်တွင်သာတွေ့ရှိသည်။ ဤသုတေသနတွေ့ရှိချက်မှ ထိုအပင်(၂)ပင်၏ အပင်ခန္ဓာဗေဒဝိသေသန လက္ခဏာများကို သိရှိနိုင်သည့်အပြင် ဆေးဖက်ဝင်အပင်မျိုးစိတ်များကို မျိုးမည်ဖော်ရာတွင်လည်း အသုံးဝင်ပါသည်။

Morphological and Anatomical Characters of Two Medicinal Plants, *Justicia decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz. of the Family Acanthaceae

1. INTRODUCTION

Acanthaceae is predominantly distributed in tropical, subtropical and temperate regions. This family consists of approximately 250 genera and about 2500 species worldwide (Backer 1965). Kress et al. (2003) recorded (33) species of *Justicia* and (2) species of *Rhinacanthus* in the family Acanthaceae growing in Myanmar. Among them, the two medicinal plants, *Justicia decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz are well known in Myanmar for their uses in traditional medicine. *Justicia decussata* Roxb. known as Ma-yar-thein, Nat-pan or Tamase-kyan in Myanmar and is being used in Religious matter especially to offer its shoots to "U Shin Gyi Nat" with sticky rice in Lower Myanmar at winter season. It is used in Myanmar as remedy to relieve asthma.

Rhinacanthus nasutus (L.) Kurz, snake jasmine, is called Htaw-la-batt in Myanmar and it is traditionally used as hair tonic in Myanmar. According to Nagathein (1970), the leaves are also useful to treat skin infection and acne. Both of these two herbs are widely cultivated as ornaments in Myanmar and they can easily be used by local people for medicine.

The fresh and dried leaves of *Justicia decussata* Roxb. are used to cure jaundice, as expectorant. The leaves extract has been used for the treatment of bronchitis and asthma for many centuries. Tender shoots are boiled and eaten with salt and sometimes mixed with curd (Cortes & Rapini 2011).

Rhinacanthus nasutus (L.) Kurz, is more commonly known as snake jasmine, which is far easier to pronounce and is commonly found in India. It is typically growing in tropical, humid climates and is technically a shrub. The value of this plant outside of that country lies in its unique chemical composition and high antioxidant property. Both of the leaves and stems of snake jasmine have both been used to treat various skin diseases. Furthermore, the decoction of the roots has a slightly different chemical makeup and is used in ringworm and other fungal infections of the skin (Khurram Afzal 2015).

Rhinacanthus nasutus (L.) Kurz, has a reputation in folk medicine because of the treatment of hypertension. In China, the stem and leaves are used to treat ringworm infections. In Thailand, it is cultivated for its ornamental value and is also especially used to treat cancer activity. The leaves may be combined with alcohol, lemon and tamarind juice. The seeds are used for scenting clothes in Madagascar. The two parts of snake jasmine, roots and leaves are externally applied as remedy to alleviate for certain skin disorders such as ringworm, eczema, and herpes (Wongsatit Chuakul et al. 2016).

Root bark is mixed with alum and black pepper and used to cure for ringworm. Root boiled in milk is an aphrodisiac (Nagathein 1970 & U Kyaw Tun 2007). Leaves are traditionally used as hair shampoo and cosmetics in Myanmar.

Rhinacanthus nasutus (L.) Kurz, is a "lung scavenger" and can also cure skin diseases. It makes the lung pure and decreased the series diabetes disease.

Morphological observations of *Justicia decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz, were made by previous researchers (Tin Tin Hlaing 1983 and Khin Su Su Kyaw

2009), although pertinent literature for anatomical studies on these species is not found yet in Myanmar so far. The present research focuses on the morphology of plants as well as the anatomy of the vegetative parts (roots, stems, petioles, midribs and lamina) of *Justicia decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz.

The aim and objectives of the present study were to find out the morphological and anatomical characteristics of the *Justicia decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz, and to provide the useful information for further pharmaceutical study.

2. LITERATURE REVIEW

Lawrence (1964) reported that Acanthaceae was a large tropical of about 240 genera and over 2200 species. The Acanthaceae are distinguished by their related families on the basis of usual presence of cystoliths in vegetative parts, the presence of bracts and bracteoles, the usually bilabiate corolla associated with the bilocular ovary, the generally dehiscing capsules.

Heywood (1978) stated that the family was composed of about 250 genera and 2000 species and this family was closely related to the Scrophulariaceae because of the irregular five-part flowers, with reduction in stamen numbers and a bicarpellate superior ovary were common features to both families.

Dassanayake 1998 described that Acanthaceae was a large pantropical family of about 250 genera and over 2500 species, predominantly in tropical and subtropical forests.

Hooker (1885) mentioned that the family Acanthaceae consisted of about 1500 species and distributed in the tropical and warm temperate regions. This family were divided into five tribes namely Thunbergieae, Nelsonieae, Ruellieae, Acantheae and Justicieae.

Small (1933) recorded it under the Order Polemoniales and about 175 genera and 2000 species were widely distributed in temperate and tropical regions.

Cronquist (1981) described that the family Acanthaceae consisted of about 250 genera and 2500 species, widespread in tropical region, with only a few species in temperate climate.

Metcalf and Chalk (1950) mentioned that the general anatomical characters of the family Acanthaceae. Acanthaceae family, which occurred chiefly in hot countries, was mainly herbaceous but some of its members were climbers or lianaes, whilst a few species were woody. It also included xeromorphic species with spiny leaves. One of the most outstanding anatomical features was the widespread occurrences of variously shaped cystoliths, which were to be found in both stem and leaf.

Metcalf & Chalk (1950) also mentioned that the hairs comprised of an assortment of both glandular and non-glandular types. Stomata, which occur on both surfaces of the leaves or were confined to the lower side, were always caryophyllaceous. Hairs included non-glandular and secretory types, the former mostly unicellular or uniseriate.

Metcalf & Chalk (1950) stated that transverse sections of the petioles through the distal end, exhibited a single arc-shaped vascular strand or a crescentic group of separate bundles. Subsidiary bundles were usually present towards the adaxial surface or an either side of the petiolar groove.

Metcalf & Chalk (1950) described that transverse sections of young stem were through the outer part of the cortex exhibiting alternating sectors of collenchyma and

chlorenchyma respectively. Pith was generally occupying a large part of the centre of the stem. In the root, the pith and primary cortex consisted of spongy tissue with well-defined intercellular spaces. The xylem was less well developed in the subterranean than in the aerial part of the root. Metcalfe & Chalk (1950) mentioned that the root of was used in the India and China for the treatment of ringworm.

Staughton (2021) stated that the decoction of the roots was used for the treatment of skin diseases and other fungal infections of the skin. The snake jasmine regulated blood sugar levels, potentially treatment for diabetes. Side effects of *Rhinacanthus* can induce nausea and stomach upset.

Nagathin (1970) described that the leaf was used for ringworm, pimples and freckles on the face. Root bark was also used in treating ringworm, eczema, in dying hairs, and as hair shampoo. Various members of the family were commonly cultivated for ornamental purpose.

3. MATERIALS AND METHODS

The fresh specimens of *Justicia decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz were collected from Amarapura Township, Mandalay Region during the flowering period of December 2017 to July 2018. Description of collecting specimens was carried out by using dissecting microscope. Identification of the species was done by referring the literature as Key to the families of flowering plants of the world (Hutchinson 1959), Flora of British India (Hooker 1885), Flora of Java (Backer 1965) and Flora of Ceylon (Dassanayake 1998). The next step is to mount each specimen together with a label of field data on a herbarium sheet which were stored in Herbarium of Botany Department, Yadanabon University for reference of other researchers.

For the anatomical study, free-hand sections of the leaves (laminae, midribs, petioles), stems and roots were prepared from the fresh specimens. The thin sections were cleaned with chloral hydrate solution, stained with safranin solution and mounted by dilute glycerine and observed under a light microscope. The size of cells and tissues were measured by an ocular micrometer and then calculated. Stomata index in leaves and stems were determined by method of Trease and Evans (2002). According to Frankly's method, a small amount of pieces of the leaves, stems and roots were separately macerated by boiling with two parts of hydrogen peroxide solution and one part of glacial acetic acid solution (Berlyn and Miksche 1946). After then, the macerated tissues were washed with water and kept in ethyl alcohol solution with a few drops of safranin and glycerine for further study.

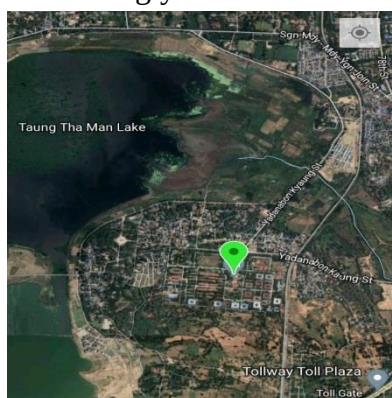


Figure 1. Location map of Yadanabon University Campus, Amarapura Township.

4. RESULTS

4.1 Morphology

4.1.1 *Justicia decussata* Roxb., Hort. Beng.4.1814.

Adhatoda decussata Nees in DC., Prod.2.408.1825.

Local name : Ma-yar-thein; Nat-pan; Nat-pan-nyo; Tamase-kyan
 Common name : Unknown
 Family : Acanthaceae

Perennial, herbs to undershrubs, 1.5 – 2.0 m high; stems and branches cylindrical, reddish-brown, pubescent; internodes 1.2 – 4.2 cm long; nodes tumid. Leaves simple, opposite and decussate, exstipulate; petiolate; leaf-blades oblong-lanceolate, 3.5 – 11.5 cm by 0.7 – 2.5 cm, green, glabrous on both surfaces, attenuate at the base, entire along the margin, acute at the apex; petioles slightly flattened, about 0.4 cm long, reddish-brown, glabrous. Inflorescences terminal and axillary spikes; peduncles terete, 8 – 24 cm long, reddish-brown, glabrous. Flowers white, about 1.2 cm in across at the anthesis, sessile; bracts small, linear-lanceolate, 2 – 4 mm long, reddish-brown, pubescent; bracteoles linear, 1 – 2 mm long, reddish-brown, pubescent. Calyx 5-partite, reddish-brown, pubescent; tubes short, 1 – 2 mm long; lobes linear-lanceolate, 2 – 4 mm long. Corolla bilabiate, 5-lobed; tubes cylindric, 8 – 10 mm long; upperlip 2-lobed, obovate, erect, emarginated with reddish-brown spots; lowerlip 3-lobed, with reddish-brown spots, oblong, 6 – 9 mm long, reflexed. Stamens 2, exserted, epipetalous; filaments filiform, 4 – 6 mm long, attached near the corolla tube, white, glabrous; anthers dithecal, oblongoid, dorsifixed, pale yellow, the cell divergent, with basal spur. Ovary superior, ovoid, 1 – 2 mm long, reddish-brown, glabrous, bilocular, with two ovules in each locule on the axile placentae; style filiform, 1.0 – 1.2 cm long, red, glabrous; stigma simple.

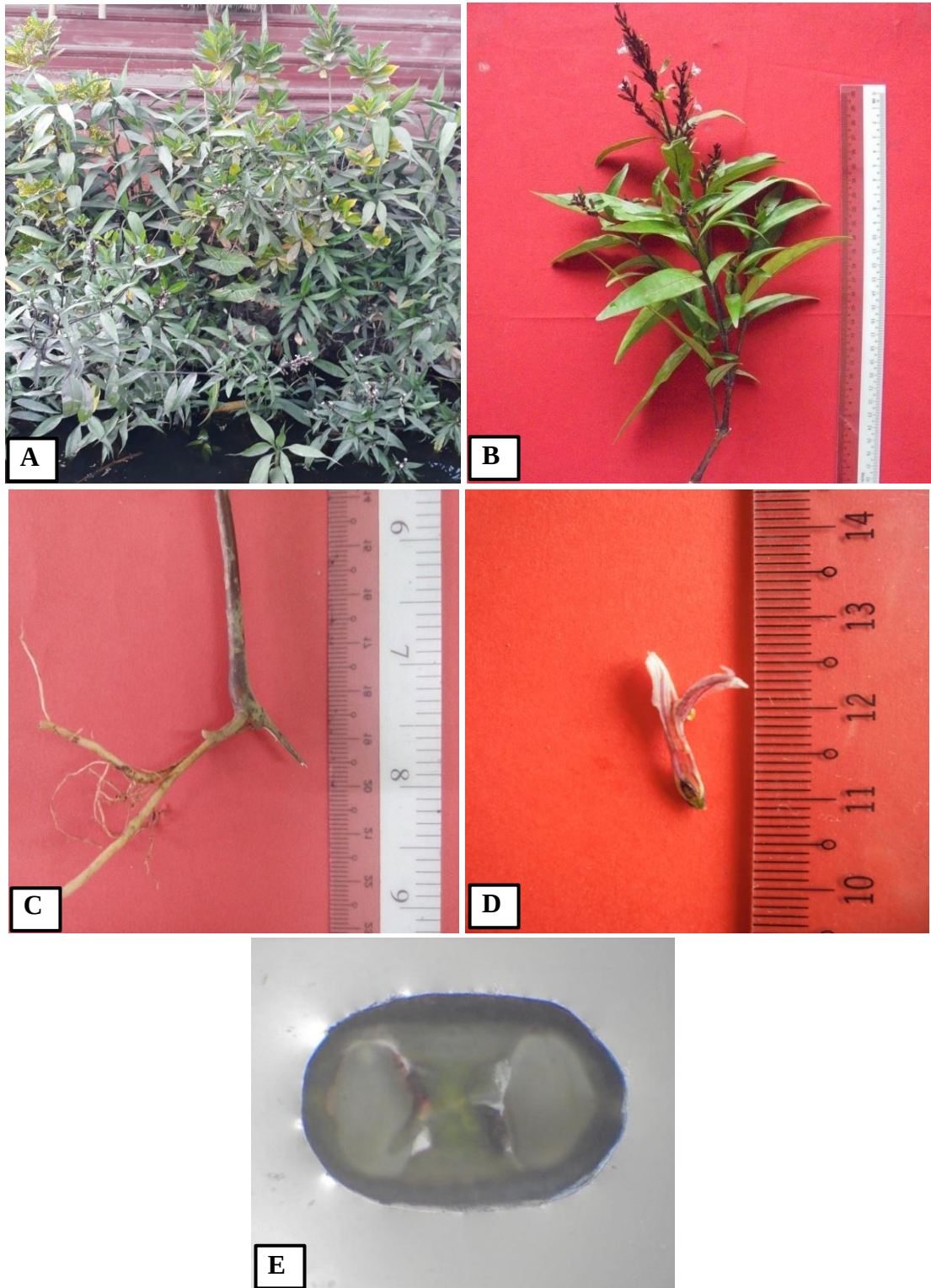
Flowering period : January to April

Specimen examined : N 21° 53' 38.562" and E 096° 04' 03.906", opposite side of Yadanabon University Campus, Amarapura Township, Mandalay Region; 3rd March 2018, Aye Nyein Chan.

Uses:

In Myanmar, remedy to relieve asthma .

In other country, the fresh and dried leaves are used to cure jaundice, as expectorant. The leaves extract are used for the treatment of bronchitis and asthma (Cortes & Rapini2011).



4.1.2. *Rhinacanthus nasutus* (L.) Kurz, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 39 (2): 79. 1870.

***Justicia nasuta* L., Sp. Pl. 16. 1753.**

Local name : Htaw-la-batt
Common name : Snake-jasmine
Family : Acanthaceae

Perennial, herbs to undershrubs, 1 – 2 m high; stems and branches hexa-angular with ridges and furrows, green, glabrescent; internodes 2.5 – 6.5 cm long; nodes tumid. Leaves simple, opposite and decussate, exstipulate; petiolate; leaf-blades oblong-elliptic to elliptic, 5.5 – 14.0 cm by 2.0 – 6.3 cm, membranous, green and pubescent on both surfaces, attenuate at the base, entire along the margin, acute at the apex; petioles subterete, 1.0 – 3.2 cm long, green, pubescent. Inflorescences terminal and axillary, paniculate cymes; peduncles terete, 2.7 – 5.0 cm long, green, pubescent. Flowers white, about 2 cm in across at the anthesis, sessile; bracts and bracteoles linear-lanceolate, 1 – 2 mm long, pale green, pubescent. Calyx 5-partite, green, pubescent; tubes short, 1 – 2 mm long; lobes linear-lanceolate, 2 – 4 mm long, green, pubescent. Corolla bilabiate, 5-lobed; tubes cylindric, 1.8 – 2.2 cm long; upperlips 2-lobed, linear, 6 – 9 mm long, erect; lower-lip 3-lobed, reddish-brown spots present on the lower-lips, obovate, 5 – 13 mm long. Stamens 2, exserted, epipetalous; filaments filiform, 2 – 5 mm long, attached near the tip of the corolla tube, white, glabrous; anthers dithecal, oblongoid, dorsifixed, pale yellow, the cell superposed. Ovary superior, ovoid, 1 – 3 mm long, green, glabrous, bilocular, with two ovules in each locule on the axile placentae; style filiform, 1.8 – 2.1 cm long, white, glabrous; stigma bifid.

Flowering period : January to April

Specimen examined : N 21° 53' 30.0" and E 096° 04' 22.5", opposite side of Yadanabon University Campus, Amarapura Township, Mandalay Region; 6th February 2018, Aye Nyein Chan.

Uses:

In Myanmar, it is traditionally used as hair tonic. The leaves are also useful to treat skin infection and acne Nagathin (1970). Root bark is used cure for ringworm. Root boiled in milk is an aphrodisiac (Nagathin 1970 & U Kyaw Tun 2007). Leaves are traditionally used as hair shampoo and cosmetics in Myanmar.

In other country, the leaves and stems are used to treat various skin diseases. the decoction of the roots is used in ringworm and other fungal infections of the skin (Afzal 2015). In China, the stem and leaves are used to treat ringworm infections and the treatment of hypertension.

In Thailand, it is also especially used to treat cancer activity. The roots and leaves are externally applied as remedy to alleviate for certain skin disorders such as ringworm, eczema, and herpes (Chuakul et al. 2016).

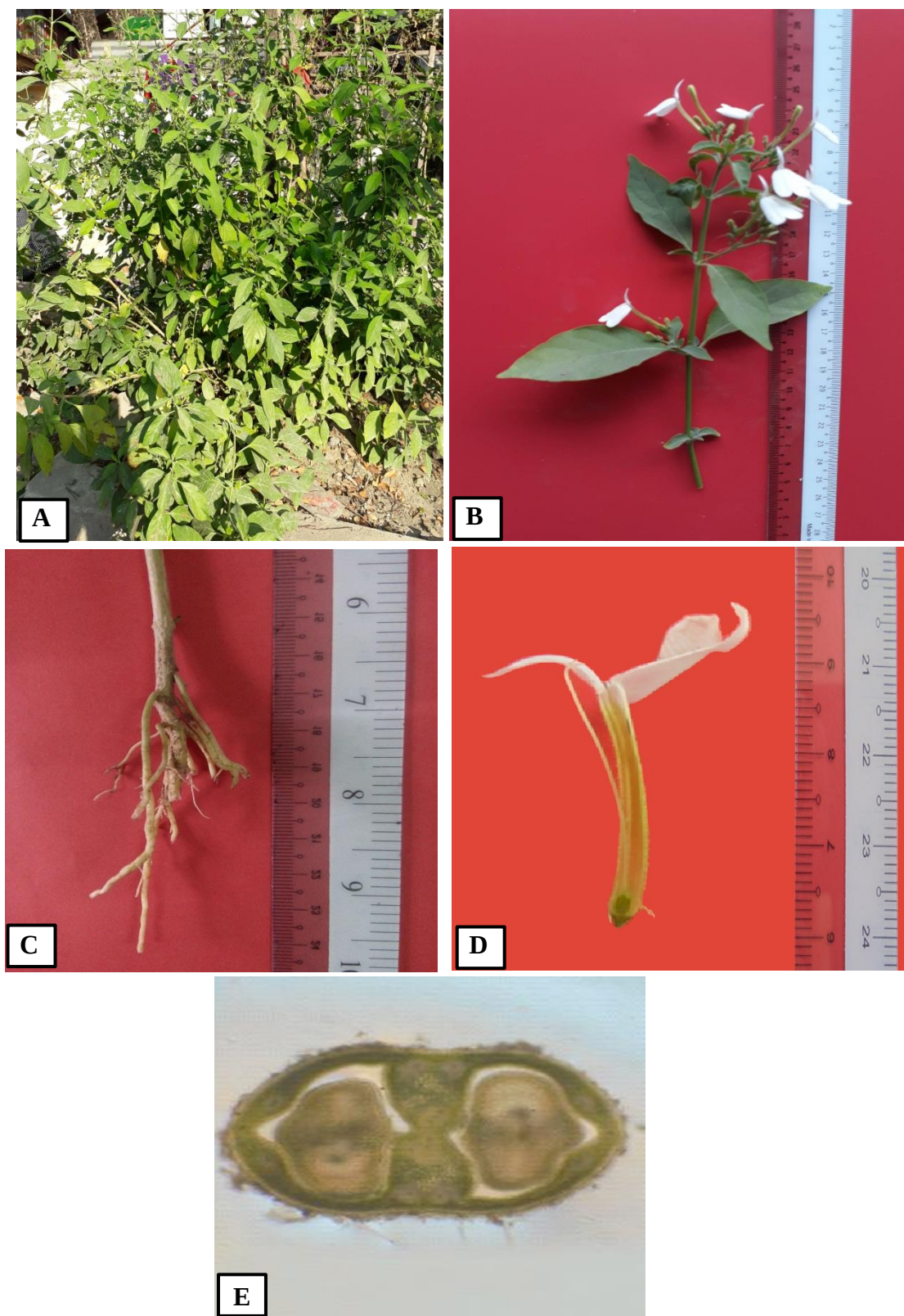


Figure 3. Habit of *Rhinacanthus nasutus* (L.) Kurz

- | | |
|---------------------------|---------------------------------|
| A. Plant in natural habit | B. A branch with inflorescences |
| C. Roots | D. L.S of flower |
| E. T.S of ovary | |

4.2. Anatomy

4.2.1. Microscopical characteristics of *Justicia decussata* Roxb.

Lamina

In transverse section, the lamina of *Justicia decussata* Roxb. studied were 320 – 500 μm thick (Fig. 4D), typically dorsiventral, venation reticulate, distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells, guard cells of the stomata and cystoliths containing cells. In surface view, epidermal cells of both surfaces parenchymatous, irregularly arranged; walls of adaxial epidermal cells thin-walled, 10.0 – 26.25 μm in length, 12.5 – 42.5 μm in breadth; walls of abaxial epidermal cells wavy, thin-walled, 18.0 – 51.25 μm in length, 11.25 – 23.75 μm in breadth; cystoliths and stomata present only on the lower surfaces; cystoliths ellipsoid in shape, 50 – 75 μm in length, 13.75 – 17.5 μm in breadth; stomata of diacytic types, stomatal index 15; the guard cells reniform, 11.25 – 25.0 μm in length, 5.5 – 7.5 μm in breadth (Fig. 4 A & B). In transverse section, epidermal cells outermost, both adaxial and abaxial epidermal cells one-layered, the cells oval or barrel-shaped, thin-walled, compact, continuous, anticlinal walls straight, outer and inner walls slightly convex; those at adaxial cells 11.25 – 23.75 μm in length, 21.25 – 50.0 μm in breadth; those at abaxial cells 8.75 – 21.25 μm in length, 7.5 – 42.5 μm in breadth; cuticle smooth and thin, 5.0 – 7.5 μm thick (Fig. 4 D).

Ground tissue system: Mesophyll cells differentiated into palisade and spongy parenchyma; palisade parenchyma lying internal to the adaxial epidermal cells, 1 – 3-layered, the layers 50 – 60 μm thick, the cells vertically elongated, compact, thin-walled, straight, 25 – 50 μm in length, 10.5 – 17.5 μm in breadth, chloroplast and cystoliths present; spongy parenchyma lying internal to the abaxial epidermal cells, 5 – or 6-layered, the layers 92.5 – 107.5 μm thick, the cells oval or rounded in shape, thin-walled, 12.5 – 31.25 μm in length, 13.75 – 41.25 μm in breadth, intercellular spaces and chloroplast present (Fig. 4 C).

Vascular tissue system: Vascular bundles embedded in the mesophyll cells, of closed collateral type, rounded or oval in shape, small; xylem at the adaxial side and phloem at the abaxial side; bundle sheath distinct, one-layered, the cells parenchymatous, thin-walled, continuous, 10 – 18 μm in length, 15 – 25 μm in breadth; bundle sheath extension at both side; phloem 3- or 4- layered, the layers 21.25 – 26.25 μm thick, the cells oval or polygonal in shape, 2.5 – 8.75 μm in length, 5 – 10 μm in breadth, phloem composed of sieve-tubes, companion cells, phloem fibres and phloem parenchyma; xylem arranged in 5- or 6- rows, metaxylem 1- to 5- celled in each row, the cells 3.75 – 15.0 μm in length, 3.75 – 12.5 μm in breadth, composed of vessel elements, tracheids, xylem fibers and xylem parenchyma (Fig. 4 F); vessel elements thick-walled, lateral walls straight, end walls transverse, thickening spiral, 187.5 – 207.5 μm in length, 10.0 – 12.5 μm in breadth; tracheids thick-walled, lateral walls straight, end walls acute, thickening spiral, 175 – 190 μm in length, 7.5 – 8.75 μm in breadth; fibers thick-walled, lumen narrow, lateral walls straight, end walls acute to acuminate, 400 – 500 μm in length, 10 – 15 μm in breadth.

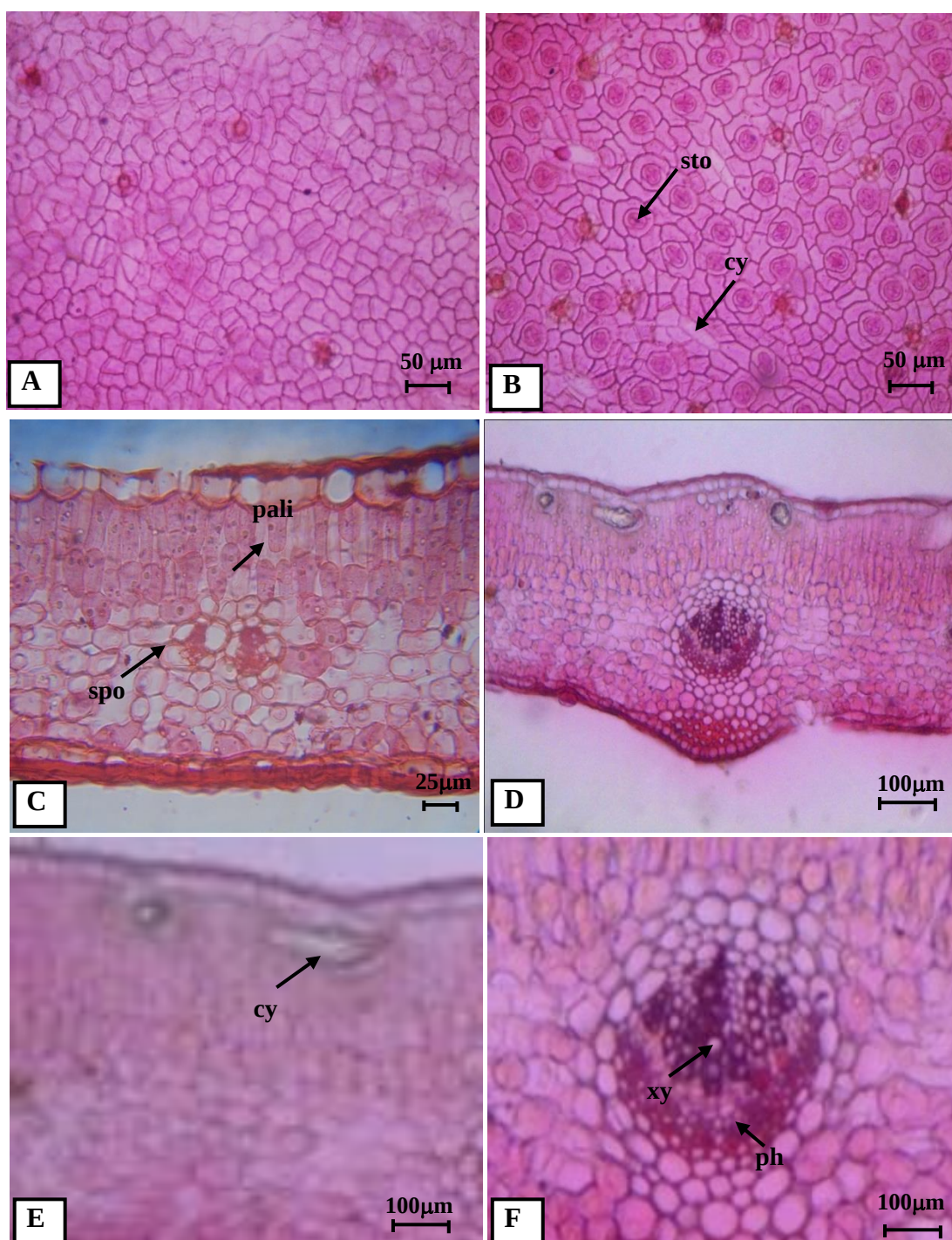


Figure 4. Internal structure of lamina of *Justicia decussata* Roxb.

- A. Surface view of adaxial side
 - B. Surface view of abaxial side showing stomata and cystoliths
 - C. T.S of a portion of lamina showing mesophyll
 - D. T.S of a portion of lateral veinlet of lamina showing vascular bundle
 - E. T.S of a portion of lamina showing epidermal cells and cystoliths
 - F. T.S of a portion of lamina showing enlarged vascular bundle
- (cy - cystoliths, sto - stomata, pali- palisade, spo-spongy, xy - xylem, ph - phloem)

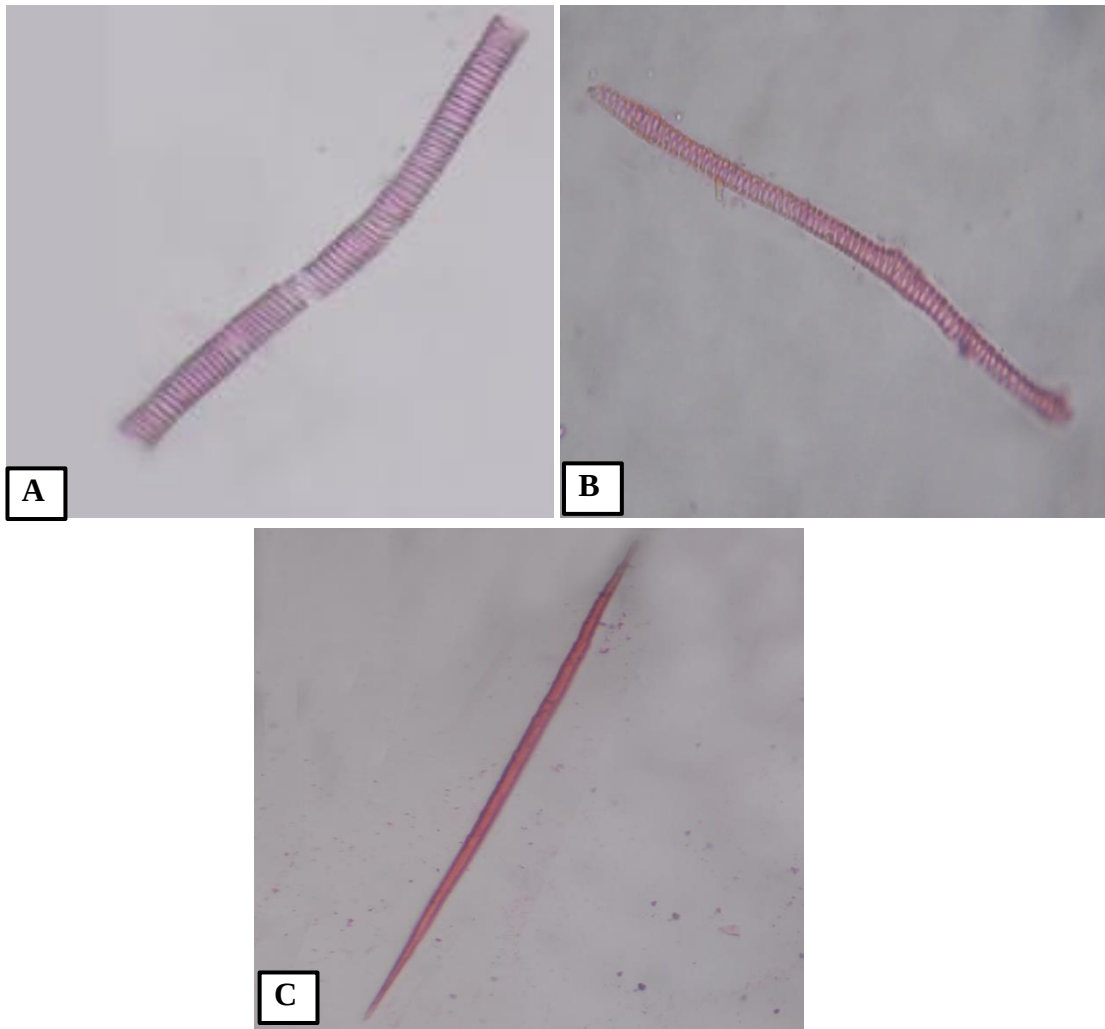


Figure 5. Macerated elements of lamina of *Justicia decussata* Roxb.

- A. Vessel element with spiral thickening
- B. Tracheid with spiral thickening
- C. Fiber

Midrib

In transverse section, the midribs studied were semicircular in outline with flattened surface at the adaxial side, about 1187.5 – 1512.5 μm in diameter (Fig. 6 B), distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells and cystoliths containing cells. In surface view, epidermal cells parenchymatous, polygonal or rectangular in shape, thin-walled, the cells 11.25 – 26.25 μm in length, 16.25 – 35.0 μm in breadth; cystoliths oval in shape, 27.5 – 41.25 μm in length, 17.5 – 37.5 μm in breadth (Fig. 6 A). In transverse section, both adaxial and abaxial epidermal cells one-layered, oval or barrel-shaped, compactly arranged, continuous, thin-walled, anticlinal walls slightly straight, outer and inner walls slightly convex; those at adaxial cells 10.0 – 26.25 μm in length, 9.5 – 23.75 μm in breadth; those at abaxial cells 13.75 – 23.75 μm in length, 8.75 – 27.5 μm in breadth; cuticle thin, 2.5 – 3.75 μm thick (Fig. 6B).

Ground tissue system: Composed of outer collenchymatous cells and inner parenchymatous cells as main mass of ground tissue. Outer collenchymatous layers lying internal to the adaxial and abaxial epidermis; those at adaxial side 5- to 8- layered, the layers 172.0 – 215.0 μm thick, the cells oval or rounded in shape, the cells 15.5 – 31.25 μm in length, 10.0 – 25.0 μm in breadth; those at abaxial side 3- to 6-layered, the layers 70 – 130 μm thick, the cells oval or rounded in shape, 15.5 – 31.25 μm in length, 10 – 25 μm in breadth (Fig. 6 C). Inner parenchymatous layers lying internal to the adaxial and abaxial collenchymatous layers; those at adaxial side 4- to 9 – layered, the layers 130 – 415 μm thick, the cells oval rounded in shape, thin-walled, the cells 17.5 – 73.0 μm in length, 18.0 – 82.5 μm in breadth; those at abaxial sides 5- to 9- layered, the layers 250 – 380 μm thick, the cells 18.75 – 72.5 μm in length, 18.0 – 71.25 μm in breadth, intercellular spaces small (Fig. 6 D).

Vascular tissue system: A large vascular bundle lying in the middle connected with two small accessory strands at the adaxial side, of closed collateral type, the large bundle crescent-shaped, 201 – 285 μm in thickness, 540 – 790 μm in width; phloem towards the abaxial side, 3- to 5- layered, the layers 25 – 30 μm thick, the cells 6.25 – 10.0 μm in length, 5.0 – 8.75 μm in breadth, composed of sieve tubes, companion cells, phloem fibers and phloem parenchyma; xylem towards the adaxial side, 23 to 31 rows, metaxylem 1- to 5-celled in each row, the cells 5.0 – 25.0 μm in length, 3.75 – 23.75 μm in breadth, composed of vessel elements, tracheids, xylem fibers and xylem parenchyma (Fig. 6 E); vessel elements thick-walled, lateral walls straight, end walls transverse or oblique, thickening spiral and reticulate, 187.5 – 265.5 μm in length, 30 – 35 μm in breadth; tracheids thick-walled, lateral walls straight, end walls oblique or acute, thickening reticulate, 217.5 – 265.5 μm in length, 10.0 – 17.5 μm in breadth; fibers thick-walled, lateral walls straight, end walls acute or acuminate, 250 – 325 μm in length, 10.0 – 12.5 μm in breadth.

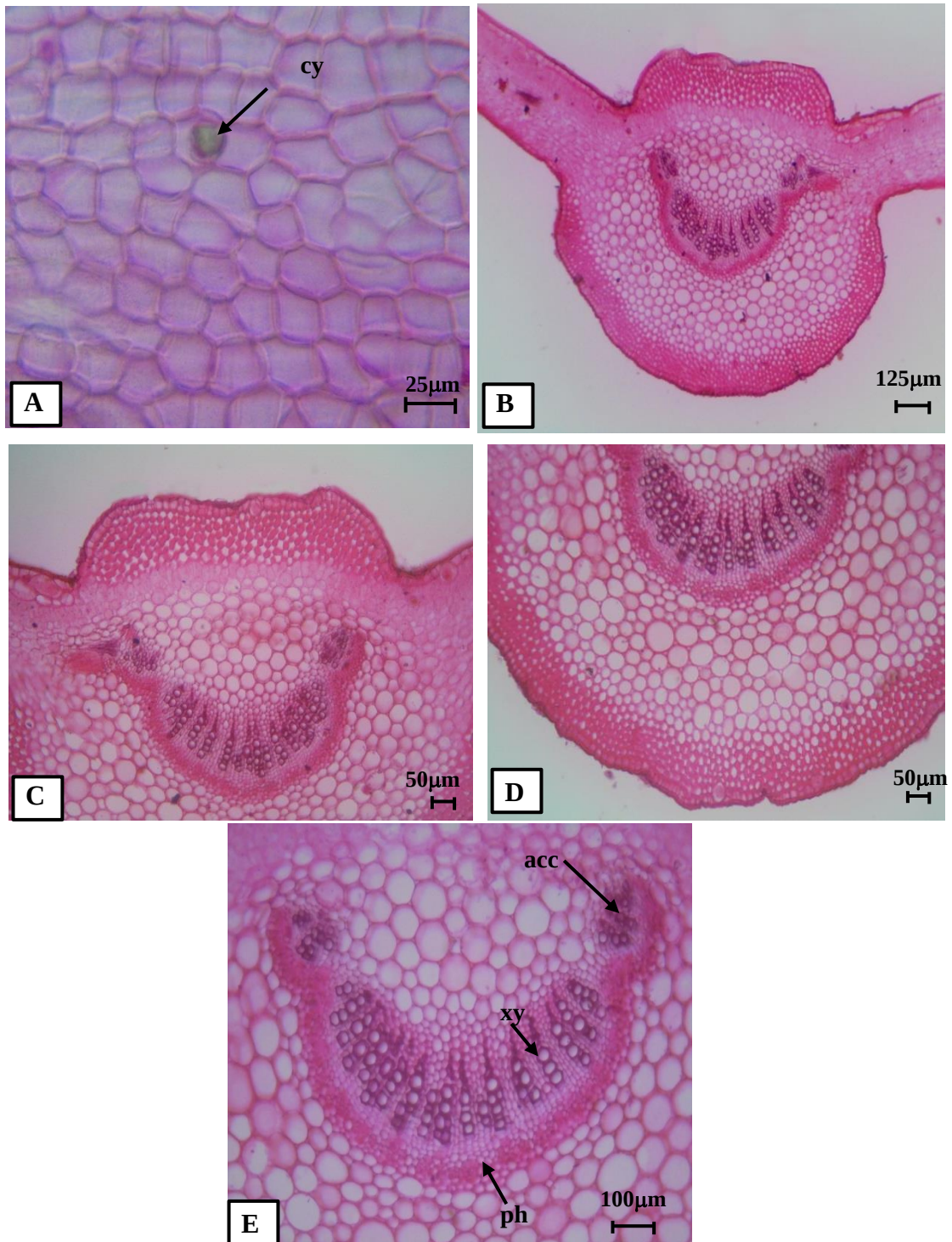


Figure 6. Internal structure of midrib of *Justicia decussata* Roxb.

- A. Surface view of midrib with cystoliths
 - B. T.S of a portion of midrib showing tissue systems
 - C. T.S of a portion of midrib showing adaxial side
 - D. T.S of a portion of midrib showing abaxial side
 - E. T.S of a portion of midrib showing vascular bundle and two accessory bundles at the adaxial side
- (cy - cystoliths, acc - accessory bundle, xy - xylem, ph - phloem)

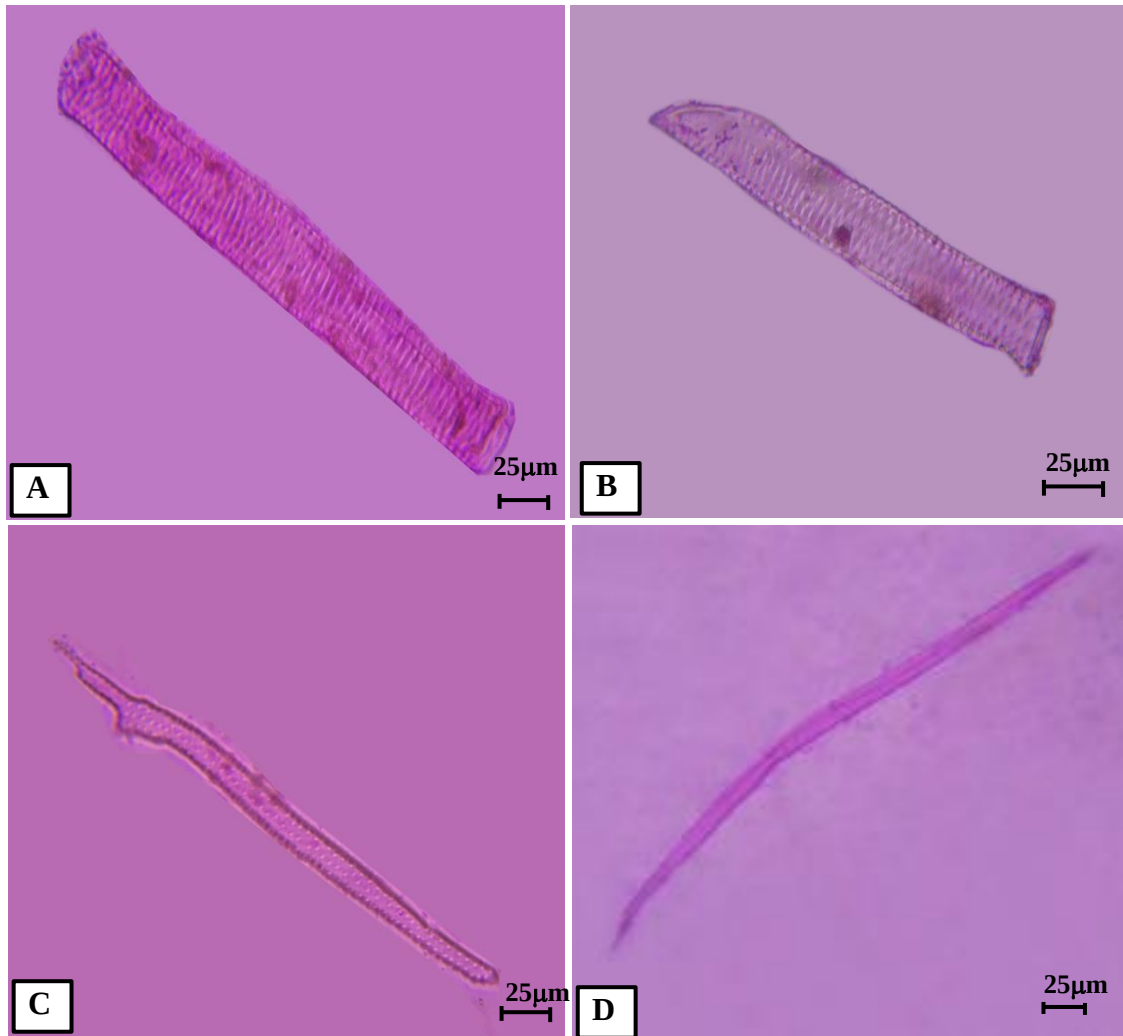


Figure 7. Macerated elements of midrib of *Justicia decussata* Roxb.

- A. Vessel element with reticulate thickening
- B. Vessel element with reticulate thickening and tailed at one end
- C. Tracheid with reticulate thickening
- D. Fiber

Petiole

In tranverse section, the petioles studied were semicircular in outline with slightly wavy margin and slightly concave at the flattened surface, 1212.5 – 1462.5 μm in diameter (Fig. 8 B), distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells. In surface view, epidermal cells parenchymatous, polygonal or rectangular in shape, thin-walled, 12.5 -37.5 μm in length, 11.25– 28.0 μm in breadth (Fig. 8 A). In transverse section, both adaxial and abaxial epidermal cells one-layered, the cells oval or barrel-shaped, thin-walled, compact, continuous, anticlinal walls straight, outer and inner walls slightly convex: those at adaxial side 10.0 – 27.5 μm in length, 11.25 – 13.25 μm in breadth; those at abaxial side 10.0 – 27.5 μm in length, 11.25 – 13.75 μm in breadth; cuticle smooth and thin, 2.5 – 7.5 μm thick (Fig. 8 B).

Ground tissue system: Composed of outer collenchymatous cells and inner parenchymatous cells as main mass of ground tissue. Outer collenchymatous layers lying internal to the adaxial and abaxial epidermis; those at adaxial side 5- to 9-layered, the layers 110 – 250 μm thick, the cells oval or rounded in shape, 6.25 – 28.0 μm in length, 5.0 – 20.5 μm in breadth; those at abaxial side 7- to 9-layered, the layers 210 – 240 μm thick, the cells oval or rounded in shape, 10 – 30 μm in length, 7.5 –18.0 μm in breadth (Fig. 8 C). Parenchymatous layers lying internal to the adaxial and abaxial collenchymatous layers; those at adaxial side 7- to 10-layered, 260 – 380 μm thick, oval or rounded in shape, thin-walled, 15.0 – 57.5 μm in length, 20.0 – 52.5 μm in breadth, intercellular spaces present; those at abaxial side 7- to 11-layered, 280 – 350 μm thick, the cells oval or rounded in shape, thin-walled, 12.5 – 36.25 μm in length, 21.25 – 72.5 μm in breadth, intercellular spaces present (Fig. 8 D).

Vascular tissue system: A large vascular bundle lying in the middle and two small accessory strands at the adaxial side, of closed collateral type, the large bundle crescent- shaped, 270 – 320 μm in thickness, 595 – 640 μm in width; phloem towards the abaxial side, 2-to 4-layered, the layers 12.5 – 50.0 μm thick, the cells 5.0 – 14.5 μm in length, 5.5 -12.5 μm in breadth, composed of sieve-tubes, companion cells, phloem fibers and phloem parenchyma; xylem towards the adaxial side, 18- to 22- rows, metaxylem 1- to 6-celled in each row, the cells 5.75 – 22.5 μm in length, 3.75 – 21.25 μm in breadth, composed of vessel elements, tracheids, xylem fibers and xylem parenchyma (Fig. 8 E); vessels elements thick-walled, lateral walls straight, end walls transverse or oblique, thickening spiral or reticulate, 212.5 – 312.5 μm in length, 20 – 25 μm in breadth; tracheids thick-walled, lateral walls straight, end walls transverse or acute, thickening spiral, 210.5 – 265.5 μm in length, 15 – 25 μm in breadth; fiber-tracheids thick-walled, lateral walls straight, end walls acute, thickening reticulate, 200.0 – 262.5 μm in length, 17.5 – 27.5 μm in breadth; fibers thick-walled, lateral walls straight, lumen narrow, end walls acute or acuminate, 400 – 500 μm in length, 10 – 15 μm in breadth.

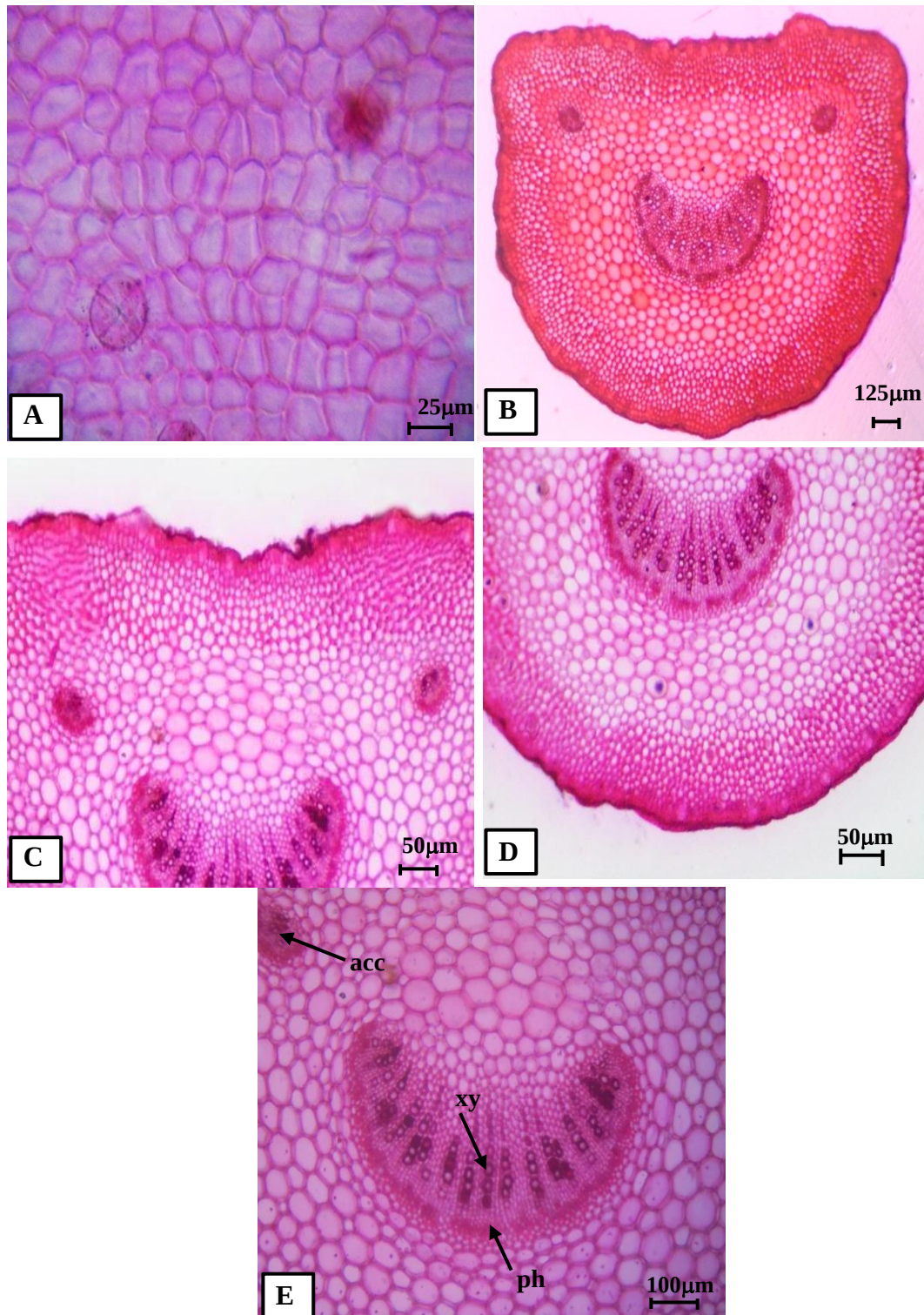


Figure 8. Internal structure of petiole of *Justicia decussata* Roxb.
 A. Surface view of petiole
 B. T.S of a portion of petiole showing tissue systems
 C. T.S of a portion of petiole showing adaxial side
 D. T.S of a portion of petiole showing abaxial side
 E. T.S of a portion of petiole showing vascular bundle and two accessory bundles at the adaxial side
 (acc - accessory bundle, xy - xylem, ph - phloem)

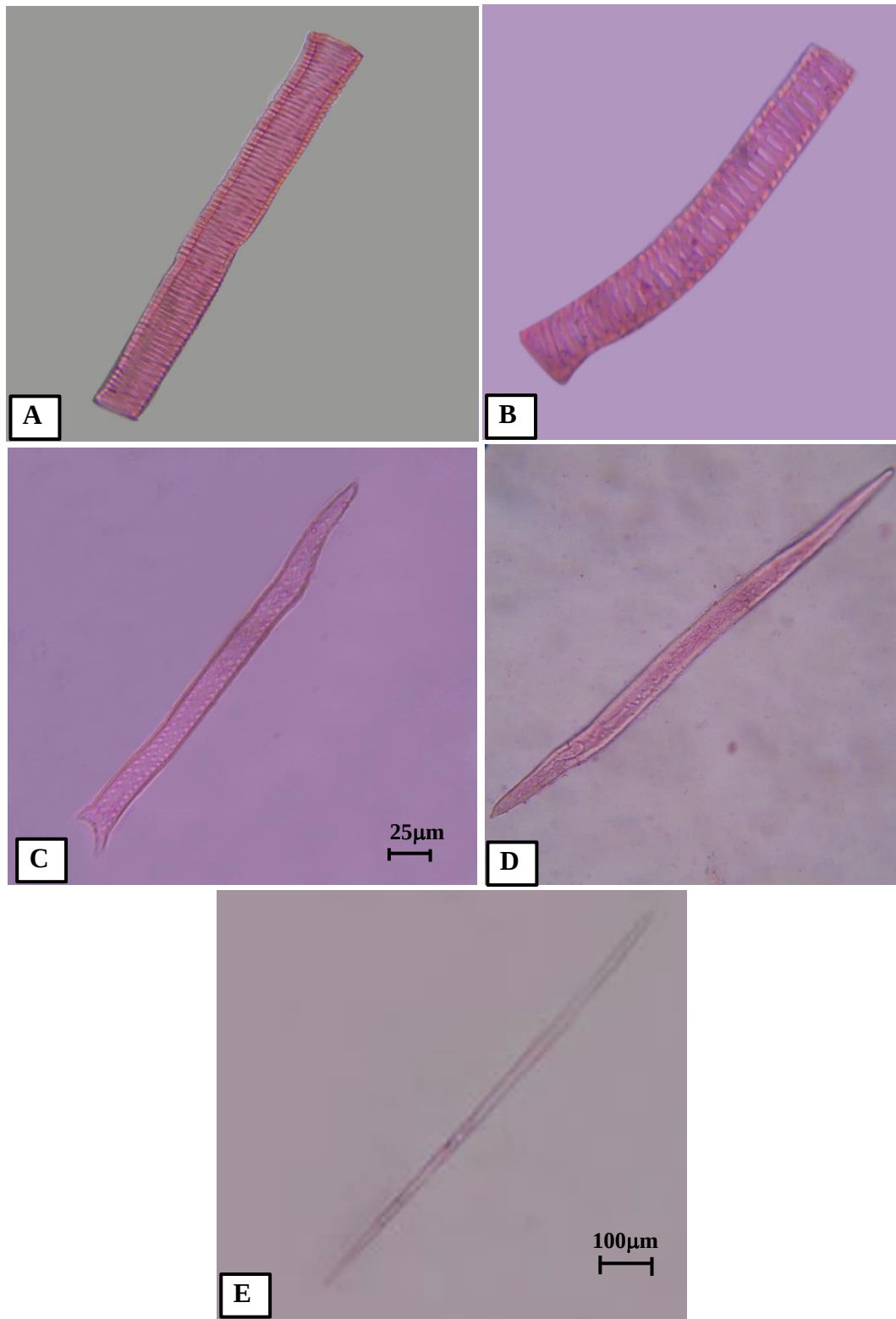


Figure 9. Macerated elements of petiole of *Justicia decussata* Roxb.

- A. Vessel element with spiral thickening
- B. Vessel element with reticulate thickening
- C. Tracheid with reticulate thickening
- D. Fiber-tracheid
- E. Fiber

Stem

Primary body

In transverse section, the young stem of *Justicia decussata* Roxb. studied were circular-shape in outline, 2000 – 2300 µm in diameter (Fig. 10 B & C), distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells, cystoliths and non-glandular trichomes. In surface view, epidermal cells parenchymatous, polygonal or rectangular in shape, thin-walled, the cells 8.75 – 27.5 µm in length, 8.5 – 25.5 µm in breadth; cystoliths oval in shape, 7.5 – 15.0 µm in length, 8.75 – 22.5 µm in breadth; trichomes multicellular, uniseriate, 112.5 – 120.0 µm in length, 10.0 – 15.0 µm in breadth (Fig. 10 A). In transverse section, the epidermal cells one-layered, compact, parenchymatous, thin-walled, oval or barrel-shaped, the cells 10.0 – 21.25 µm in length, 8.75 – 16.25 µm in breadth; non-glandular trichomes multicellular, uniseriate, 112.5 – 180.0 µm in length, 10.5 – 15.0 µm in breadth; cuticle smooth and thin, 1.25– 3.75 µm thick (Fig. 10B).

Ground tissue system : Composed of outer collenchymatous and well-defined group of inner parenchymatous cortical cells, endodermis, pericycle and pith; outer collenchymatous cells 3- to 8-layered, the layers 57.5 – 148.75 µm thick, the cells oval or rounded in shape, the cells 8.75 – 22.5 µm in length, 5.0 – 18.75 µm in breadth; inner parenchymatous cells 6-to 8-layered, the layers 145 – 175 µm thick, the cells oval or polygonal in shape, the cells 10.0 – 33.75 µm in length, 17.5 – 48.0 µm in breadth, intercellular spaces small; endodermis one-layered, the cells compact, parenchymatous, thin-walled, barrel-shaped, the cells 11.25 – 21.25 µm in length, 12.5 – 37.5 µm in breadth; pericycle forming scalarenchymatous cells, 3.75 – 7.5 µm in length, 2.5 – 8.0 µm in breadth; pith parenchymatous 15- to 24-layered, the layers 1200 – 1300 µm thick, the cells 22.5 – 67.5 µm in length, 21.25 – 73.75 µm in breadth, intercellular spaces small or absent (Fig. 10 B).

Vascular tissue system: Vascular tissue lying internal to the cortex, bundle of collateral type, vascular bundle forming discontinuous circular ring, phloem toward the outer and xylem toward the inner; phloem 1-to 3-layered, the layers 8.75 – 25.0 µm thick, the cells 6.25 – 15.0 µm in length, 5.0 – 12.5 µm in breadth, composed of sieve-tubes, companion cells, phloem fiber and phloem parenchyma; xylem towards the abaxial side, 1- to 4- celled in each row, protoxylem towards the pith, metaxylem towards the periphery, endarch, metaxylem 25 – 30 µm in length, 20.0 – 27.5 µm in breadth, protoxylem 2.5 – 6.25 µm in length, 3.0 – 7.5 µm in breadth, composed of vessel elements, tracheids, fibers and xylem parenchyma (Fig. 10 C).

Secondary body

Periderm: Periderm does not form in the stem studied.

Secondary vascular system: Vascular cambium lying between phloem and xylem; parenchymatous (Fig. 10E), 1 – 3 layered with immediate derivatives, rectangular in shape, thin-walled, some cells slightly flattened, meristematic, differentiated into fusiform initial and ray initial; fusiform initial gives rise to sieve tubes, companion cells and phloem parenchyma outward, gives rise to vessel elements, xylem fibers, and xylem parenchyma inward; ray initial gives rise to phloem ray cells outward, xylem ray cells inward.

Secondary phloem lying between primary phloem and vascular cambium (Fig. 10D&E), consisted of sieve tubes, companion cells, phloem parenchyma, phloem fiber and phloem ray cells.

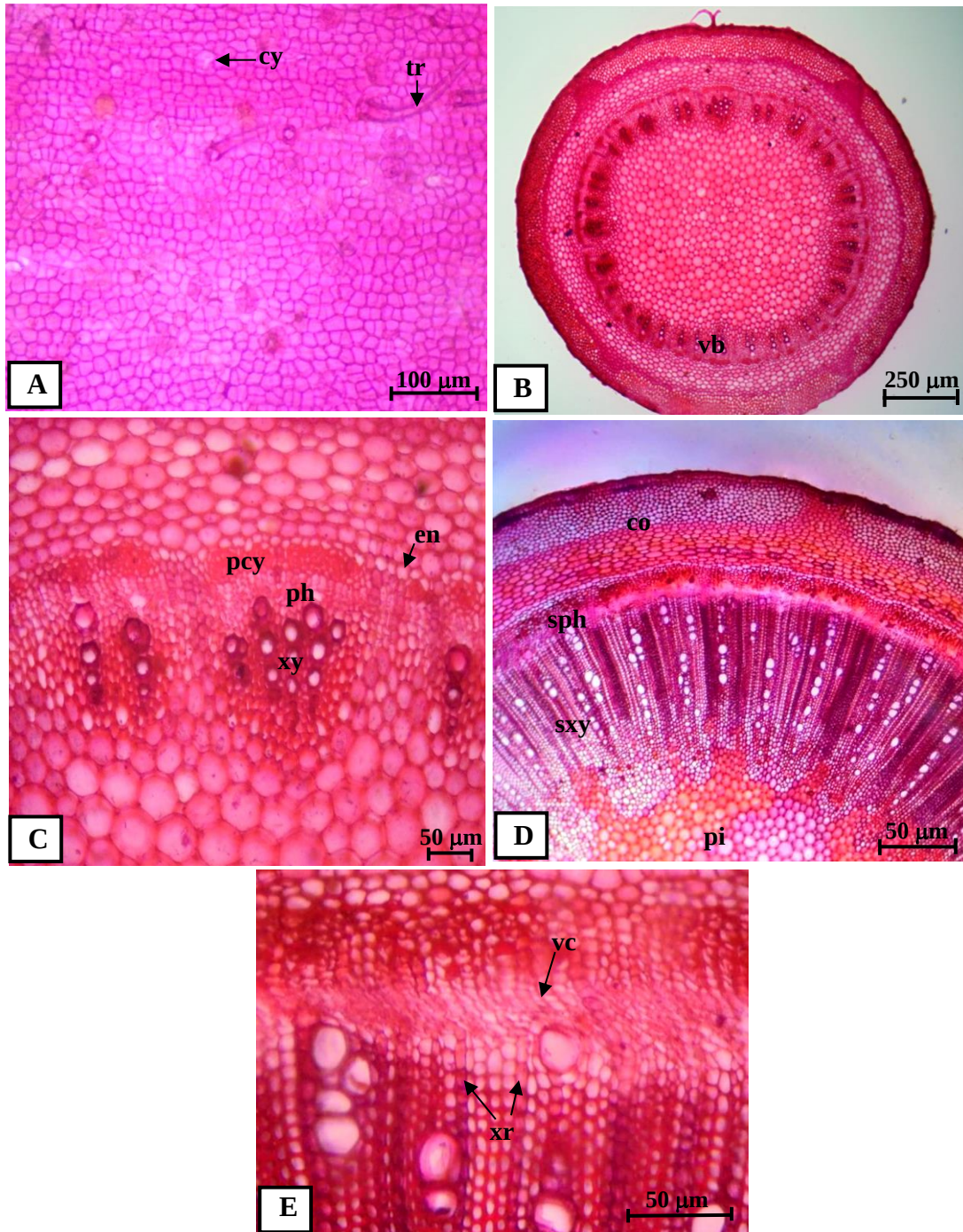


Figure 10. Internal structure of stem of *Justicia decussata* Roxb.

- A. Surface view of stem with crystal and dular trichomes
 - B. T.S of a portion of young stem showing tissue systems
 - C. T.S of a portion of young stem showing vascular bundle
 - D. T.S of a portion of stem showing secondary tissue
 - E. T.S of a portion of stem showing vascular cambium
- (tr - trichome, cy - cystolith, vb - vascular bundle, xy - xylem, ph - phloem, en - endodermis, pcy - pericycle, co - cortex, sph - secondary phloem, sxy - secondary xylem, pi - pith, vc - vascular cambium, pr - phloem ray, xr - xylem ray)

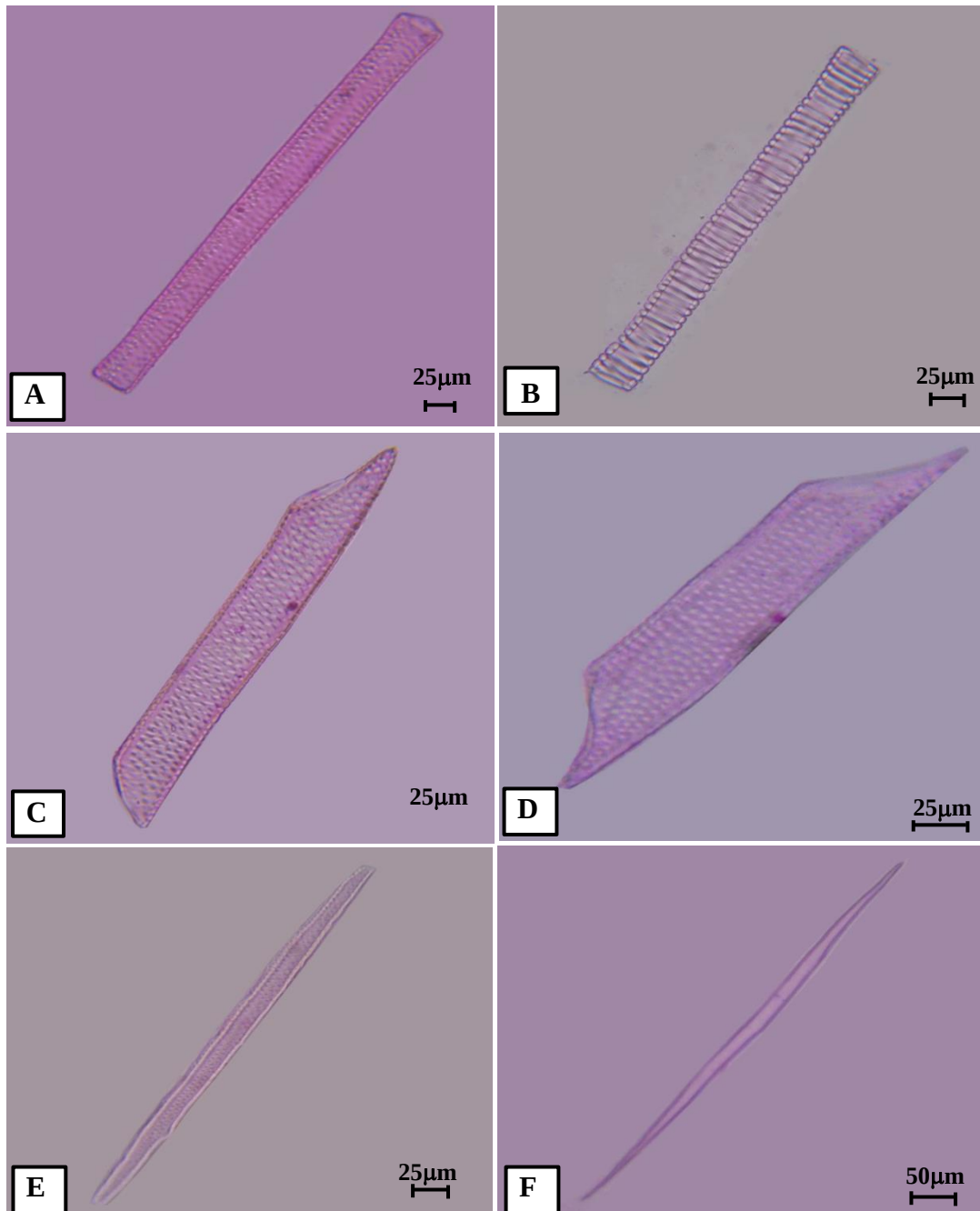


Figure 11. Macerated elements of stem of *Justicia decussata* Roxb.

- A. Vessel element with reticulate thickening
- B. Vessel element with spiral thickening
- C. Vessel element with pitted and reticulate thickening
- D. Vessel element with pitted and reticulate thickening
- E. Tracheid with reticulate thickening
- F. Fiber

Secondary xylem lying between primary xylem and vascular cambium (Fig. 10 D & E), composed of vessel elements, fibers and xylem parenchyma, and xylem ray cells; vessel elements thick-walled, lateral walls straight, end walls transverse or oblique, tailed at both ends or tailless, perforation plate simple, thickening spiral, reticulate and pitted, 187.5 – 287.5 μm in length, 27.5 – 37.5 μm in breadth; tracheids thick-walled, lateral walls straight, end walls acute, thickening reticulate and pitted, 267.5 – 350.0 μm in length, 17.5 – 20.0 μm in breadth; fibers thick-walled, lumen narrow, lateral walls straight, end walls acute or acuminate, 440 – 480 μm in length, 15 – 20 μm in breadth.

Root

Primary body

In transverse section, the young roots of *Justicia decussata* Roxb. studied were circular in outline, about 450 – 480 μm in diameter (Fig. 12 A & B), distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system : In transverse section, the cells of epiblema one layered, the cells 15.0 – 17.5 μm in length, 7.5 – 12.5 μm in breadth, rectangular or irregular in shape, some cells ruptured, outer wall deeply stained (Fig. 12 A).

Ground tissue system : Composed of cortex, endodermis and pericycle. Cortex 5 or 6 layered, the layers 112.5 – 125.0 μm thick, parenchymatous, oval or irregular in shape 13.75 – 27.5 μm in length, 20 – 35 μm in breadth, intercellular spaces present; endodermis one-layered, the cells 8.75 – 12.5 μm in length, 10.5 – 15.0 μm in breadth, compact, parenchymatous, barrel shaped or irregular in shape; pericycle one layered, the cells 8.0 – 11.25 μm in length, 6.25 – 12.5 μm breadth, compact, parenchymatous, thin-walled, irregular in shaped (Fig. 12 A).

Vascular tissue system : In transverse section, vascular bundles radially arranged, tetrarch, xylem and phloem occur in separate patches arranged on alternate radii; phloem 4-or 5-layered, the layers 11.75 – 18.75 μm thick, composed of sieve-tubes, companion cells, phloem fibers and phloem parenchyma; xylem arranged in exarch pattern, protoxylem arranged towards the periphery, metcolylem toward the pith, composed of vessel elements, tracheids, fibers and xylem parenchyma (Fig. 12 B).

Secondary body

Periderm: Periderm formed in peripheral zone of the cortex, just internal to 1 – 4 layers of cortical cells, consisted of phellogen or cork cambium, phellem or cork, and phelloderm (Fig. 12 D & E).

Phellogen or cork cambium lying between cork cells and phelloderm, the cells one layered, parenchymatous, meristematic, rectangular, tangentially flattened, colourless (Fig. 12 D & E).

Phellem or cork cells derived from phellogen or cork cambium, lying outside the cork cambium, 3 or 4 layered, parenchymatous, tangentially flattened, colourless. Phelloderm derived from phellogen or cork cambium, lying inside the cork cambium, 2 or 3 layered, parenchymatous, tangentially flattened, colourless (Fig. 12 D & E).

Secondary vascular system: Vascular cambium lying between phloem and xylem; one layered, parenchymatous, meristematic cells, rectangular in shape, thin-walled, tangentially flattened, colourless, differentiated into fusiform initial and ray initial; fusiform initial gives rise to sieve tubes, companion cells, and phloem parenchyma outward, and gives rise to vessel elements, xylem fibers, and xylem parenchyma inward; ray initial gives rise to phloem ray cells outward, xylem ray cells inward.

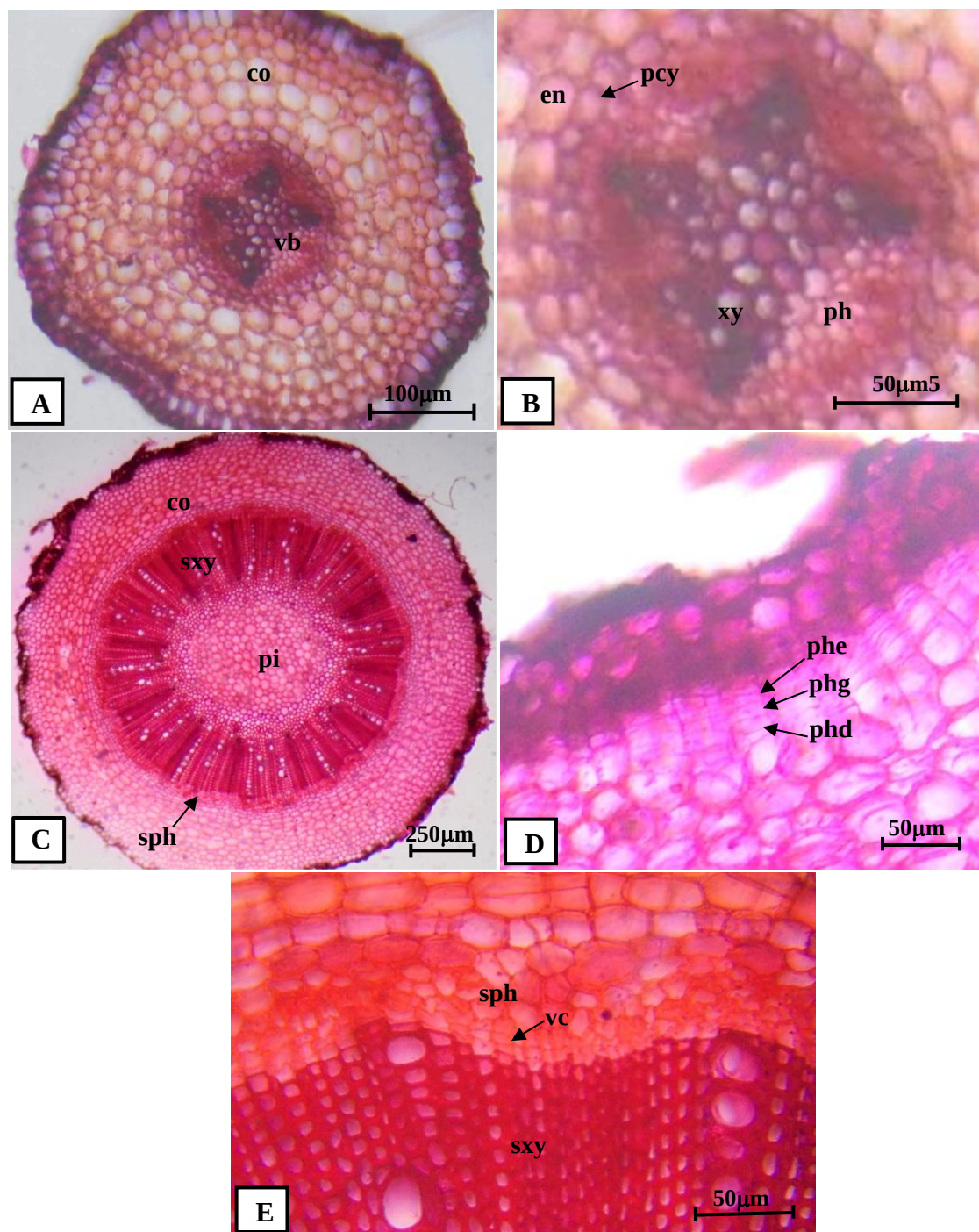


Figure 12 .Internal structure of root of *Justicia decussata* Roxb.

- A. T.S of a young root showing outline and tissue system
- B. T.S of a portion of young root showing vascular systems
- C. T.S of a root showing secondary tissue

- D. T.S of a portion of root showing secondary periderm
 E. T.S of a portion of root showing vascular cambium
 (co - cortex, vb - vascular bundle, en - endodermis, pcy - pericycle, ph -phloem, xy - xylem, sph - secondary phloem, sxy -secondary xylem, pi - pith, phg - phellogen, phe - phellem, phd - phelloderm, vc - vascular cambium)

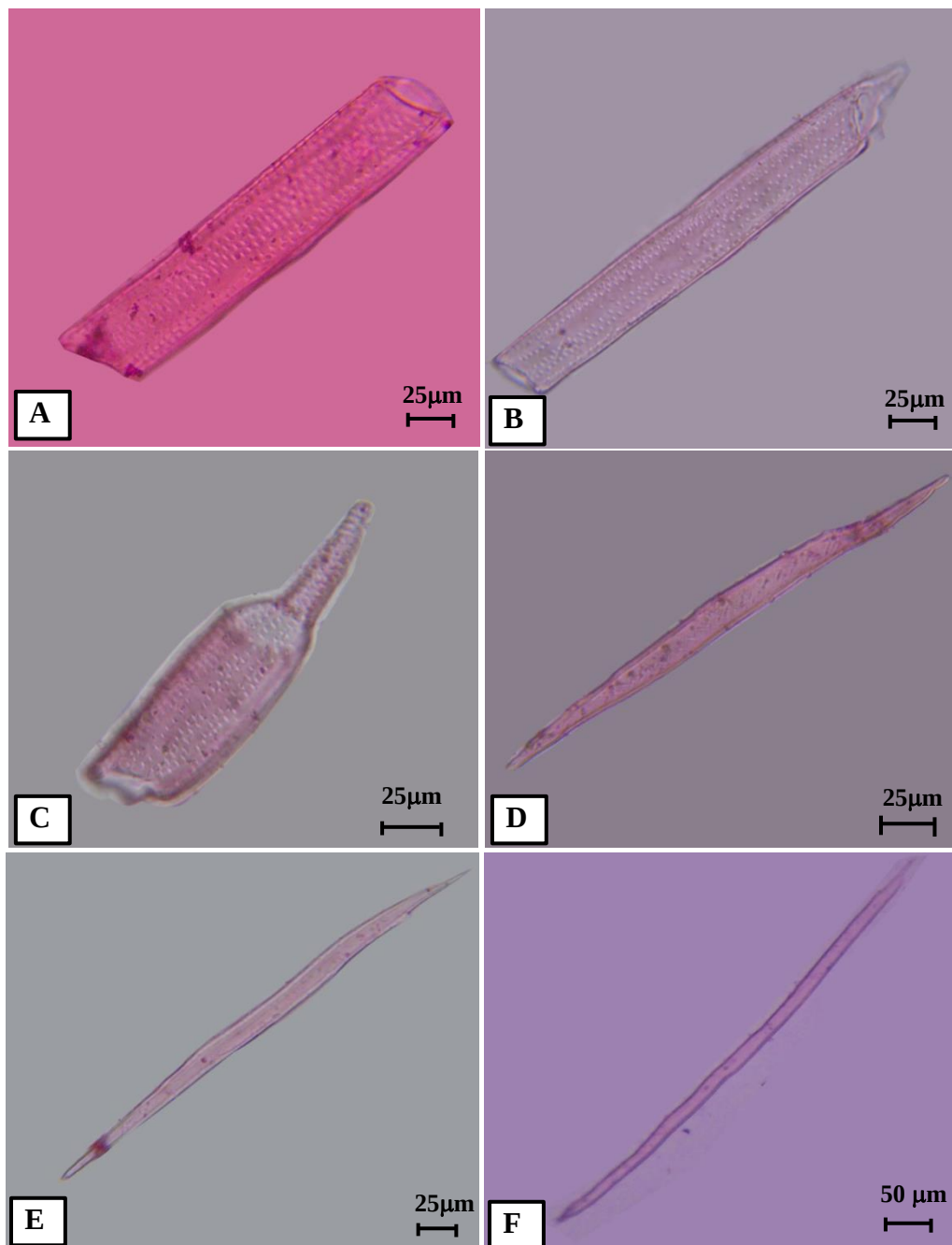


Figure 13. Macerated elements of root of *Justicia decussata* Roxb.

- A. Vessel element with pitted and reticulate thickening
 B. Vessel element with pitted
 C. Vessel element with pitted and reticulate thickening
 D. Tracheid with reticulate thickening
 E. Fiber-tracheid
 F. Fiber

Secondary phloem lying between primary phloem and vascular cambium, derived from vascular cambium, consists of sieve tubes, companion cells, phloem parenchyma, and phloem ray cells (Fig. 12 D & E).

Secondary xylem lying between primary xylem and vascular cambium, derived from vascular cambium, consists of vessel elements, fibers and xylem parenchyma cells (Fig. 12 D & E), vessel elements thick-walled, lateral walls straight, end walls transverse or oblique, tailed at one end or tailless, perforation plates simple, thickening pitted, 175 – 300 µm in length, 25.0 – 47.5 µm in breadth; tracheids thick-walled, lateral walls straight, end walls acute, thickening reticulate, 212.5 – 250.0 µm in length, 15.0 – 17.5 µm in breadth; fibers thick-walled, lumen narrow, lateral walls straight, end walls acute to acuminate, 450 – 500 µm in length, 10 – 15 µm in breadth.

4.2.2. Microscopical characteristics of *Rhinacanthus nasutus* (L.) Kurz

Lamina

In transverse section, the laminae of *Rhinacanthus nasutus* (L.) Kurz studied were 300 – 500 µm thick (Fig. 14 D), typically dorsiventral, venation reticulate, distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells, guard cells of the stomata, cystoliths containing cells and trichomes. In surface view, epidermal cells of both surfaces parenchymatous, irregularly arranged; adaxial epidermal cells deeply wavy, thin-walled, 25.0 – 102.5 µm in length, 12.5 – 37.5 µm in breadth; cystoliths ellipsoid in shape, 50 – 150 µm in length, 12.5 – 22.5 µm in breadth; abaxial epidermal cells wavy, thin-walled, 35.5 – 60.0 µm in length, 12.5 – 35.0 µm in breadth; stomata of diacytic types, stomatal index 26; the guard cells reniform, 25 – 30 µm in length, 7.5 – 10.0 µm in breadth; cystoliths ellipsoid in shape, 62.5 – 125.0 µm in length, 12.5 – 27.5 µm in breadth; trichomes unicellular or multicellular, uniseriate, 75 – 300 µm in length, 10.0 – 37.5 µm in breadth (Fig. 14 A & B). In transverse section, epidermal cells outermost, both adaxial and abaxial epidermal cells one-layered, the cells oval or barrel-shaped, thin-walled, compact, continuous, anticlinal walls straight, outer and inner walls slightly convex; cells 10 – 35 µm in length, 10 – 40 µm in breadth at adaxial side; cells 10 – 30 µm in length, 7.5 – 27.5 µm in breadth at abaxial side; cuticle smooth and thin, 5.0 – 7.5 µm thick (Fig. 14 D).

Ground tissue system: Mesophyll cells differentiated into palisade and spongy parenchyma; palisade parenchyma lying internal to the adaxial epidermal cells, one-layered, the layers 27.5 – 47.5 µm thick, the cells vertically elongated, compact, thin-walled, straight, 27.5 – 47.5 µm in length, 5.0 – 10.5 µm in breadth, chloroplast abundant; spongy parenchyma lying internal to the abaxial epidermal cells, 2- or 3- layered, the layers 70.5 – 90.5 µm thick, the cells oval or rounded in shape, thin-walled, 10.0 – 27.5 µm in length, 12.5 – 42.5 µm in breadth, intercellular spaces and chloroplast present (Fig. 14 C).

Vascular tissue system: Vascular bundles embedded in the mesophyll cells, of closed collateral type, rounded or oval-shaped, small. Xylem lying at the adaxial side and phloem at the abaxial side; phloem 1- to 4- layered, the layers 15 – 30 µm thick, the cells oval or polygonal in shape, the cells 5.0 – 7.5 µm in length, 2.5 – 5.0 µm in breadth, phloem composed of sieve- tubes, companion cells, phloem fibres and phloem parenchyma; xylem arranged in 4- or 5- rows, metaxylem 1- to 4- celled in each row, the cells 10 – 20 µm in length, 10 – 15 µm in breadth, composed of vessel elements, tracheids, fibers and xylem parenchyma (Fig. 14 E); vessel elements thick- walled, lateral walls straight, end walls transverse, thickening spiral,

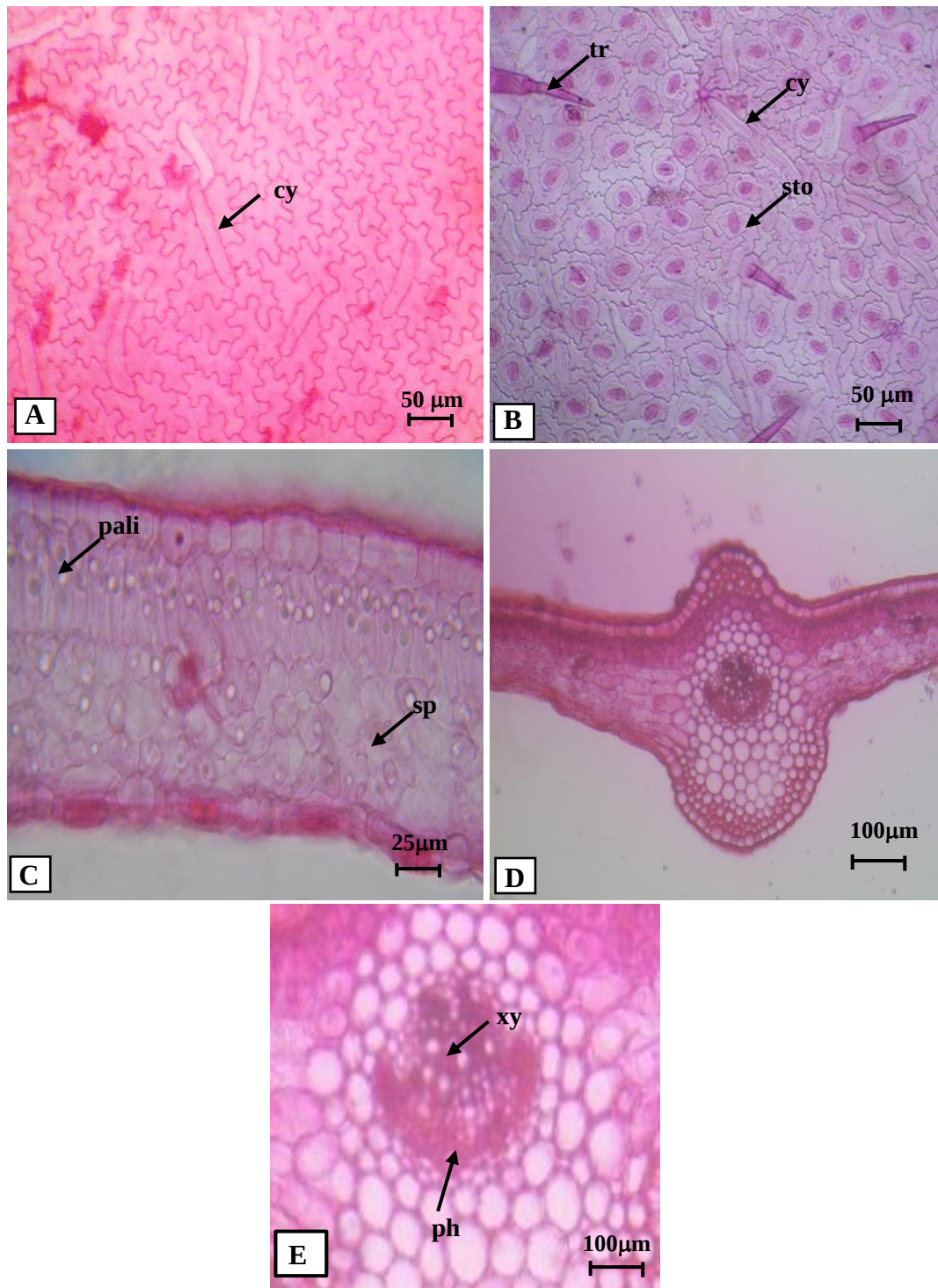


Figure 14. Internal structure of lamina of *Rhinacanthus nasutus* (L.) Kurz
 A. Surface view of adaxial side showing cystoliths
 B. Surface view of abaxial side showing trichomes stomata and cystoliths
 C. T.S of a portion of lamina showing mesophyll
 D. T.S of a portion of lateral veinlet of lamina showing vascular bundle
 E. T.S of a portion of lamina showing enlarged vascular bundle
 (cy - cystoliths, tr - trichome, sto - stomata, pali - palisade, sp - spongy, xy - xylem, ph - phloem)

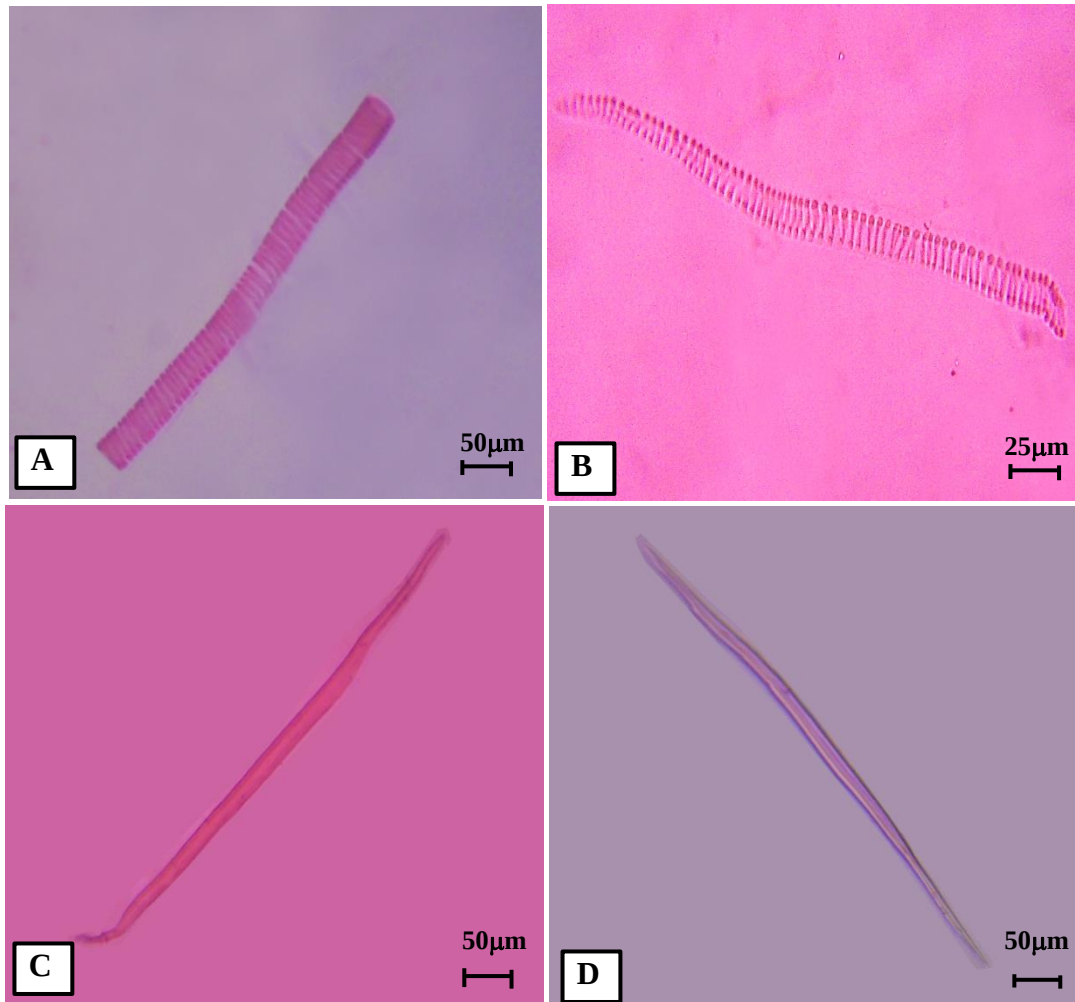


Figure 15. Macerated elements of lamina of *Rhinacanthus nasutus* (L.) Kurz

- A. Vessel element with spiral thickening
- B. Tracheid with spiral thickening
- C. Fiber-tracheid
- D. Fiber

100 – 400 μm in length, 17.5 - 20.0 μm breadth; tracheids thick-walled, lateral walls straight, end walls acute, thickening spiral, 320 – 625 μm in length, 15 – 20 μm in breadth; fiber-tracheids thick-walled, lateral walls straight, end walls acute, 250 – 550 μm in length, 10 – 20 μm in breadth; fibers thick-walled, lumen narrow, lateral walls straight, end walls acute to acuminate, 400 – 500 μm in length, 10 – 15 μm in breadth.

Midrib

In transverse section, the midribs studied were oval in outline, 1215.5 – 1350.0 μm in diameter (Fig. 16 B), distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells and non-glandular trichomes. In surface view, epidermal cells parenchymatous, polygonal or rectangular in shape, thin-walled, 22.5 – 62.5 μm in length, 12.5 – 37.5 μm in breadth; non-glandular trichomes multicellular, uniseriate, 250 – 325 μm in length, 25.0 – 31.25 μm in breadth (Fig. 16 A). In transeverse section, both adaxial and abaxial epidermal cells one-layered, oval or barrel-shaped, compactly arranged, continuous, thin-walled, anticlinal walls slightly straight, outer and inner walls slightly convex; those at adaxial cells 15.0 – 28.75 μm in length, 10 – 25 μm in breadth; those at abaxial cells 7.5 – 18.75 μm in length, 12.5 – 32.5 μm in breadth; cuticle thin, 1.25 – 2.5 μm thick; non-glandular trichomes multicellular, uniseriate, 100.0 – 240.0 μm in length, 20 – 25 μm in breadth (Fig. 16 B).

Ground tissue system: Composed of outer collenchymatous cells and inner parenchymatous cells as main mass of ground tissue. Outer collenchymatous layers lying internal to the adaxial and abaxial epidermis; those at adaxial sides 3- to 5- layered, the layers 82 – 102 μm thick, the cells oval or rounded in shape, 7.5 – 20.75 μm in length, 7.5 – 15.25 μm in breadth; those at abaxial sides 2- to 5-layered, the layers 15 – 82 μm thick, the cells oval or rounded in shape, 7.5 – 20.5 μm in length, 6.25 – 20.5 μm in breadth (Fig. 16 C). Inner parenchymatous layers lying internal to the adaxial and abaxial collenchymatous layers; those at adaxial sides 9 -to 10- layered, the layers 300 – 520 μm thick, the cells oval or rounded in shape, thin-walled, 25 – 60 μm in length, 20 – 60 μm in breadth; those at abaxial sides 9- to 11- layered, the layers 250 – 320 μm thick, the cells oval or rounded in shape, thin-walled, 32 – 61 μm in length, 20 – 55 μm in breadth, intercellular spaces small (Fig. 16 D).

Vascular tissue system: A large vascular bundle lying in the middle separated with two small accessory strands at the adaxial side, of open collateral type, the large bundle crescent-shaped, 270 – 330 μm in thickness, 580 – 950 μm in width; phloem towards the abaxial side, 2- to 4- layered, the layers 12.5 – 37.5 μm thick, the cells 6.25 – 12.5 μm in length, 6.25 – 12.5 μm in breadth, composed of sieve-tubes, companion cells, phloem fibers and phloem parenchyma; vascular cambium lying between xylem and phloem cells, 2- or 3- layered, the layers 10 – 40 μm thick, the cells 2.5 – 7.5 μm in length, 3 – 10 μm in breadth; xylem towards the adaxial side, 23 to 26 rows, metaxylem 1- to 6-celled in each row, the cells 2.5 – 8.75 μm in length, 3.0 – 7.5 μm in breadth, xylem composed of vessel elements, tracheids, fibers and xylem parenchyma (Fig. 16E); vessel elements thick-walled, lateral walls straight, end walls transverse, thickening spiral, 200 – 380 μm in length, 17.5 – 30.0 μm in breadth; tracheids thick-walled, lateral walls straight, end walls oblique or acute, thickening reticulate, 200 – 375 μm in length, 12.5 – 15.0 μm in breadth; fiber-tracheid thick-walled, lateral walls straight, end walls oblique or acute, 250 – 440 μm in length, 10 – 25 μm in breadth; fibers thick-walled, lateral walls straight, end walls acute or acuminate, 450 – 500 μm in length, 10 – 20 μm in breadth.

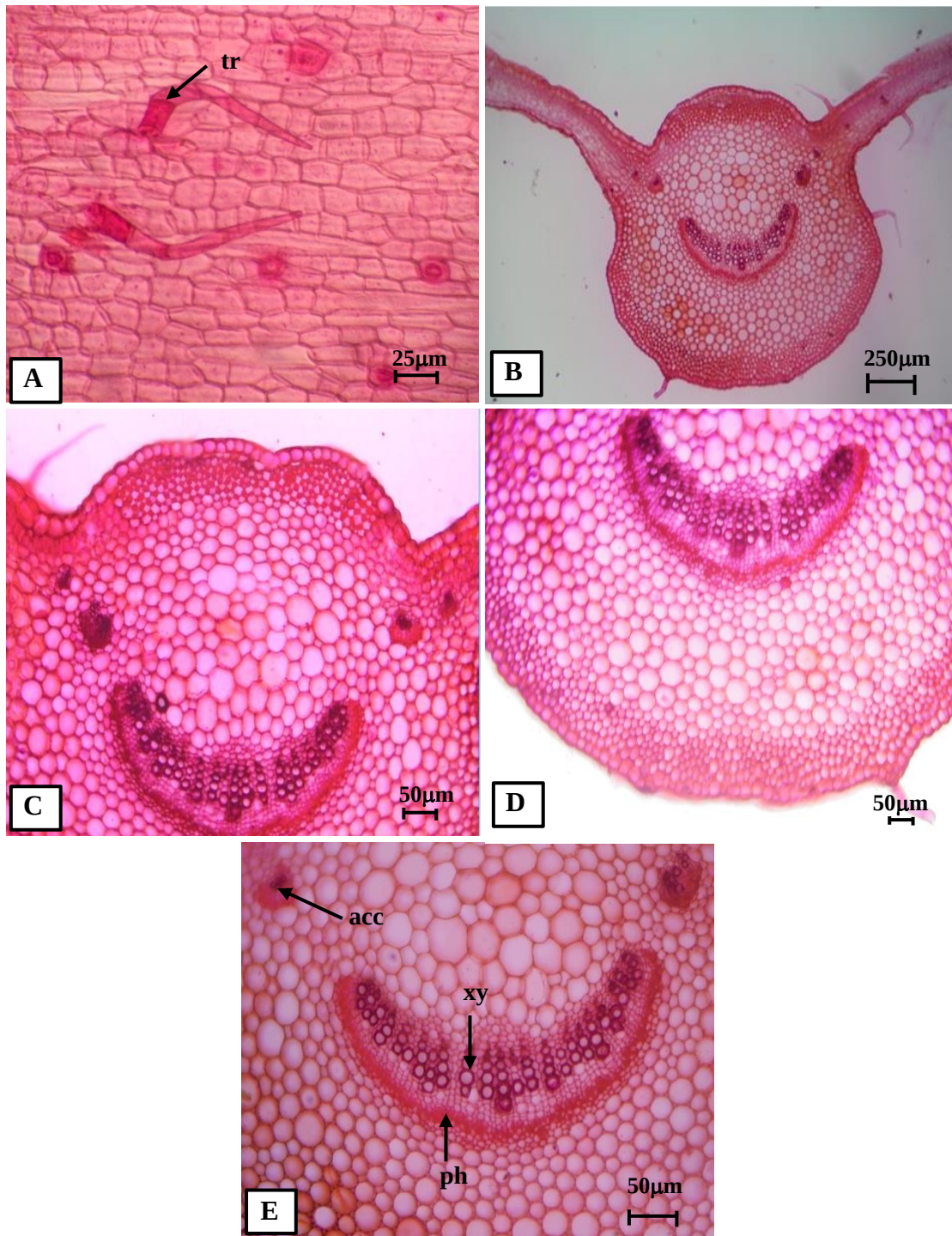


Figure 16. Internal structure of midrib of *Rhinacanthus nasutus* (L.) Kurz

- A. Surface view of midrib with trichomes
- B. T.S of a portion of midrib showing tissue systems
- C. T.S of a portion of midrib showing adaxial side
- D. T.S of a portion of midrib showing abaxial side
- E. T.S of a portion of midrib showing vascular bundle and two accessory bundles at the adaxial side
(tr - trichome, acc - accessory bundle, xy - xylem, ph - phloem)

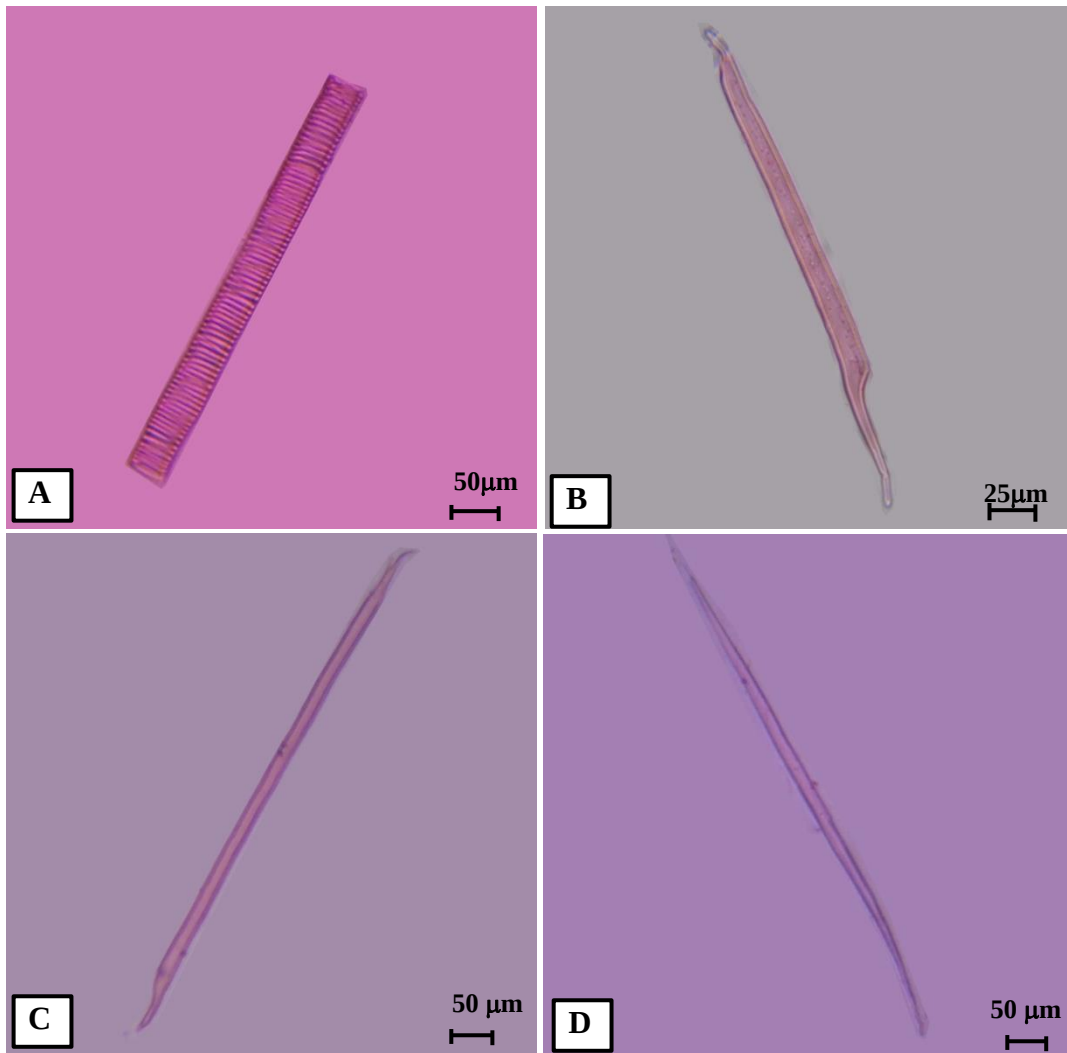


Figure 17. Macerated elements of midrib of *Rhinacanthus nasutus* (L.) Kurz

- A. Vessel element with spiral thickening
- B. Tracheid with reticulate thickening
- C. Fiber-tracheid
- D. Fiber

Petiole

In tranverse section, the petiole studied were semicircular in outline with two small protuberance at adaxial side, 1612.5 – 1837.5 µm in diameter (Fig. 18 B), distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells, non-glandular trichomes and cystoliths containing cells. In surface view, epidermal cells parenchymatous, polygonal or rectangular in shape, thin-walled, 25 – 65 µm in length, 15 – 30 µm in breadth; trichomes multicellular, uniseriate, 130 – 250 µm in length, 25 – 30 µm in breadth; cystoliths ellipsoid in shape, 40 – 150 µm in length, 20 – 40 µm in breadth (Fig. 18A). In tranverse section, both adaxial and abaxial epidermal cells one-layered, the cells oval or barrel-shaped, thin-walled, compact, continuous, anticlinal walls straight, outer and inner walls slightly convex; those at adaxial side 15 – 35 µm in length, 12.0 – 37.5 µm in breadth; those at abaxial side 16.5 – 32.5 µm in length, 12.5 – 35.0 µm in breadth; glandular trichomes head 4-celled, 25.0 – 27.5 µm in length, 45.0 – 52.5 µm in breadth, stalk 18.75 – 25.0 µm in length, 20.75 – 33.0 µm in breadth; non-glandular trichomes multicellular, uniseriate, 75.0 – 237.5 µm in length, 10.0 – 25.5 µm in breadth; cuticle smooth and thin, 1.25 – 2.5 µm thick (Fig. 18 B).

Ground tissue system: Composed of outer collenchymatous cells and inner parenchymatous cells as main mass of ground tissue. Outer collenchymatous layers lying internal to the adaxial and abaxial epidermis; those at adaxial side 4- to 8- layered, the layers 100 – 150 µm thick, the cells oval or rounded in shape, 15 – 40 µm in length, 10 – 40 µm in breadth; those at abaxial side 4- or 5- layered, the layers 100 – 111 µm thick, the cells oval or rounded in shape, 10 – 35 µm in length, 12.5 – 35.0 µm in breadth (Fig. 18C). Inner parenchymatous layers lying internal to collenchymatous layers; those at adaxial side 6- to 10- layered, the layers 300 – 530 µm thick, the cells oval or rounded in shape, thin-walled, 30 – 100 µm in length, 20 – 100 µm in breadth, intercellular spaces present; those at abaxial side 6- to 9- layered, the layers 250 – 420 µm thick, the cells oval or rounded in shape, thin-walled, 20 – 72 µm in length, 25 – 75 µm in breadth, intercellular spaces present (Fig. 18D).

Vascular tissue system: A large vascular bundle lying in the middle and two small accessory strands at the adaxial side, of open collateral type, the large bundle crescent-shaped, 170 – 150 µm in thickness, 450 – 860 µm in width; phloem towards the abaxial side, 2- or 3- layered, the layers 12.5 – 37.5 µm thick, the cells 2.5 – 10.0 µm in length, 5.0 – 12.5 µm in breadth, composed of sieve-tubes, companion cells, phloem fibers and phloem parenchyma; cambiform cells located between xylem and phloem cells, 2- or 3- layered, the layers 10 – 40 µm thick, the cells 2.5 – 7.5 µm in length, 3.5 – 10.0 µm in breadth, rectangular in shape, flattened; xylem towards the adaxial side, 25- to 28- rows, metaxylem 2-to 10- celled in each row, the cells 2.5 – 8.25 µm in length, 3.75 – 7.5 µm in breadth, xylem composed of vessel elements, tracheids, fibers and xylem parenchyma (Fig. 18 E); vessels elements thick-walled, lateral walls straight, end walls transverse, thickening spiral, 200 – 275 µm in length, 20 – 25 µm in breadth; tracheids thick-walled, lateral walls straight, end walls transverse or acute, thickening spiral, 450 – 575 µm in length, 15 – 25 µm in breadth; fiber-tracheids thick-walled, lateral walls straight, end walls acute, 300 – 550 µm in length, 10 – 15 µm in breadth; fibers thick-walled, lumen narrow, lateral walls straight, end walls acute, 350 – 500 µm in length, 7.5 – 10.0 µm in breadth.

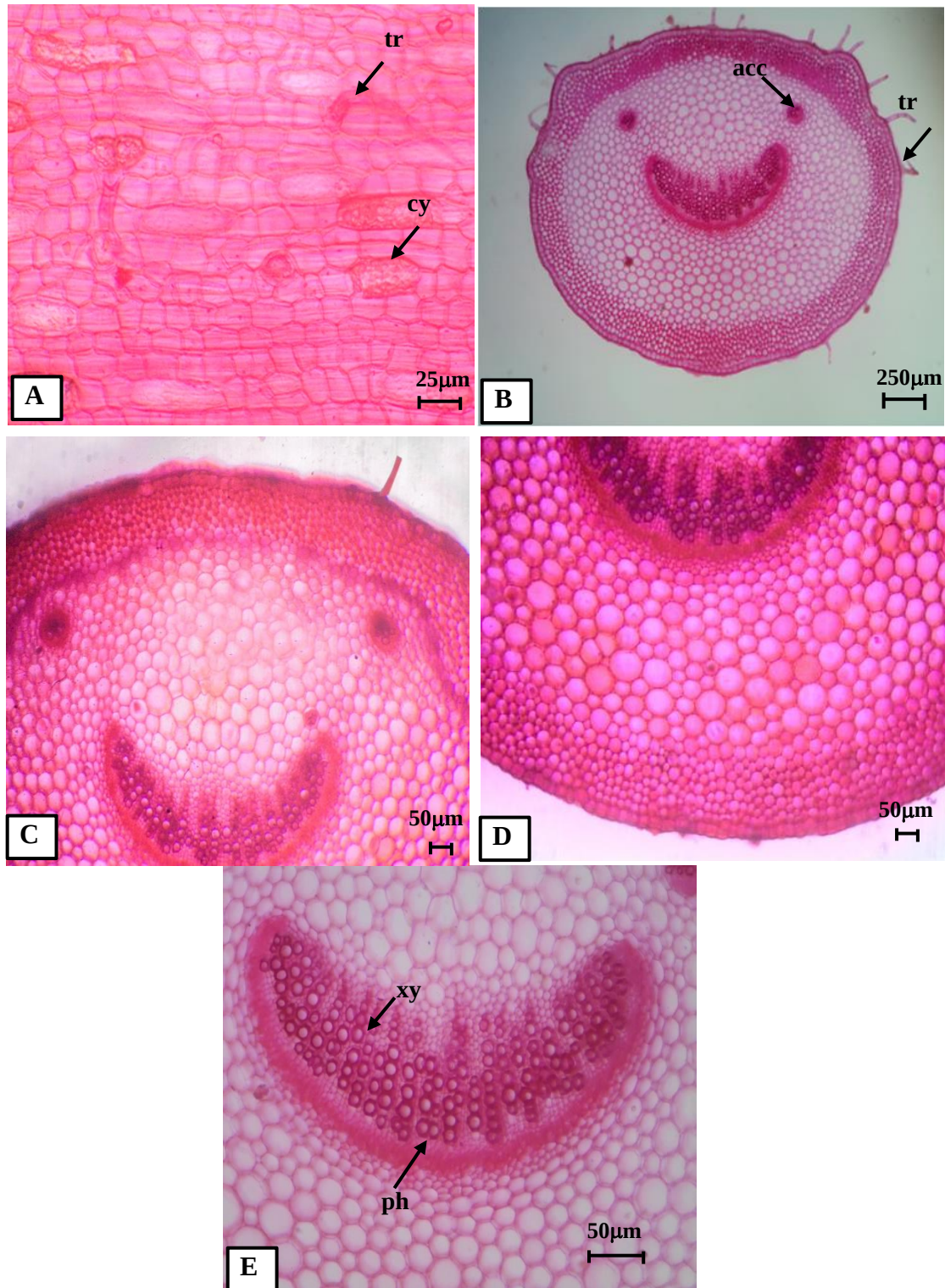


Figure 18. Internal structure of petiole of *Rhinacanthus nasutus* (L.) Kurz

- A. Surface view of petiole with trichomes and cystoliths
 - B. T.S of a portion of petiole showing tissue systems
 - C. T.S of a portion of petiole showing adaxial side
 - D. T.S of a portion of petiole showing abaxial side
 - E. T.S of a portion of petiole showing vascular bundle
- (tr - trichome, cy - cystoliths, acc - accessory bundle, xy - xylem, ph - phloem)

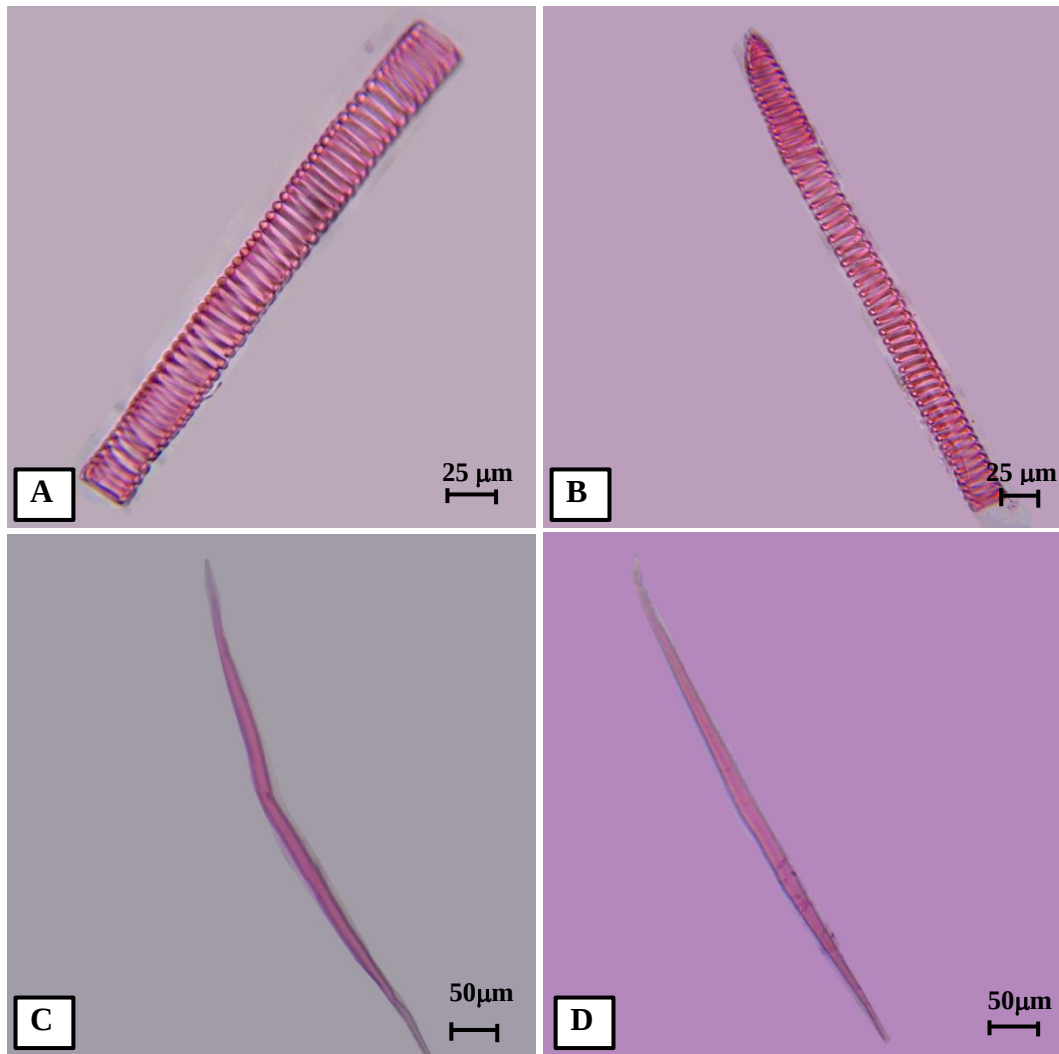


Figure 19. Macerated elements of petiole of *Rhinacanthus nasutus* (L.) Kurz

- A. Vessel element with spiral thickening
- B. Tracheid with spiral thickening
- C. Fiber-tracheid
- D. Fiber

Stem

Primary body

In transverse section, the young stems of *Rhinacanthus nasutus* (L.) Kurz studied were hexa-angular in outline with ridges and furrow, 1500.0 – 1987.5 µm in diameter (Fig. 20 B) distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: Composed of epidermal cells, guard cells of the stomata and cystoliths. In surface view, epidermal cells parenchymatous, polygonal or rectangular, thin-walled, 15 – 60 µm in length, 15 – 40 µm in breadth; stomata present of diacytic type, stomatal index 6; the guard cells reniform, 25.0 – 32.5 µm in length, 5.0 – 8.75 µm in breadth; cystoliths ellipsoid or oval in shape, 61 – 200 µm in length, 25 – 30 µm in breadth (Fig. 20 A). In transverse section, the epidermal cells one-layered, compact, parenchymatous, thin-walled, oval or barrel-shaped, the cells 20 – 35 µm in length, 12 – 25 µm in breadth; cuticle thin, 1.25 – 2.5 µm thick (Fig. 20 B).

Ground tissue system: Composed of well-defined groups of outer collenchymatous cells in the six ridges and inner parenchymatous cortical cells, endodermis, pericycle and pith; outer collenchymatous cells 1-to 5-layered, the layers 22 – 90 µm thick, the cells oval or rounded in shape, the cells 5 – 25 µm in length, 5 – 20 µm in breadth; inner parenchymatous cells 2-to 5-layered, the layers 35 – 80 µm thick, the cells oval or rounded or polygonal in shape, the cells 5 – 30 µm in length, 15 – 30 µm in breadth, intercellular spaces small; endodermis one-layered, the cells compact, parenchymatous, thin-walled, barrel-shaped, the cells 10 – 30 µm in length, 5 – 23 µm in breadth; large strand of pericyclic sclerenchymatous cells forming arcs on each vascular bundle, 25- to 30- celled in each ridge, the cells 5.0 – 8.75 µm in length, 10 – 15 µm in breadth; pith parenchymatous 12- to 14 -layered, the layers 1125.0 – 1262.0 µm thick, the cells 20 – 65 µm in length, 15 – 120 µm in breadth, intercellular spaces present (Fig. 20 B).

Vascular tissue system: Vascular tissue lying internal to the cortex, six large vascular bundles in the angle of the stem separated from one another, of open collateral type, each bundle 100 – 130 µm thick; phloem 3- or 4- layered, the layers 15 – 35 µm thick, the cells 3.0 – 5.75 µm in length, 5 – 10 µm in breadth, composed of sieve-tubes, companion cells, fiber and xylem parenchyma; vascular cambium between xylem and phloem cells, 3- to 4- layered, the layers 20 – 30 µm thick, the cells 5.0 – 8.75 µm in length, 8.75 – 12.5 µm in breadth, rectangular in shape, flattened; xylem 5 to 11 rows, 1- to 4- celled in each row, protoxylem towards the pith, metaxylem towards the periphery, endarch, metaxylem 22.5 – 35.0 µm in length, 17.5 – 30.0 µm in breadth, protoxylem 2.5 – 5.0 µm in length, 1.25 – 5.5 µm in breadth, composed of vessel elements, tracheids, fibers and xylem parenchyma (Fig. 20 C).

Secondary body

Periderm: Periderm does not form in the stem.

Secondary vascular system: Vascular cambium lying between phloem and xylem, cambial cells one layered, forming a continuous ring by uniting fascicular cambium and interfascicular cambium, parenchymatous, meristematic, cells rectangular, tangentially flattened, colourless, differentiated into fusiform initial and ray initial; fusiform initial gives rise to sieve-tubes, companion cells and phloem parenchyma outside; and it gives rise to vessel elements, fibers, and xylem parenchyma; ray initial gives rise to phloem ray cells outside and xylem ray cells inside.

Secondary phloem lying between primary phloem and vascular cambium, derived from vascular cambium, consisted of sieve tubes, companion cells, phloem parenchyma and ray parenchyma (Fig. 20D & E)

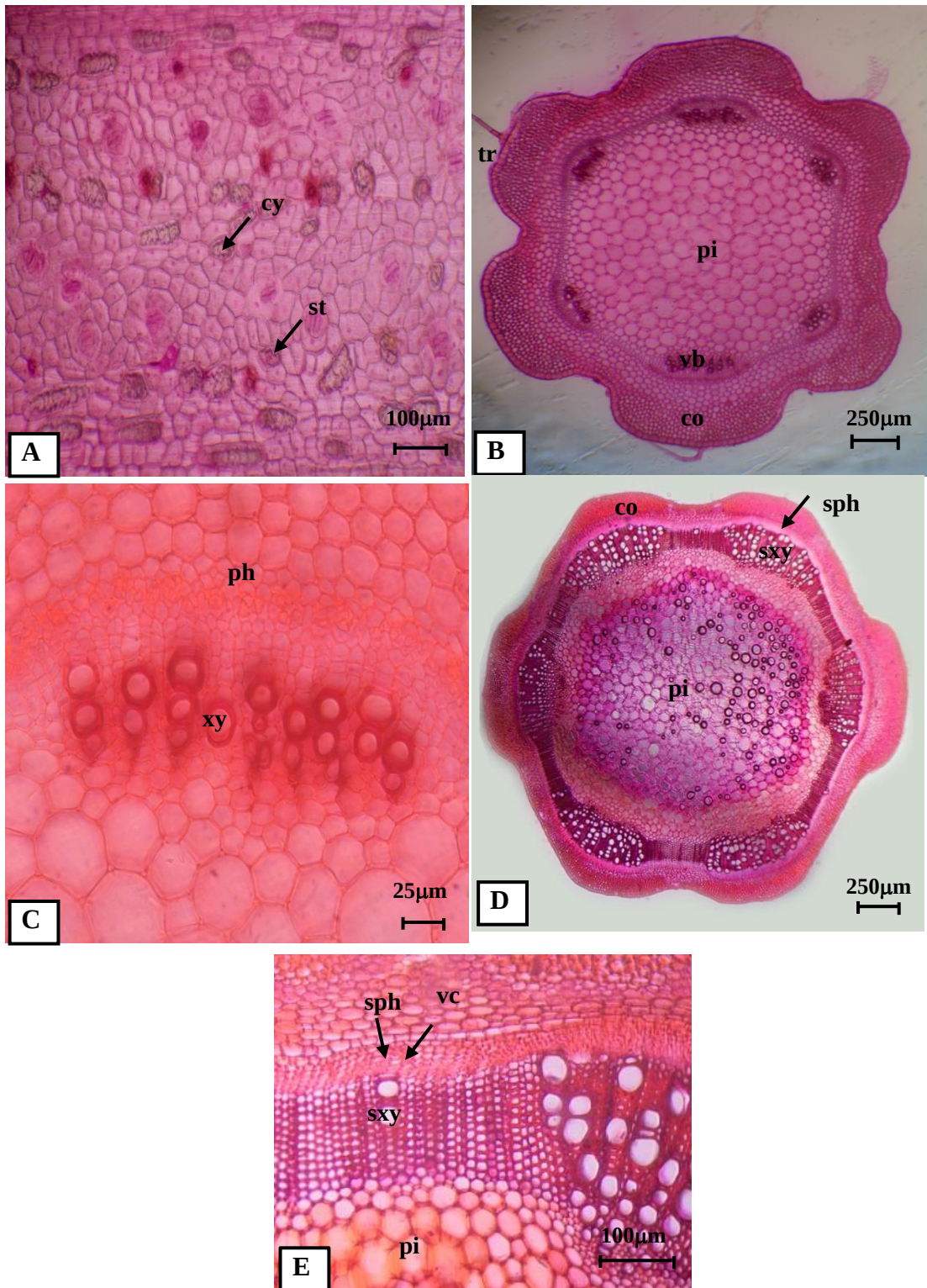


Figure 20. Internal structure of stem of *Rhinacanthus nasutus* (L.) Kurz

- A. Surface view of stem with cystoliths and stomata
- B. T.S of a portion of young stem showing tissue systems
- C. T.S of a portion of young stem showing vascular bundle
- D. T.S of a portion of stem showing secondary tissue
- E. T.S of a portion of stem showing vascular cambium

(cy - cystoliths, st - stomata, vb - vascular bundle, co - cortex, pi - pith, tr - trichome, xy - xylem, ph - phloem, vc - vascular cambium sxy - secondary xylem, sph - secodnary phloem)

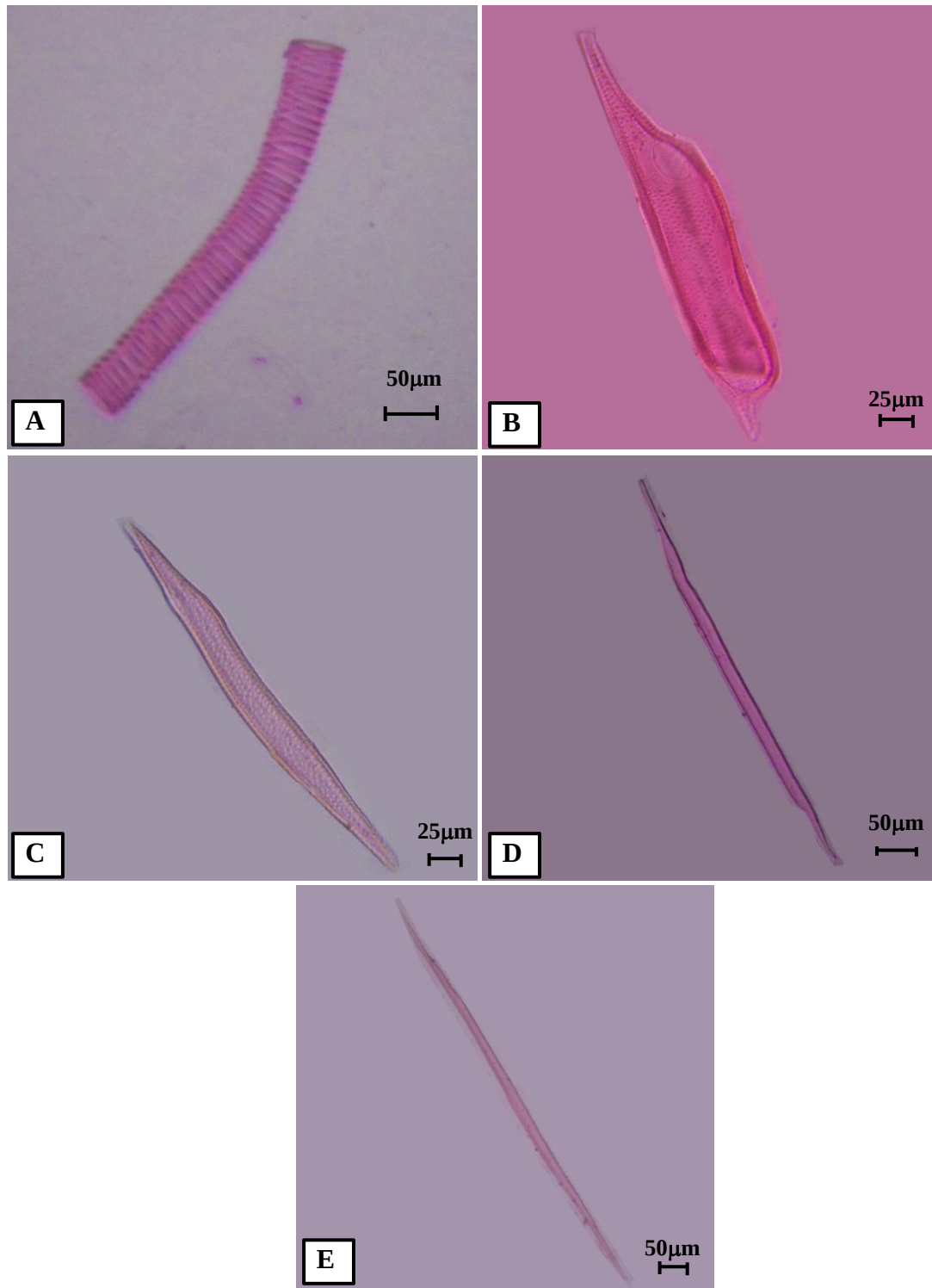


Figure 21. Macerated elements of stem of *Rhinacanthus nasutus* (L.) Kurz

- A. Vessel element with spiral thickening
- B. Vessel element with pitted
- C. Tracheid with pitted thickening
- D. Fiber-tracheid
- E. Fiber

Secondary xylem lying between primary xylem and vascular cambium, derived from vascular cambium, consisted of vessel elements, fibers, xylem parenchyma and ray parenchyma (Fig. 20 D & E); vessel elements thick-walled, lateral walls straight, end walls transverse or oblique, tailed at both ends or tailless, perforation plate simple, thickening spiral and pitted, 250 – 275 μm in length, 20 – 55 μm in breadth; tracheids thick-walled, lateral walls straight, end walls acute, thickening reticulate, 300 – 325 μm in length, 17.5 – 32.5 μm in breadth; fiber-tracheids thick-walled, lateral walls straight, end walls acute, 250 – 600 μm in length, 15 – 25 μm in breadth; fibers thick-walled, lumen narrow, lateral walls straight, end walls acute or acuminate, 600 – 800 μm in length, 20 – 30 μm in breadth.

Root

In transverse section, the young roots of *Rhinacanthus nasutus* (L.) Kurz studied were circular in outline, about 1062.5 – 1100.0 μm in diameter (Fig. 22 A), distinguishable into dermal, ground and vascular tissue systems.

Dermal tissue system: In transverse section, the cells of epiblema one-layered, the cells 12.5 – 28.75 μm in length, 8.75 – 23.75 μm in breadth, rectangular or irregular in shape, some cells ruptured, outer wall deeply stained (Fig. 22 A).

Ground tissue system: Composed of cortex, endodermis, pericycle and pith. Cortex 11- to 15- layered, the layers 330.0 – 362.0 μm thick, parenchymatous, oval or irregular in shape, intercellular spaces and cystoliths present; endodermis one-layered, the cells 5.5 – 15.5 μm in length, 6.25 – 15.0 μm in breadth, compact, parenchymatous, barrel-shaped or irregular in shape; pericycle one-layered, the cells 25.0 – 35.0 μm in length, 10.0 – 25.0 μm in breadth, compact, parenchymatous, thin-walled, irregular in shaped; pith small, parenchymatous, the cells rounded or polygonal (Fig. 22 A).

Vascular tissue system: In transverse section, vascular bundles radially arranged, tetrarch, xylem and phloem occur in separate patches arranged on alternate radii; phloem 5- or 6- layered, the layers 12.5 – 20.0 μm thick, composed of sieve-tubes, companion cells, and phloem parenchyma; xylem arranged in exarch pattern, protoxylem arranged towards the periphery, metaxylem towards the pith, composed of vessel elements, tracheids, fibers and xylem parenchyma (Fig. 22 B).

Secondary body

Periderm: Periderm does not form.

Secondary vascular tissue: Vascular cambium lying between phloem and xylem and forming a continuous ring, one layered, parenchymatous, meristematic, cells rectangular, tangentially flattened, colourless, cambium gives rise to secondary phloem outside and secondary xylem inside.

Secondary phloem lying between primary phloem and vascular cambium, composed of sieve tubes, companion cells, and phloem parenchyma (Fig. 22 C & D).

Secondary xylem lying between primary xylem and vascular cambium, composed of vessel elements, fibers and xylem parenchyma (Fig. 22 C & D), vessel elements thick-walled, lateral walls straight, end walls transverse or oblique, tailed at one end or tailless, perforation plates simple, thickening pitted, 250 – 300 μm in length, 32.5 – 57.5 μm in breadth; tracheids thick-walled, lateral walls straight, end walls acute, thickening reticulate, 250 – 325 μm in length, 15.0 – 20.0 μm in breadth; fibers thick-walled, lumen narrow, lateral walls straight, end walls acute to acuminate, 300 – 400 μm in length, 10 – 15 μm in breadth.

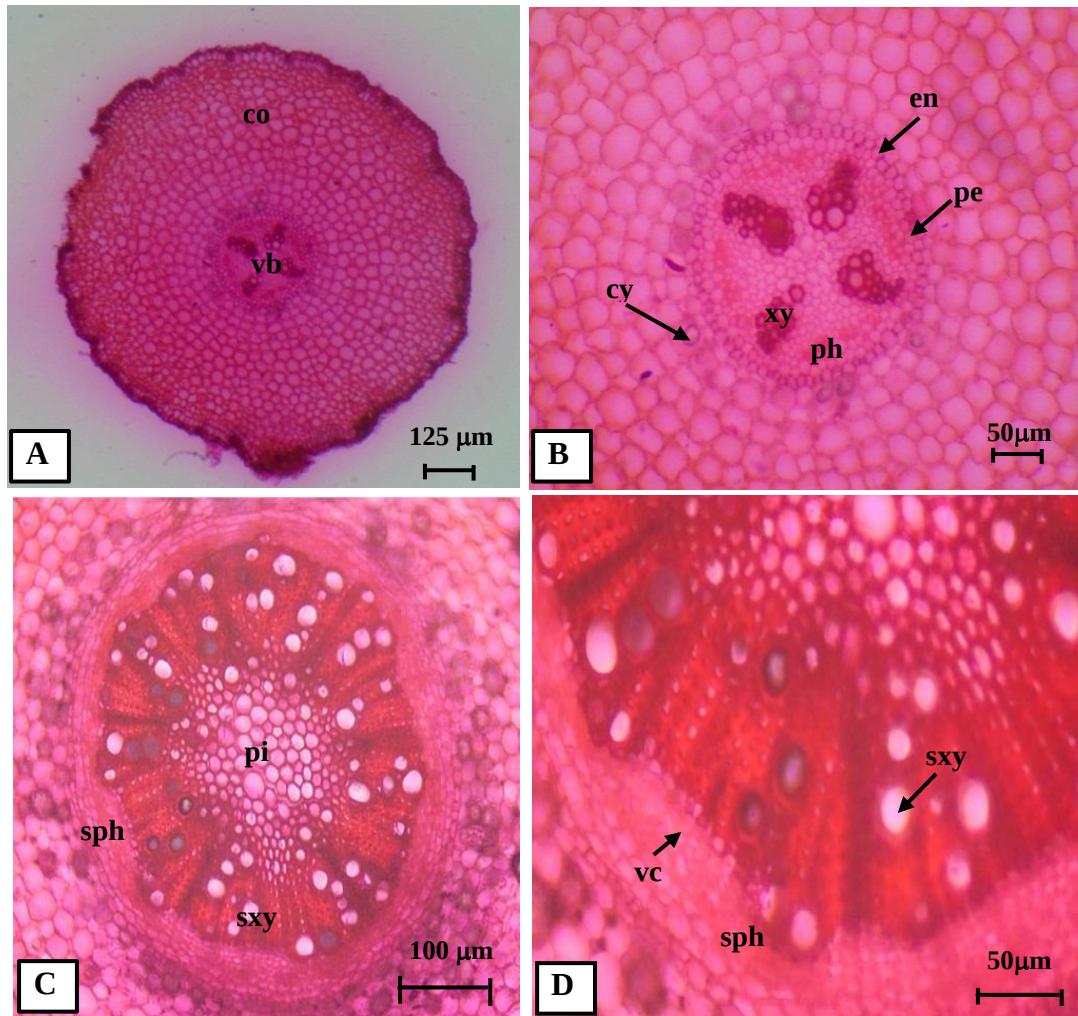


Figure 22. Internal structure of root of *Rhinacanthus nasutus* (L.) Kurz

- A. T.S of a portion of young root showing outline and tissue systems
 - B. T.S of a portion of young root showing tetrarch arrangement of vascular tissue
 - C. T.S of a portion of root showing secondary vascular tissue
 - D. T.S of a portion of root showing vascular cambium
- (co - cortex, vb - vascular bundle, cy - cystoliths, en - endodermis, pe - pericycle, xy - xylem, ph - phloem, pi - pith, vc - vascular cambium, sxy - secondary xylem, sph - secondary phloem)

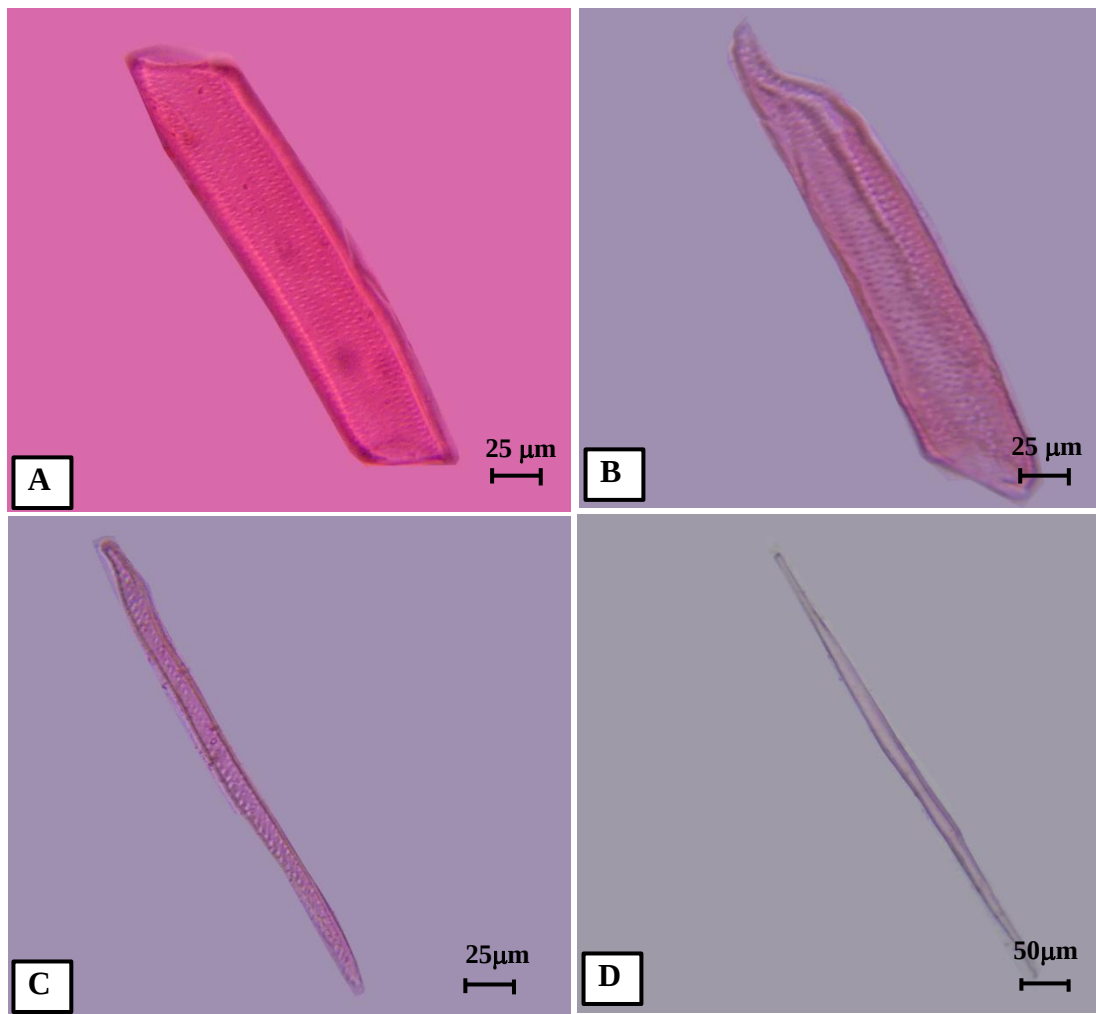


Figure 23. Macerated elements of root of *Rhinacanthus nasutus* (L.) Kurz

- A. Vessel element with pitted
- B. Vessel element with pitted
- C. Tracheid with reticulate thickening
- D. Fiber

Table 1. Comparative morphological characters of leaves and inflorescences

Species		<i>Justicia decussata</i> Roxb.	<i>Rhinacanthus nasutus</i> (L.) Kurz
Characters			
Leaves	Types of leaves	simple	simple
	Shapes of leaf-blades	oblong-lanceolate	oblong-elliptic to elliptic
	Sizes of leaf-blades	3.5-11.5 cm by 0.7-2.5 cm	5.5-14.0 cm by 2.0-6.3 cm
	Texture of leaf - surfaces	glabrous on both surfaces	pubescent on both surfaces
Inflorescences	Position and types of inflorescences	terminal and axillary spikes	terminal and axillary paniculate cymes
	Colours of flowers	white	white
	Sizes of flowers	1.2 cm	2.0 cm
	Shapes of bracts	linear-lanceolate	linear-lanceolate
	Texture of bracts	pubescent	pubescent

Table 2. Comparative morphological characters of calyx and corolla

Characters \ Species		<i>Justicia decussata</i> Roxb.	<i>Rhinacanthus nasutus</i> (L.) Kurz
Calyx	Number of sepal	5-partite	5-partite
	Texture of sepal	pubescent	pubescent
Corolla	Shapes of petal	bilabiate	bilabiate
	Number of petal	5-lobed	5-lobed
	Shapes of upper lip	obovate	linear
	Shapes of lower lip	oblong	obovate

Table 3. Comparative morphological characters of androecium and gynoecium

Species		<i>Justicia decussata</i> Roxb.	<i>Rhinacanthus nasutus</i> (L.) Kurz
Characters			
Androecium	Number of stamens	2	2
	Sites of stamens	exserted	exserted
	Length of filaments	4-6 mm long	2-5 mm long
	Shapes of anthers	oblongoid	oblongoid
	Colours of anthers	yellow	pale yellow
Gynoecium	Shapes of style	filiform	filiform
	Shapes of stigma	simple	bifid

Table 4. Comparative anatomical characters of laminae, midribs and petioles

Characters	Species		<i>Justica decussata</i> Roxb	<i>Rhinacanthus nasutus</i> (L.) Kurz
	Tissue system			
Laminae	Dermal Tissue system	trichomes	absent	present (abaxial side)
		Stomata	present (abaxial side)	present (abaxial side)
		Cystoliths	present (abaxial side)	present (both side)
	Ground Tissue system	Layers of Palisade parenchyma	1- to 3-layered	one-layered
		Layers of spongy parenchyma	5 - or 6-layered	2 - or 3-layered
	Vascular Tissue system	Types of Vascular bundles	closed collateral	closed collateral
		Shapes of vascular bundles	rounded or oval shaped	rounded or oval shaped
Midribs	Dermal Tissue system	trichomes	absent	present
		Cystoliths	present	absent
	Ground Tissue system	Layers of adaxial collenchyma	5 - to 8-layered	3 - to 5-layered
		Layers of abaxial collenchyma	3 -to 6-layered	2 - to 5-layered
		Layers of adaxial parenchyma	4 - to 9-layered	9 - or 10-layered
		Layers of abaxial parenchyma	5 - to 9-layered	9 - to11-layered
	Vascular Tissue system	Arrangement of vascular bundles	a large vascular bundle and two small accessory bundles	a large vascular bundle and two small accessory bundles
Petioles	Dermal Tissue system	Non-glandular trichomes	absent	present
		Stomata	absent	present
		Cystoliths	absent	present
	Ground Tissue system	Layers of adaxial collenchyma	5 - to 9-layered	4 - to 8-layered
		Layers of abaxial collenchyma	7 -to 9-layered	4 - or 5-layered
		Layers of adaxial parenchyma	7 -to10-layered	6 - to 10-layered
		Layers of abaxial parenchyma	7 -to11-layered	6 - to 9-layered
	Vascular Tissue system	Arrangement of vascular bundles	a large vascular bundle and two small accessory bundles	a large vascular bundle and two small accessory bundles

Table 5. Comparative anatomical characters of stems and roots

Characters	Species		<i>Justicia decussata</i> Roxb.	<i>Rhinacanthus nasutus</i> (L.) Kurz
	Tissue system			
Young Stems	Dermal Tissue System	trichome	present	absent
	Ground Tissue System	collenchyma in cortex	3- to 8-layered	1- to 5-layered
		parenchyma in cortex	6- to 8-layered	2- to 5-layered
		pith	15- to 24-layered	12- to 14-layered
	Vascular Tissue System	Vascular bundle	a circular ring	six large vascular bundles in the angle of the stem separated
Young Roots	Dermal Tissue System	Epidermal cells	epiblema	epiblema
	Ground Tissue System	Layers of cortex	11- to 14-layered	11- to 15-layered
	Vascular Tissue System	vascular cylinder	tetrarch	tetrarch
Mature Stems	Vascular Tissue System	Vascular cambium	Present (Secondary growth formed)	Present (Secondary growth formed)
Mature Roots	Ground Tissue System	Periderm	Present	absent

5. DISCUSSION AND CONCLUSION

In present study, the morphological and anatomical characters of *Justicia decussata* Roxb.(Ma-yar-thein) and *Rhinacanthus nasutus* (L.) Kurz (Htaw-la-batt) belonging to the family Acanthaceae are studied and described. Both of the plants studied are found to be growing cultivating in Mandalay region.

According to morphological study, *Justicia decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz are perennial herbs to undershrubs; stems and branches of *Justicia decussata* Roxb. are cylindrical and pubescent and those of *Rhinacanthus nasutus* (L.) Kurz are hexa-angular with ridges and furrows and glabrescent. The leaves of both of two species are simple, opposite and decussate and exstipulate. The leaf-blades are oblong-lanceolate in *Justicia decussata* Roxb. and oblong-elliptic to elliptic in *Rhinacanthus nasutus* (L.) Kurz. Inflorescences are terminal and axillary spikes in *Justicia decussata* Roxb. whereas terminal and axillary paniculate cymes in *Rhinacanthus nasutus* (L.) Kurz.

The corollas of both species are bilabiate. The number of stamens are 2, exserted and epipetalous in both species. The anthers are dorsifixed, the cell divergent with basal spur in *Justicia decussata* Roxb. but superposed in *Rhinacanthus nasutus* (L.) Kurz. Ovary is bilocular with two ovules in each locule in the axil placentae in both species. The morphological characters observed in this research were in agreement with those described by Hooker (1885), Backer (1965), Lawrence (1964), Dassanayake (1998), Thin Thin Hlaing (1983), Khin Su Su Kyaw (2009) and May Tha zin Phyto (2016).

In transverse sections of lamina, midribs, petioles, stems and roots showed the three tissue systems such as dermal, ground and vascular tissue systems.

In surface view of lamina, diacytic type of stomata is found on lower surfaces of both species. Cystoliths are found in the epidermal cells on lower surfaces in *Justicia decussata* Roxb. and in the epidermal cells on both surfaces in *Rhinacanthus nasutus* (L.) Kurz. The trichomes are found only in *Rhinacanthus nasutus* (L.) Kurz they are non-glandular, multicellular and uniseriate.

In tranverse section of lamina, the epidermal cells are one-layered and covered with thin cuticle in both species. Mesophyll was differentiated into palisade parenchyma and spongy parenchyma. Palisade cells are 1 – 3 layered in *Justicia decussata* Roxb. but one-layered in *Rhinacanthus nasutus* (L.) Kurz. Spongy cells are 5 or 6 layered in *Justicia decussata* Roxb. but 2 or 3 layered in *Rhinacanthus nasutus* (L.) Kurz. In addition, bundles of the lateral veinlets are closed and collateral, rounded or oval in shape in both species.

In surface views of midribs and petioles, the epidermal cells are polygonal or rectangular in both species and non-glandular trichomes are present only in *Rhinacanthus nasutus* (L.) Kurz. The ground tissue of midribs and petioles are differentiated into outer collenchymatous and inner parenchymatous cells.

In the midribs of *Justicia decussata* Roxb., a large vascular bundle was found to be lying at the middle and connected with two small accessory strands at the adaxial side, and closed and collateral. In the petiole of *Rhinacanthus nasutus* (L.)Kurz., a large vascular bundle was lying in the middle but separated from two small accessory ones.

In transverse section of petioles, vascular bundles are collateral and closed in *Justicia decussata* Roxb. but collateral and open in *Rhinacanthus nasutus* (L.) Kurz.

In surface view of stems, the epidermal cells were polygonal or rectangular in shape in both of the two species; trichomes are present in *Justicia decussata* Roxb they are non-glandular and multicellular. Diacytic type of stomata are present on the surface of the stem of *Rhinacanthus nasutus* (L.) Kurz, but no stomata are found in that of *Justicia decussata* Roxb.. Cystoliths are found in the stems of both species.

In transverse section, the stems of *Justicia decussata* Roxb. are circular in outline but those of *Rhinacanthus nasutus* (L.) Kurz are found to be hexa-angular with ridges and furrows.

In the young stems, the ground tissue is composed of cortex, endodermis, pericycle and pith in both species. Cortex is composed of well-defined group of outer collenchymatous and inner parenchymatous cells in both of the two species. Endodermis was the innermost layer of cortex, the cell parenchymatous in both species and pericycle was composed of sclerenchymatous cells.

In the stem of *Rhinacanthus nasutus* (L.) Kurz. each of six vascular bundles are arranged in each angle of the stem forming a hexa-angular ring, and each bundle collateral and open. In *Justicia decussata* Roxb., vascular bundles are forming a continuous ring and of closed collateral types. These characters were in accordance with those described by Metcalfe and Chalk (1950 & 1975).

The roots of *J. decussata* Roxb. and *Rhinacanthus nasutus* (L.) Kurz. studied are circular in outline in transverse section. The vascular bundles of the roots of both species are radially arranged and forming a tetrarch. Endodermis and pericycle enclosed the vascular bundle in both of the two species. These characters were similar to those mentioned by Metcalfe and Chalk (1950).

In the stems of both of species, vascular cambium forms between phloem and xylem, and secondary growth was found due to the activity of vascular cambium. However, periderm formation does not occur in both species studied. Similarly, vascular cambium formation occurs between phloem and xylem in the root of both of the two species and secondary growth was also found due to the activity of cambium.

In the root of *Justicia decussata* Roxb., phellogen or cork cambium was formed in the periphery of the cortex and periderm developed by the division of the cork cambial cells. However, there was no periderm formation in the root of *Rhinacanthus nasutus* (L.) Kurz.

The findings in this research provide the information on the morphology, anatomy and medicinal uses of the species for further pharmacognoscic studied. Moreover, morphological characters of the two species studied are useful in identification of the flowering plants. The anatomical characters will also support in the identification of the members of the family Acanthaceae.

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REFERENCES

- AjmalShah,M., Sermwittayawong,D & Jakkawanpitak, C. 2018. Antidiabetic Napthoquinones and Their plant Resources in Thailand. <http://www.researchgate.net>.
- Backer, C.A. 1965.Flora of Java.Vol. 2. Nordhoff. Groningen. The Netherlands.
- Barlyn, Graeme p. and Jerome p. Miksche. 1976. Botanical Microtechnique and Cytochemistry. The Iowa State University.
- Brimson,J, Tencomnao,T, 2014.Medicinal herbs and antioxidants : potential of *Rhinacanthus nasutus* for diseases treatment? Phytochemistry reviews ISSN : 1568 – 7767, Food and Agriculture Organization of the United Nations, Chulalongkorn University.
- Chuakul, W., Soonthornchareonnon, N. & Saralamp, P. 2016. *Rhinacanthus nasutus* (PROSEA). Plant Resources of South-East Asia.
- Cortes, Ara Luiza Andrade& Alessandro Rapini 2011.Four new species of *Justicia* (Acanthaceae) from the Caatinga biome of Bahia, Brazil in *Kaw Bullentian* 66(3) 2011.
- Cronquist, Arthur, 1981. An integrated System of Classification of Flowering Plants. Columbia University Press. New York.
- Dassanayake, M.D. 1998.A Revised Handbook to the Flora of Ceylon.Vol. 12. Amerind Publishing. Co. Pvt Ltd., New Delhi.
- Esau, K. 1965. Plant Anatomy, 2nd ed. John Wiley and Sons, Inc., New York. London.
- Heywood, V. H. 1978.Flowering Plants of the World. Clarendon Press. Oxford.
- Hooker.J.D. 1885.Vol. 4.Flora of British India.Oxford-Clarendon Press.
- Hundley. H. G. & Chit Ko Ko., 1987. List of Trees, shrubs, Herbs sand Principal Climber of Burma, Supt. Grovt. Prit. And Stay. Rangoon.
- Hutchinson, J., 1959. The Families of Flowering Plants.2nd.ed. Vol. 1.Dicotyledons. Oxford University Press, London.
- Khin Su Su Kyaw, 2009. Taxonomy and Pollen Morphology of family Acanthaceae from Upper Myanmar. Ph.D. Thesis. Department of Botany, University of Mandalay.
- Khurram Afzal 2015. Pharmacological and phytochemical importance in ethnopharmacology: pharmaceutical: Drug Research.
- Kress, W. John, Robert A. DeFilipps, Ellen Farr and Yin Yin Kyi, 2003.A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar.Department of Systematic Biology-Botany.National Museum of Natural History, Washington DC, USA.
- Kyaw Tun, 2007. Myanmar Medicinal Plant database. [www.ansinet. orq/fullt_ext/jbs44498.500. pdf](http://www.ansinet.orq/fullt_ext/jbs44498.500.pdf).
- Lawrence, H. M. 1964. Taxonomy of Vascular Plants.The Macmillan Company. New York.
- Metcalfe, C. R. & Chalk, L. 1950. Anatomy to the Dicotyledons.Vol. 1 and II. The Clarendon Press, Oxford.
- Metcalfe, C. R. & Chalk, L. 1979. Anatomy to the Dicotyledons 2nd ed. Vol. 1 and II.Published in the United States by Oxford University Press, New York.
- Nagathin, Ashin.1970. Illustrated Medicinal Handbook (in Myanmar).Mingalar Press, Yangon.

- Santra, S.C, Chatterjee, TP.∞ Das, A.P. 1989. College Botany Practical Vol. 1 New Central Book Agency (P) Ltd.
- Sharma, OP. 1993. Plant Taxonomy. Tata Mc Graw-Hill Publishing Company Limited, New York.
- Small, 1933. Manual of The Southeastern Flora, chapel Hill. Vol.1.
- Staughton, J. 2021. 8 Amazing Benefits of Rhinacanthus Nasutus. <http://www.organicfacts.net/health-benefits/herbs-and-species/rhinacanthus-nasutus.html>.
- Subrahmanyam, N.S. 1995. Modern Plant Taxonomy Reader in Botany, Sir Venketashwara College, University of Delhi.
- Thin Thin Hlaing, 1983. A Taxonomic Revision of the Family Acanthaceae in Upper Burma. M.Sc Thesis. Dept. of Botany, Univ. of Mandalay.
- Trease, G. E. and W.C. Evans. 2002. Pharmacognosy 15th ed. Harcourt Publishers Ltd., London.
- The International Plant Names Index. 2005. Acanthaceae. *Justicia decussate* Roxb. International Plant Names Index. 2005.
- The International Plant Names Index. 2005. Acanthaceae. *Rhinacanthus nasutus* (L.) Kurz. International Plant Names Index. 2005.
- The Plant List. 2013. The Plant List. A working list of all plant species. The Plant List (2013). Version 1.1. Published on the Internet: <http://www.Theplantlist.org>