The Republic of theUnion of Myanmar
Ministry of Environmental Conservation and Forestry
Forest Research Institute

Investigation of Morphological and Stem Anatomical Features of Five Rattan Species Growing in Ayeyarwady Region

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August, 2013

ဧရာဝတီတိုင်းဒေသကြီးတွင်ပေါက်ရောက်လျှက်ရှိသောကြိမ်(၅)မျိုး၏ပြင်ပရုပ်သွင်နှင့် အင်္ဂါဗေဒလက္ခဏာများအားစူးစမ်းလေ့လာခြင်း

ကျော်ဝင်းမောင်၊ လက်ထောက်သုတေသနအရာရှိ

အောင်ကျော်လင်း၊ လက်ထောက်ညွှန်ကြားရေးမှူး
သစ်တောသုတေသနဌာန

ကြူကြူသင်း၊ လက်ထောက်ကထိက
သစ်တောတက္ကသိုလ်

စာတမ်းအကျဉ်း

ဤစာတမ်းသည်စစ်မှန်သော အမျိုးအမည်ခွဲခြားခြင်းနှင့် ကြိမ်၏အင်္ဂါဗေဒ လက္ခဏာရုပ်များ အပေါ်အခြေခံ၍ ကြိမ်လုံး၏ဂုဏ်သတ္တိများကို သတ်မှတ်ရန်အတွက် ရှေ့ပြေး လေ့လာမှု တစ်ရပ်ဖြစ်ပါသည်။ ဤစာတမ်းတွင် ဧရာဝတီတိုင်းဒေသကြီး ပုသိမ်မြို့နယ်တွင် ပေါက်ရောက်သော ကြိမ်(၅)မျိုး၏အရေးပါ သောပြင်ပရုပ်သွင်လက္ခဏာများကိုလေ့လာခဲ့ပါသည်။ သို့ရာတွင် ၄င်းကြိမ်မျိုးများကို စစ်မှန်သောကြိမ်မျိုး များအဖြစ် အမျိုးအမည်ခွဲခြားနိုင်ရန်အတွက် ပြင်ပရုပ်သွင်လက္ခဏာများကို အသေးစိတ်လေ့လာရန် လိုအပ်ပါသေးသည်။ ကြိမ်လုံး၏အင်္ဂါဗေဒ လက္ခဏာရုပ်များပေါ် ကြိမ်မျိုးစိတ်များ ခွဲခြားရာတွင်အသုံးဝင် သည့် လက္ခဏာရုပ်များဖြစ်သော Epidermal cells များ၏ပုံသဏ္ဌာန်၊ Ground tissue အမျိုး အစား၊ Vascular bundle အရွယ်အစား၊ Metaxylem vessel diameter စသည်တို့ကို လေ့လာခဲ့ ပါသည်။ ထို့အပြင် ကြိမ်လုံး၏ဂုဏ်သတ္တိများဖော်ထုတ်ရာတွင် အရေးပါသော အင်္ဂါဗေဒလက္ခဏာရုပ် များကို အောက်ခြေမှစ၍(၅)ဆစ်ခြားစီယူထားသော ကြိမ်လုံးအစိတ်အပိုင်း Internode (၅)ခုမှ လေ့လာခဲ့ ပါသည်။ ကြိမ်လုံးများ၏ဂုဏ်သတ္တိနှင့် အင်္ဂါဗေဒလက္ခဏာရုပ်များ ဆက်စပ်မှုကို နားလည်ခြင်း အားဖြင့် ကြိမ်အချောထည်လုပ်ငန်းနှင့် အသုံးချခြင်းကို ပိုမိုကောင်းမွန်တိုးတက် လာစေနိုင်ပါသည်။ ဤစာတမ်းတွင် စပ်းသပ်လေ့လာခဲ့သောကြိမ် (၅)မျိုးမှာ ကြိမ်ခါး (*Calamus viminalis* Willd) ၊ ကြိမ်နီ(*Calamus guruba* Ham) ၊ လမဲကြိမ် (*Calamus longisetus* Griff.) ၊ သိုင်းကြိမ် (*Calamus erectus* Roxb) ၊ ယမထာကြိမ် (*Calamus latifolius* Roxb) တို့ဖြစ်ပါသည်။

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Abstract

The investigation is a preliminary study for authenticated identification and determination of cane properties through anatomical characteristics of rattan. The important morphological features of five rattan species growing in Pathein Township, Ayeyarwady Region are studied. However more detail studies on morphology are still required to be authenticated. The stem anatomical characters such as epidermal cell shape, ground tissue type, size of vascular bundle and metaxylem vessel diameter which respectively is useful to distinguish at species level are mentioned in this paper. Moreover, promising characters to determine properties of cane are also observed on five pieces of cane from bottom to top with 5 internodes interval. The understanding of correlation between anatomical characteristics and properties of cane will assist to improve the processing and utilization of rattan. The five rattan species examined in this study are Kyein kha (*Calamus viminalis* Willd.), Kyein ni (*Calamus guruba* Ham**.**), Lame kyein **(***Calamus longisetus* Griff**.)**, Thaing kyein (*Calamus erectus* Roxb) and Yamata kyein (*Calamus latifolius* Roxb).

Keywords: calamus, epidermal cells, ground tissue, rattan, vascular bundle

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1. Introduction

Rattan is the colloquial name given to a large group of climbing palms belonging to family Arecaceae. Since their stems are used to make cane, they are also called “cane” as another common name of rattan. Rattan is very popular as raw materials for furniture, construction, handicraft and other industries because of their properties such as durable, elastic, lightweight, lustrous and flexible. At a local level, rural people have being widely used rattan as their household utilities since immemorial time. On the other hand rattans are also one of great social significance in providing source of income for some poorest communities in rural societies. Nowadays, rattan have become one of economically important items because of the technology development in industries on their processing and utilization.

Despite their economic importance and recent upsurge of interest in the rattan resource, the morphological and anatomical information of rattan remains poorly known. Although some rattans possess great silvicultural potential and excellent qualities they remain taxonomically unclassified. Because of that there were problem in selecting the species of unclassified rattan in harvesting from nature or cultivation. Another problem is the use of common name by people of

different localities which results is confusion. In harvesting for commercial purposes the problem is very serious. Inventory of rattan (RRI) and by taxonomic classification is urgently necessary from natural forests and plantations if or when commercializing the species. The inventory concerning rattan on their identification, classification is done only a little or lacking

Apart from that the most important product of rattan are cane that is the rattan stem stripped off leafsheaths. The quality of cane depends on the anatomical structure. The processing and utilization of rattans are also influenced to a great extent by structural composition of the stem. Moreover, anatomical characters might be useful for identification of cane because the cane without morphological features such as leafsheaths, leaflets and spines cannot be morphologically identified. Although anatomical characteristics of rattan could be valuable to identify and improved the utilization of rattan resources, a careful survey through available literatures show that there was very rare report concerning anatomical studies of rattans.

For that reason, the present study emphasized on morphological and stem anatomical characteristics of five rattans species growing in Ayarwady Region. The five rattans species studied in this paper are Kyein Kha. (*Calamus viminalis* Willd), Kyein Ni. (*Calamus garuba* Ham), Lame Kyein (*Calamus longisitus* Griff.), Thaing Kyein. (*Calamus erectus* Roxb) and Yamata Kyein. (*Calamus latifolius* Roxb.)

2. Objectives

To investigate the morphological ar 2 tomical features of five rattans species growing in Ayarwaddy Region,

To improve the understanding on morphology of rattan

3. Literature review

Rattans are found largely concentrated with 10 genera and 574 species in South East Asia (H. Singh & C.T Yuan 1999). In Myanmar 5 genera of rattan with 34 species are recorded. They are *calamus, demonorops, korthasia, plectocomia and plectocomiopsis.* Among them genus *calamus* is most dominately found growing in Myanmar. Furthermore, most of the *calamus* species are also economically important.

According to Tomlinson et.al (2001), genus *calamus* contains the most riches of number in species compared to other plants and constituted 15% of all plants. They are also climbing plants and their stems reach length of over 100 m. Tomlison. et.al (2001) also mentioned that most of *calamus* species possess the morphological features such as branched sympodial rhizome system, recurve spines along the stem, unbranched and flowerless inflorescence called flagella which is originated in the axils of a leaf. According to Kyaw Lwin(2008), the morphological characters of genus *calamus* are armed perennial climbers, alternate and pinnatisect leaves with rachis produced into an armed cirrus and leafsheath with or without a lateral armed flagellum.

Bhat.et.al (1993), Tomlison et.al (2001) and Cai Zemo (2005) investigated stem anatomical structure of genus *calamus.* They revealed that the epidermis of genus *calamus* is silicified and their outer walls are thickened. The epidermis has few stomata (Tomlison, 2001 but sucken stomata (Bhat, 1993) and a few sucken stomata Cai Zemo. Although Bhat et.al 1993 stated that mostly a one or two layer hypodermis is distinct with unlignified, Cai Zemo and Tomlison et.al (2001) did not recognize the hypodermal layer. The cortex with of *calamus* is variable within the stem and between the species. Generally, species with basal internode with large diameter have a relatively wide cortex (Bhat et.al, 1993, Tomlison et.al 2001 and Cai Zemo)

Central cylinder consists of ground tissue and vascular bundles. Bhat et.al (1993) mentioned that ground tissue is composed of isodiametric or slightly elongated and stellate parenchymatus cell with intercellular spaces. He also divided the ground parenchyma into three types. Type A consists of cells which are weakly branched leaving regular rounded intercellular spaces. In type B, cells are smaller and rounded with irregular intercellular spaces. Type C, comprises of large and rounded cells with thin walls and relatively small intercellular spaces. In this type, some of the intercellular sp 3 often modify themselves into secretory cavities. According to Tomlison et.al (2001) gr tissue of *calamus* includes elongated thin-walled raphide sacs with short cluster of raphide crystals at wide interval and granular mucilaginous cell contents. He also described that tannin cells are scattered within ground tissue.

Bhat et.al (1993) revealed that typical vascular bundle of genus *calamus* is composed of xylem, phloem and fibrous sheath. In xylem there are found a solitary wide metaxylem vessel and narrow protoxylem vessel with interspacing xylem parenchyma cells. However, Tomlinson et.al (2001) found a solitary metaxylem vessel, a narrow phloem strand and few associated fibers in narrowest vascular bundles. They have no protoxylem.

Tracheary elements are up to 3040 µm in length and their end walls are imperforate or perforate. If they are perforate, their oblique or transverse plates show scalariform or simple perforations (Bhat et.al. 1988; Weiner & liese 1990) lateral wall pitting varies from simple to false bordered pit (Bierhorst & Zamora 1965) and opposite to alternate (Bhat et.al 1993).

Three distinct types of tracheary elements were found in the *calamus* stem. They are wide metaxylem vessels, narrow metaxylem vessels and protoxylem. Wide metaxylem vessels are completely sheathed by elongated parenchyma cells with wide pits. Their perforation plates are always simple with transverse to slightly oblique and walls. Narrow metaxylem vessels are found in narrow peripheral bundles and their perforation plates were scalariform with few thickening bars on obloque end walls. Protoxylem consisted of tracheids only, with tapered ends, the walls sculpturing either annular or helical protoxylem elements were very variable in length

and longer than metaxylem vessels. They were not also sheathed continuously with pitted parenchyma cells (Tomlinson et.al 2001).

According to Bhat et.al (1993) the phloem tissues of *calamus* consisted of 2 strands of uniseriate or rarely biseriate sieve tubes distributed on two lateral sides of the solitary metaxylem vessel. However, Tomlison et.al (2001) described that a pair of lateral phloem strands consisted of a single series of wide sieve cells and phloem strands were enclosed by a narrow band of sheathing fibers.

4. Materials and methods

Rattan studied in this paper were collected from rhizomatous clump growing at compartment 8 of Chaung Thar Reserved forest and unclassed forest in Pathein Township. The sample of 5 cm length were taken from t 4 ddle of base, sixth, twelfth, eighteenth and twenty-fourth internodes of each rhizomatous c for each species

For morphological studies, measurement of vegetative parts and photo image recording were carried out in the field in that it is difficult to take out the vegetative parts such as leaf and leafsheath, flagellum and cirrus because of their large size.

For stem anatomical studies the specimens of each species were softened by boiling in water for 12 hours. After boiling specimens were placed in solution of mixed glycerine and 50% alcohol for 2-3 days before cutting, they were cut into 25-30 µm thick slices by sliding microtome. For mounting, the specimens were stored in 50% alcohol and glycerine solution. For staining and mounting, the sections stored in alcohol-glycering solution were washed in water until the sections were free from alcohol-glycerine. After which, these sections were immersed in 3% ferric ammonium sulphate for about 10-15 seconds and then washed in water at least three times and transferred into 0.5% haematoxylene for about 10-15 seconds and washed again in water. They were then put into safranin stock solution overnight. The sections were removed from the safranin solution and destained and dehydrated by the series of 50%, 70%, 90%, 95% alcohol for 5-10 minutes respectively. Then they were cleared with xylene 2 times and then they were put into clove oil for further cleaning. After which, these sections were placed and mounted on the slide with Canada balsam. Finally the mounted slides were then dried for a week in the air.

The rattan specimens were macerated for study of individual elements by treatment with a mixture of equal volume of 30% hydrogen peroxide and glacial acetic acid using Franklin's methods (1946). They were then washed in water and kept in 50% alcohol-glycerin and safranin solution for further studies. For each cells. 50 elements were measured.

5. Observation

5. 1.*Calamus viminalis* Willd.

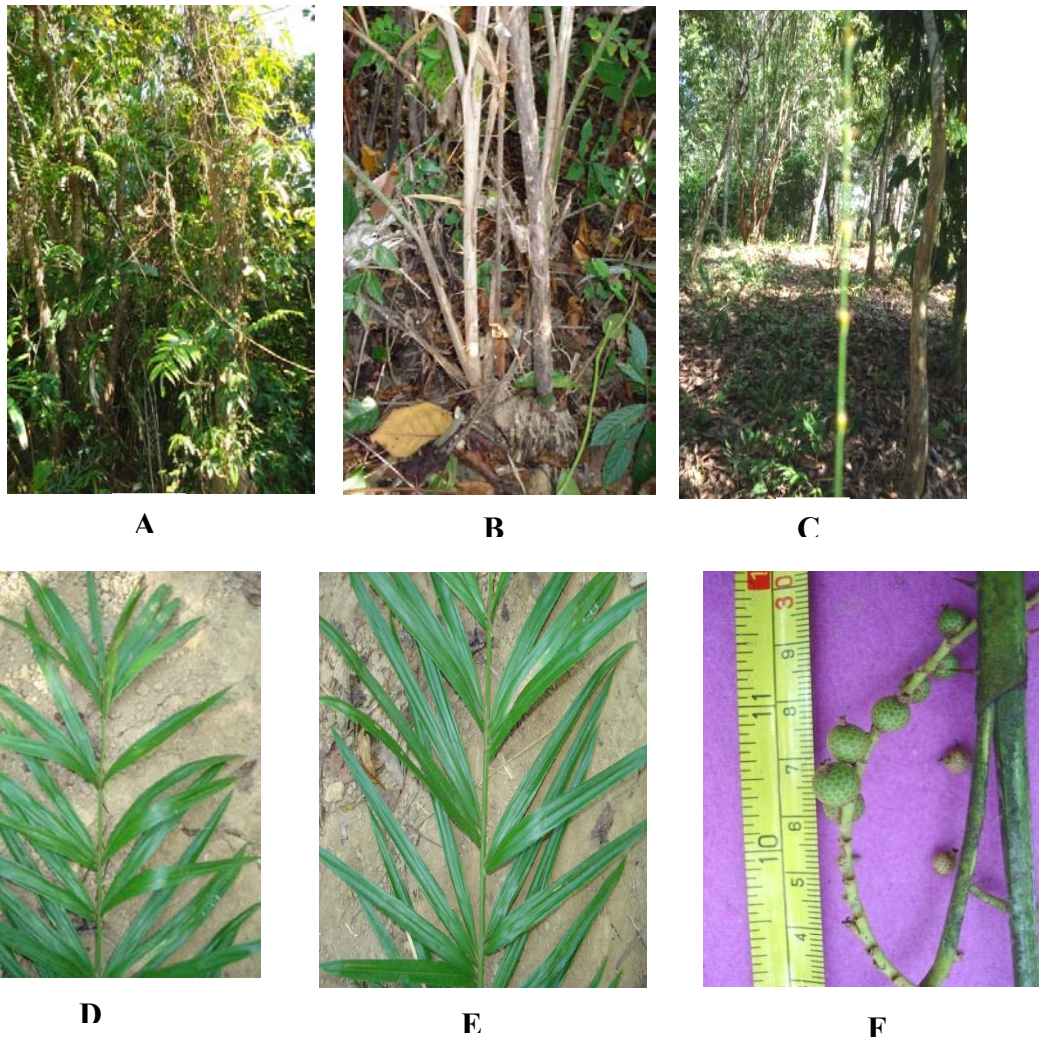
Morphological characters

Stem cluster forming; stem thickness with leafsheath 3 cm – 4.5 cm and without 2 cm – 2.5 cm in diameter; leave ecirrate, 1.10 m – 1.30 m long; petiole 20 cm – 43 cm in length and 1.5 cm – 2 cm in diameter; rachis 80 cm – 95 cm long, bearing scattered flat triangular spines on the lower surface, soft 1 cm - 3 cm long; leaflets arranged in group of 2 – 3 pairs and 38 - 40 numbers on each side of the rachis, 15cm – 25 cm length and 2 cm – 2.5 cm in width, single nerved, upper and lower surface green, bristles present on the both surface; leafsheath dull grey colour; the thorns present on the leafsheath, stiff, scattered, sometimes whorl, flat triangular shape, 1 cm – 2.5 cm long; knee inconspicuous; inflorescence flagellate, longer than leaves; fruits globose, 5 -8 mm in length and 5 - $\frac{7}{5}$ nm in diameter, pale reddish- brown, 6 – 7 series of scales.

Anatomical characters

Epidermis single layer, mean thickness 35.07 µm (range 25.62 – 41 µm), Stomata density 6 – 22 /mm², epidermal cells rectangular shape in transverse section; hypodermal cells 2 – 3 layers; mean cortex width 134.65µm (range92.25 – 186.55 µm), cells rounded or oval in transverse section, vascular bundle sparsely distributed in cortex; ground parenchyma cells thinner walls, type C; vascular bundle density 6 – 14 /mm² in periphery and 3 – 9 /mm² in inner, mean radial length 250.38 µm (range 123 – 410 µm) in periphery, 405.80 µm (range 245.05 – 563.75 µm) in inner, mean tangential width 186.92µm (range 102.50 – 328 µm) in periphery and 390.79 µm (range 205 463.35 µm) in inner; phloem fields 2, each with 4 – 7 sieve tubes, arrangement in uniseriate row; metaxylem vessel single in each vascular bundle, mean diameter 61.59µm (range 26.65 – 109.67 µm) in periphery, 144.15µm(range 84.05 – 238.72 µm) in inner, mean length 1464.92 µm (range 820 – 1943.40 µm) in inner; protoxylem consists of only tracheal elements, number of tracheal elements 1 – 12 per protoxylem, mean length 1601 µm (range 1332.50 – 2085.83 µm) mean width 36.21µm ; fiber percentage decrease from periphery to inner, wavy fiber present; mean length 933.49 µm (range 346.45 – 1437.95 µm), mean width 13.72 (range 8.25 – 19.50 µm), mean wall thickness 4.62 µm (range 2.50 – 7.50 µm) in periphery and mean length 941.72 µm (range 416.25 – 1767.10 µm), mean width 14.29 µm (range 8 – 88 µm), mean wall thickness 3.59 µm (range 1.75 – 6 µm) in inner, fiber bundles absent, raphide sac consists of 42.88%.

Figure. 5.1A Morphological characters of *Calamus viminalis* Willd



A. Habit as seen

B. Mature plant of *calamus viminalis* Willd. showing leafsheath

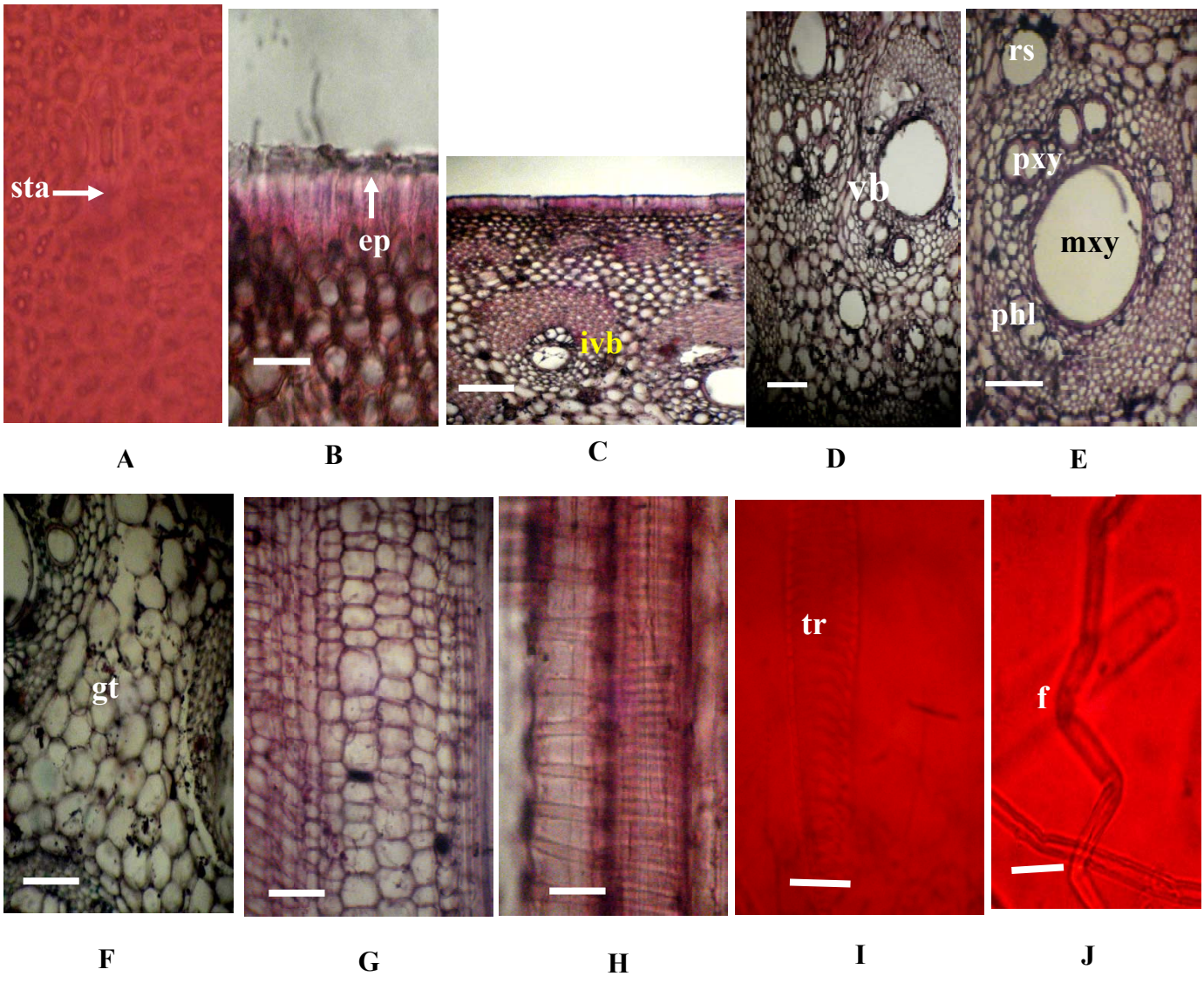
C. flagellate of *calamus viminalis* Willd.

D. Leaflets in top portion of leaf

E. Leaflets in lower portion of leaf

F. Part of infructescence

Figure.5.1B Anatomical characters of *Calamus viminalis* Willd.



A. The stomata (sta) of surface view. Scale bar 100 µm

B. Transverse section of a rattan stem with epidermis (ep). Scale bar 26 µm

C. Outer portion (periphery) in transverse section showing incomplete vascular bundles (ivb).Scale bar 100 µm

D. Inner portion in transverse section showing complete vascular bundle (vb). Scale bar 100 µm

E. Vascular bundle with two phloem fields in transverse section, phloem(phl), raphide sac(rs), metaxylem vessel(mxy), protoxylem(pxy). Scale bar 100 µm

F. Ground parenchyma (gt) in transverse section. Scale bar 100 µm

G. Ground parenchyma (gt) in longitudinal section. Scale bar 100 µm

H. Longitudinal section showing the arrangement of protoxylem consist of tracheid only, the wall sculpturing either annular or helical. Scale bar 26 µm

I. Isolated cell of tracheid (tr). Scale bar 26 µm

J. Isolated cells of wavy fibers (f). Scale bar 26 µm

5. 2. *Calamus guruba* Ham.

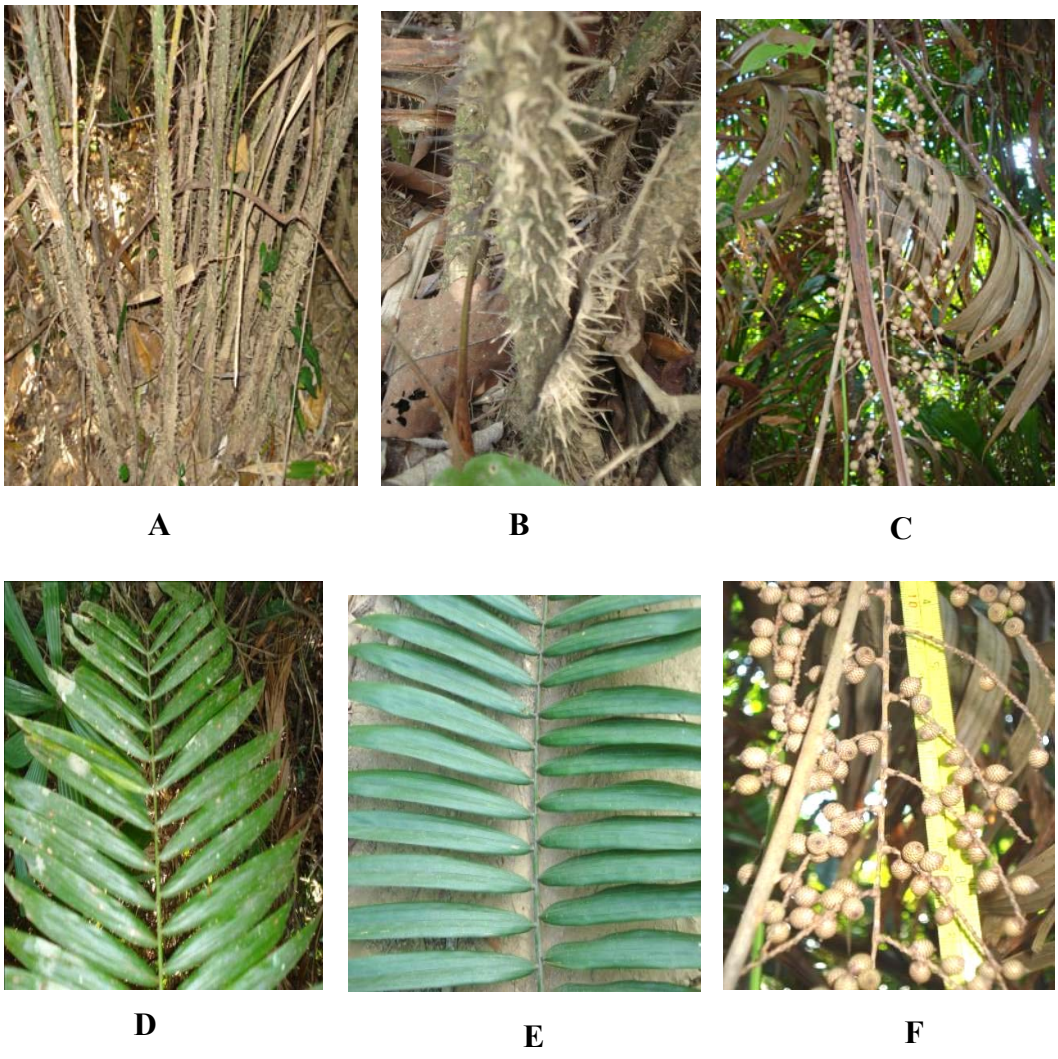
Morphological characters

Stem cluster forming; stem thickness with leafsheath 3 cm – 3.5 cm and without leafsheath 2 cm – 2.5 cm in diameter; leave ecirrate, 0.79 m – 1.35 m long; petiole 34.5 cm – 52.30 cm in length and 1.75 cm – 2 cm in diameter; rachis 58 cm –**76** cm long, bearing scattered with slenderical sharp shape on the lower surface, 1.2 cm – 3.3 cm long; leaflets alternate, regularly arrangement, 32 – 33 numbers on each side of the rachis, 11cm – 33 cm length and 1 cm – 2.5 cm in width, 5 nerved, upper surface dull green, lower surface dark green, bristles present on the both surface; leafsheath brown colour; the thorns present on the leafsheath, soft, densely and irregularly arranged, small, 1 cm – 2.5 cm long, knee inconspicuous; inflorescence flagellate, longer than leaves; fruits globose and with prominent short beak, 9 mm – 10 mm in length and 7 mm – 8 mm in diameter, yellowish-brown colour, 6 – 7 series of scales.

Anatomical characters

Epidermis single layer, mean thickness 23.16 µm (range 20.50 – 27.33 µm), Stomata density 10 – 12/mm², epidermal cells quadrilateral shape in transverse section; hypodermal cells absent; mean cortex width 160.15µm (66.52 – 251.12 µm), cells rounded or oval in transverse section, vascular bundle sparsely distributed in cortex; ground parenchyma cells thinner walls, type C; vascular bundle density 12 – 18 /mm² in periphery and 3 – 6 /mm² in inner, mean radial length 215 µm (range 94.30 – 366.95 µm) in periphery, 395.39 µm (range174.25 – 604.75 µm) in inner, mean tangential width 200.93µm (range 86.10 – 350.55µm) in periphery and 312.9 µm (range 147.60 – 453.05 µm) in inner; phloem fields 2, each with 3 – 5 sieve tubes, arrangement in uniseriate row; metaxylem vessel single in each vascular bundle, sometimes 2 in periphery, mean diameter 47.26µm (range 30.7.75 – 89.17µm) in periphery, 157.27µm(range 75.85 – 263.82 µm) in inner, mean length 1267.76µm (range 943.12 – 1688.68 µm)in inner; protoxylem consists of only tracheal elements, number of tracheal elements 1 – 12 per protoxylem, mean length 2152.84µm (range 1588.75 – 2921.25 µm), mean width 58.93µm (range 46.12 – 71.75); fiber percentage decrease from periphery to inner; mean length 1013.32 µm (range 336.20 – 2142.25 µm), mean width 10.93 (range 2.50 – 20.50 µm), mean wall thickness 3.95 µm (range 3 – 6.75 µm) in periphery and mean length 1041.58 µm (range 434.60 – 1808 µm), mean width 12.57 µm (range 7 – 21 50 µm), mean wall thickness 3.92 µm (range 2 – 9 µm) in inner, fiber bundles consists of 72.71%. Raphide sac absent.

Figure. 5.2A Morphological characters of *Calamus guruba* Ham.



A Habit as seen

B. Mature plant of *calamus guruba* Ham. showing leafsheath

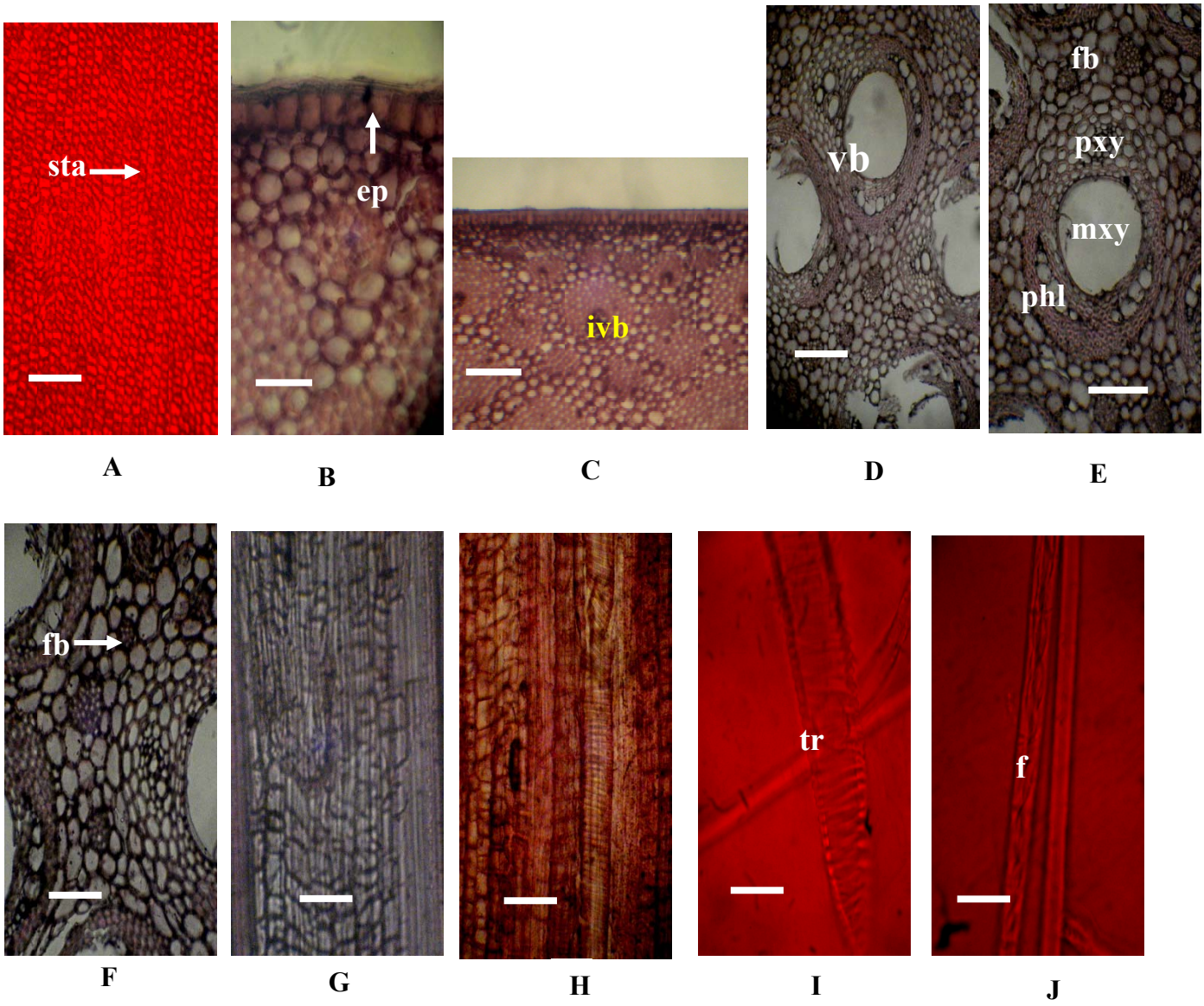
C. flagellate of *calamus guruba* Ham.

D. Leaflets in top portion of leaf

E. Leaflets in lower portion of leaf

F. Part of infructescence

Figure. 5.2B Anatomical characters of *Calamus guruba* Ham.



A. The stomata (sta) of surface view. Scale bar 100 µm

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E. Vascular bundle with two phloem fields in transverse section, phloem (phl), metaxylem vessel(mxy), protoxylem (pxy), fiber bundle (fb). Scale bar 100 µm

F. Ground parenchyma (gt) and fiber bundles (fb) in transverse section. Scale bar 100 µm

G. Ground parenchyma (gt) in longitudinal section. Scale bar 100 µm

H. Longitudinal section showing the arrangement of protoxylem consist of tracheid only, the wall sculpturing either annular or helical. Scale bar 26 µm

I. Isolated cell of tracheid (tr). Scale bar 26 µm

J. Isolated cells of fiber (f). Scale bar 26 µm

5. 3. *Calamus longisetus* Griff.

Morphological characters

Stem cluster forming, massive; stem thickness with leafsheath 5 cm – 7 cm and without leafsheath 4cm – 5cm in diameter; leave ecirrate, 1.29m – 1.57m long; petiole 1.20 m in length and 3 cm in diameter; rachis 1.5m long, bearing grouped with flat triangular spines on the lower surface, soft, brittles, 2 cm – 4 cm long; leaflets arranged in group of 2 – 3 pairs and 26 – 29 numbers on each side of the rachis, 35cm – 60 cm length and 3.3cm – 5 cm in width, single nerved, upper and lower surface green, bristles present on the both surface; leafsheath grey colour; the thorns present on the leafsheath, soft and brittle, densely, triangular shape, 1.5cm – 4cm long; knee inconspicuous; infloresence flagellate, longer than leaves; fruits ellipsoid and with prominent beak, 20 – 27mm in length and 13 – 15 mm in diameter, dark brown in colour, 5 – 6 series of scales.

Anatomical characters

Epidermis single layer, mean thickness 40.78 µm (range 35.87 – 46.17 µm), Stomata density 26 – 39/mm², epidermal cells radially elongated shape in transverse section; hypodermal cells 2 – 3 layers; mean cortex width 193.15µm (143.50 – 238.31µm), cells rounded or oval in transverse section, vascular bundle sparsely distributed in cortex; ground parenchyma cells thinner walls, type A and B; reddish – brown gum deposits present; vascular bundle density 6 – 11/mm² in periphery and 2 – 6/mm² in inner, mean radial length 337.70 µm (range 179.37 – 479.18µm) in periphery, 511.87 µm (range 176.81 – 907.12 µm) in inner, mean tangential width 256.14µm (range 156.31 – 361.31µm) in periphery and 399.69 µm (range 148.62 – 635.50 µm) in inner; phloem fields 2, each with 3 – 7 sieve tubes, arrangement in uniseriate row; metaxylem vessel single in each vascular bundle, reddish – brown gum deposits and tyloses present in some vascular bundle, mean diameter 61.28 µm (range 35.87 – 93.53µm) in periphery, 189.57µm (range 71.75 – 294.68 µm) in inner, mean length 1576.27 µm (range 1265.87 – 1668.62 µm) in inner; protoxylem consists of only tracheal elements, number of tracheal elements 2 – 13 per protoxylem, mean length 2726.30 µm (range 1640 – 4305 µm) mean width 74.48 µm (range 30.75 – 102.50) ; fiber percentage decrease from periphery to inner; helical thickening present, mean length 1060.60 µm (range 427.93 – 2032.06 µm), mean width 13.36 (range 8.12 – 20.62 µm), mean wall thickness 5.16 µm (range 2.50 – 8.97 µm) in periphery and mean length 1146.50 µm (range 474.06 – 2388.75 µm), mean width 14.16 µm (range 8.12 – 21.56 µm), mean wall thickness 4.75 µm (range 2.18 – 9.06 µm) in inner, thick walled, fiber bundles absent, raphide sac absent.

Figure.5.3A Morphological characters of *Calamus longisetus* Griff.

A

B

C

D

E

F

A Habit as seen

B. Mature plant of *calamus longisetus* Griff. showing leafsheath

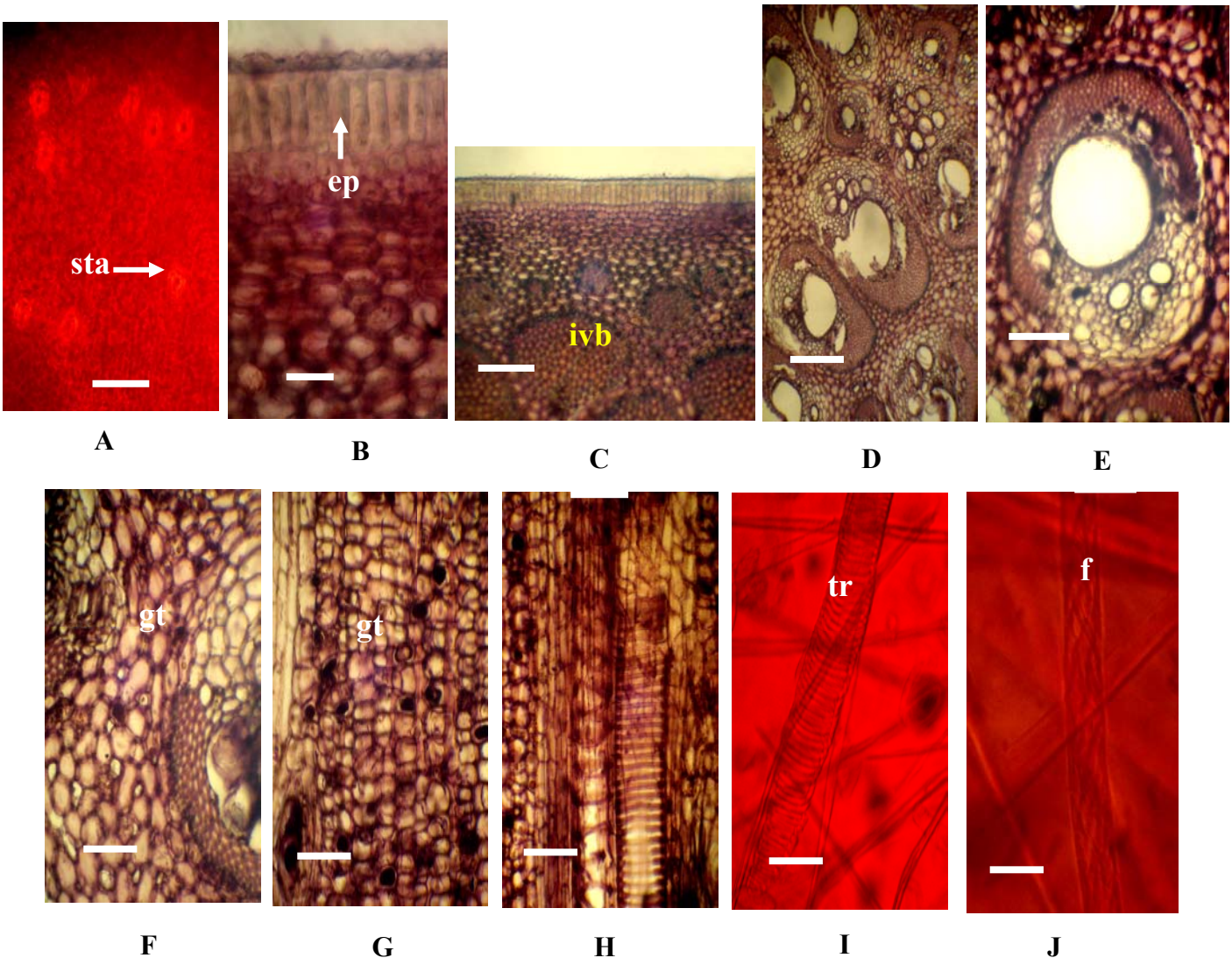
C. flagellate of *calamus longisetus* Griff.

D. Leaflets in top portion of leaf

E. Leaflets in lower portion of leaf

F. Part of infructescence

Figure.5.3B Anatomical characters of *Calamus longisetus* Griff.



A. The stomata (sta) of surface view. Scale bar 100 µm

B. Transverse section of a rattan stem with epidermis (ep). Scale bar 26 µm

C. Outer portion (periphery) in transverse section with incomplete vascular bundle (ivb). Scale bar 100 µm

D. Inner portion in transverse section with complete vascular bundle (vb). Scale bar 100 µm

E. Vascular bundle with two phloem fields in transverse section, phloem (phl), metaxylem vessel (mxy), protoxylem (pxy). Scale bar 100 µm

F. Ground parenchyma (gt) in transverse section. Scale bar 100 µm

G. Ground parenchyma (gt) in longitudinal section. Scale bar 100 µm

H. Longitudinal section showing the arrangement of protoxylem consist of tracheid only, the wall sculpturing either annular or helical. Scale bar 26 µm

I. Isolated cell of tracheid (tr). Scale bar 26 µm

J. Isolated cells of fibers with helical thickening (f). Scale bar 26 µm

5. 4. *Calamus erectus* Roxb.

Morphological characters

Stem cluster forming; stem thickness with leafsheath 4.5 cm – 7.5 cm and without leafsheath 3cm – 3.5cm in diameter; leave cirrate, 2.25m – 3.15m long; petiole 69cm – 100cm in length and 1.8cm in diameter; rachis 2.4m long, bearing scattered flat triangular spines on the upper and lower surface, stiff, 0.6 cm – 2.5 cm long; leaflets alternate, regularly arrange, pendulous, 74 – 76 numbers on each side of the rachis, 13cm – 52cm in length and 2cm – 3cm in width, single nerved, upper and lower surface green, bristles present on the both surface; leafsheath dark green colour; the thorns present on the leafsheath, stiff and brittle, irregularly arrangement, flat triangular shape, 3cm – 5cm long; knee inconspicuous; inflorescence eflagellate, longer than leaves ; fruits globose, 13 – 17 mm in length and 14 – 15 mm in diameter, straw yellow in colour, 7 series of scales.

Anatomical characters

Epidermis single layer, mean thickness 42.62 µm (range 37.92 – 45.19 µm), Stomata density 24 – 38/mm², epidermal cells rectangular shape in transverse section; hypodermal cells 1 – 2 layers; cortex width 153.75 – 351.06 µm (243.57µm), cells rounded or oval in transverse section, vascular bundle sparsely distributed in cortex; ground parenchyma cells thinner walls, type A and B; vascular bundle density 13 – 19/mm² in periphery and 1 – 2 /mm² in inner, mean radial length 451.17 µm (range 196.80 – 785.15 µm) in periphery, 641.77 µm (range 352.60 – 951.25 µm) in inner, mean tangential width 316.92µm (range 155.80 – 498.15 µm) in periphery and 464.78 µm (range 231.65 – 643.70 µm) in inner; phloem fields 2, each with 3 – 6 sieve tubes, arrangement in uniseriate row, sometime biseriate; metaxylem vessel single in each vascular bundle, mean diameter 70.11µm (range30.75 – 116.85 µm) in periphery, 216.84µm(range 104.54 – 305.50 µm) in inner, mean length1243.79µm (range 666.25 – 1742.50 µm) in inner; protoxylem consists of only tracheal elements, number of tracheal elements 1 – 15 per protoxylem, mean length 1793.75 µm (range 461.25 – 1973.12 µm) mean width 73.75 µm (range 71.75 – 82 µm); fiber percentage decrease from periphery to inner; mean length 868.70 µm (range 356.70 – 1363 µm), mean width 15.96 (range 8.50 – 24.50 µm), mean wall thickness 5.34 µm (range 2.50 – 8.50 µm) in periphery and mean length 942.83 µm (range 391.55 – 1711.75 µm), mean width 19 µm (range 12 – 27.50 µm), mean wall thickness 5.67 µm (range 2.50 – 9 µm) in inner, thick walled , fiber bundles absent, raphide sac consists of 8.32%.

Figure.5.4A Morphological characters of *Calamus erectus* Roxb.

A

B

C

D

E

F

A Habit as seen

B. Mature plant of *calamus erectus* Roxb. showing leafsheath

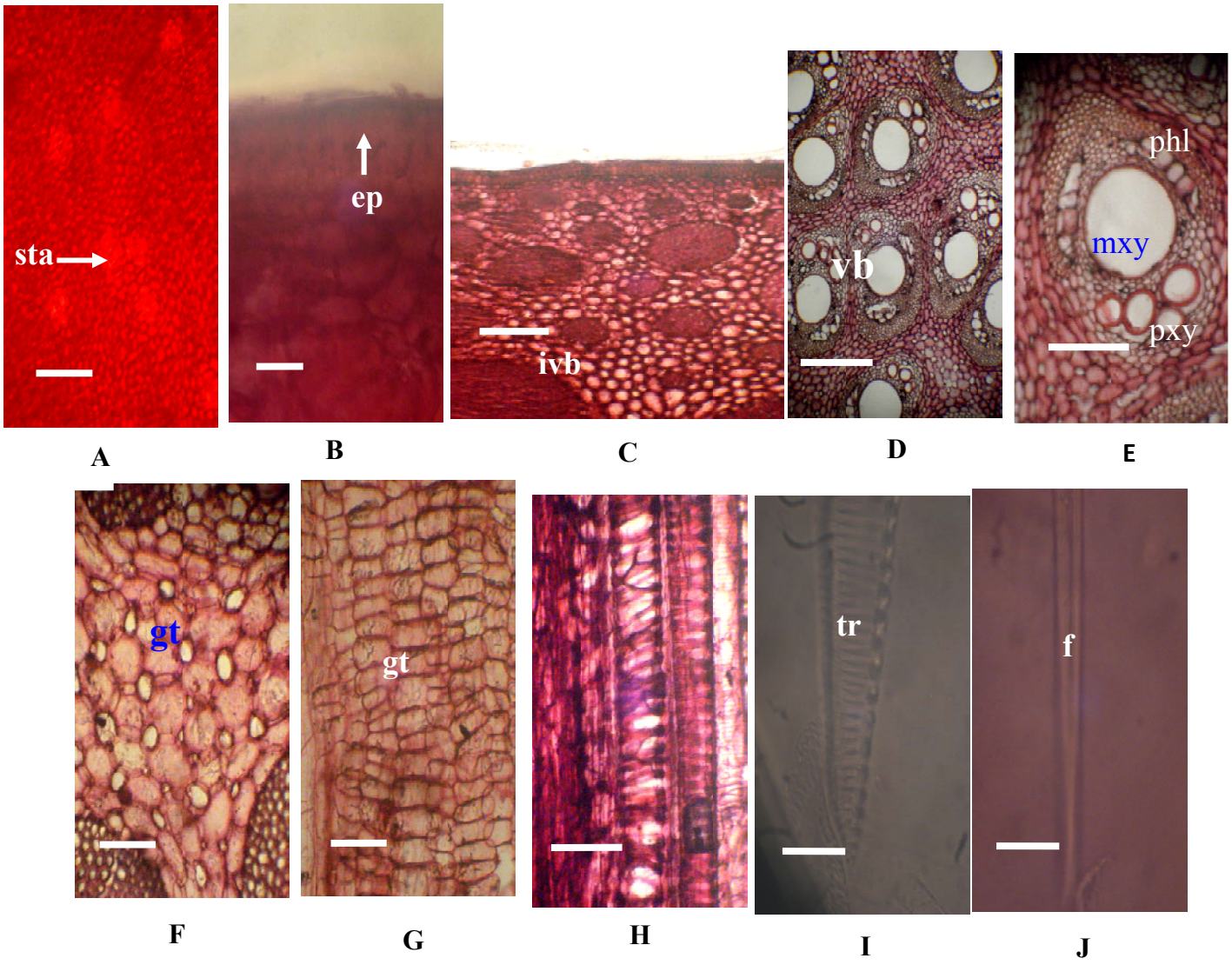
C. Cirrus of *calamus erectus* Roxb.

D. Leaflets in top portion of leaf

E. Leaflets in lower portion of leaf

F. Part of infructescence

Figure.5.4B Anatomical characters of *Calamus erectus* Roxb.



The stomata (sta) of surface view. Scale bar 100 µm

A. Transverse section of a rattan stem with epidermis (ep). Scale bar 26µm

B. Outer portion (periphery) in transverse section with incomplete vascular bundle (ivb). Scale bar 100µm

C. Inner portion in transverse section with complete vascular bundle (vb). Scale bar 100µm

D. Vascular bundle with two phloem fields in transverse section, phloem (phl), metaxylem vessel (mxy), protoxylem (pxy). Scale bar 100µm

E. Ground parenchyma (gt) in transverse section. Scale bar 100µ

F. Ground parenchyma (gt) in longitudinal section. Scale bar 100µm

G. Longitudinal section showing the arrangement of protoxylem consist of tracheid only, the wall sculpturing either annular or helical. Scale bar 26 µm

H. Isolated cell of tracheid (tr). Scale bar 26µm

I. Isolated cells of fibers (f). Scale bar 26µm

5.5. *Calamus latifolius* Roxb.

Morphological characters

Stem solitary; stem thickness with leafsheath 4.5 cm – 5 cm and without leafsheath 2 cm – 3.5 cm in diameter; leave cirrate, 1.8 m – 3 m long; petiole 4 cm – 12 cm in length and 1.6 – 2 cm in diameter; rachis 2 m – 3.10m long, bearing scattered with flat triangular spines on the lower surface, stiff, 0.5 cm – 1 cm long; leaflets generally arranged in group of 2 pairs and 14 – 16 numbers on each side of the rachis, sometimes single near the base, 32cm – 50 cm length and 5 cm – 12 cm in width, 6 nerved, upper and lower surface dark green, without bristles on both surface, smooth. leafsheath dark grey colour; the thorns present on the leafshath, stiff, scattered or slightly whorl arrangement, flat triangular shape, 1.5 cm – 4.3 cm long, knee conspicuous; inflorescence eflagellate, shorter than leaves; fruits ellipsoid , dark brown in colour while young. Mature fruits were not found.

Anatomical characters

Epidermis single layer, mean thickness 62.54 µm (range 57.40 – 68.67 µm), Stomata density 14 - 18 /mm², epidermal cells radially elongated shape in transverse section; hypodermal cells 4 – 5 layers; cortex width 98.40 – 168.10 µm (133.44 µm), cells rounded or oval in transverse section, vascular bundle sparsely distributed in cortex; ground parenchyma cells thinner walls, type A to B; vascular bundle density 4 – 8 /mm² in periphery and 1 – 4/mm² in inner, mean radial length 305.35 µm (range 127.10 – 530.96 µm) in periphery, 648.79 µm (range 317.70 – 897.90 µm) in inner, mean tangential width 221.66 µm (range 94.30 – 346.45 µm) in periphery and 537.38 µm (range 235.75 – 745.35µm) in inner; phloem fields 2, sieve tubes 3 – 8 per phloem field, arrangement in uniseriate row; metaxylem vessel single in each vascular bundle, mean diameter 73.03 µm (range 32.03 – 125.56 µm) in periphery, 296.56 µm(range 138.37 – 410 µm) in inner, mean length 1804.83 µm (range 1563.06 – 2352.37 µm) in inner; protoxylem consists of only tracheal elements, tracheids 2 – 16 per protoxylem, mean length 2492.12 µm (range 1255.62 – 4100 µm), mean width 54.50 µm (range 38.45 – 97.93 µm), fiber percentage decrease from periphery to inner; mean length 984.04 µm (range 315.70 – 1869.60 µm), mean width 14.58 µm (range 9.50 – 21 µm), mean wall thickness 6.37 µm (range 3.75 – 9.50 µm) in periphery and mean length 1092.07 µm (range 401.80 – 1945.45 µm), mean width 17.03 µm (range 10.05 – 25.50 µm), µm), mean wall thickness 6.92 µm (range 3.75 – 10 µm) in inner, thick walled, fiber bundles absent, raphide sac absent.

Figure.5. 5A Morphological characters of *Calamus latifolius* Roxb.

A

B

C

D

E

F

A. Habit as seen

B. Mature plant of *calamus latifolius* Roxb. showing leafsheath

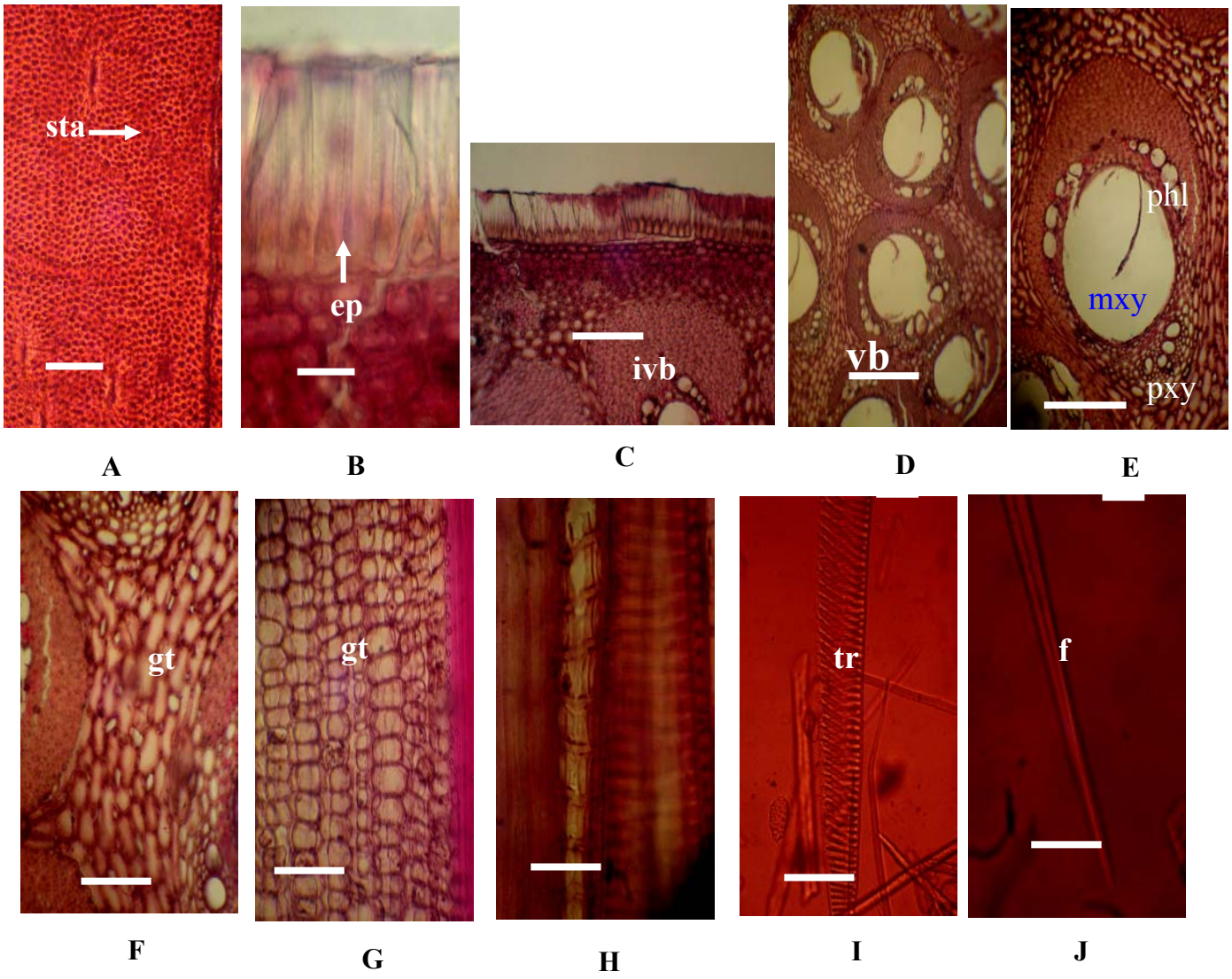
C. Cirrus of *calamus latifolius* Roxb.

D. Leaflets in top portion of leaf

E. Leaflets in lower portion of leaf

F. Part of infructescence

Figure.5.5B Anatomical chara ***Calamus latifolius*** **Roxb.**



A. The stomata (sta) of surface view. Scale bar 100 µm

B. Transverse section of a rattan stem with epidermis (ep). Scale bar 26µm

C. Outer portion (periphery) in transverse section with incomplete vascular bundle (ivb). Scale bar 100µm

D. Inner portion in transverse section with complete vascular bundle (vb). Scale bar 100µm

E. Vascular bundle with two phloem fields in transverse section phloem (phl), metaxylem vessel (mxy), protoxylem (pxy). Scale bar 100µm

F. Ground parenchyma (gt) in transverse section. Scale bar 100µ

G. Ground parenchyma (gt) in longitudinal section. Scale bar 100µm

H. Longitudinal section showing the arrangement of protoxylem consist of tracheid only, the wall sculpturing either annular or helical. Scale bar 26 µm

I. Isolated cell of tracheid (tr). Scale bar 26µm

J. Isolated cells of fibers (f). Scale bar 26µm

6. Discussion

Any activity in conservation, management or sustainable use of rattan must be based on a sound taxonomy which is based on an understanding of morphology of rattans (A. Henderson, 2008). To improve the understanding of morphology of rattans the morphological features of five rattan species growing in Ayeyarwady Region were therefore studied.

Within the genus species can be identified with the help of characters like cluster forming or non cluster forming stem, thickness of stem, arrangement of leaflets on rachis, bristle on the leaflet surface, cirrus which is climbing organ extending from leaf tip, flagellum which is whip like climbing organ derived from an inflorescence and bearing reflexed spines, fruit shape and scale series covering on the fruit (Dransfield & Manokaran, 1996). In this research promising morphological characteristics of five species growing in Pathein Township which are widely used at local level are studied.

Among five species studied stems of *Calamus latifolius* Roxb. is solitary and the remaining are cluster. The stem diameter which is one of important features to distinguish species within genus is shown in table 6. 1.

Table 6.1. Stem diameter of five rattans growing in Ayeyarwady Region

species	Stem diameter with leafsheath	Stem diameter without leafsheath
Calamus viminalis Willd.	3 cm – 4.5 cm	2 cm – 2.5 cm
Calamus guruba Ham.	3 cm – 3.5 cm	2 cm – 2.5 cm
Calamus longisetus Griff.	5 cm – 7 cm	4 cm – 5 cm
Calamus erectus Roxb.	4.5 cm – 7.5 cm	3 cm – 3.5 cm
Calamus latifolius Roxb.	4.5 cm – 5 cm	2 cm – 3.5 cm

In the leaves of *Calamus erectus* Roxb and *Calamus latifolius* Roxb. is found cirrus, Leaves of *C. viminalis* Willd, *C. guruba* Ham and *C.longisetus* is found flagellum. Grouped spines are found on the lower surface of rachis of *Calamus longisetus* Griff. whereas scattered spines are found on those of other species. The leaflets of *Calamus erectus* Roxb.and *Calamus guruba* Ham.arrange in alternate on rachis and those of *Calamus erectus* Roxb.are pendulous. The venation of all species studied are single nerved except *Calamus guruba* Ham and *Calamus latifolius* Roxb. In *Calamus guruba* Ham it is 5-nerved and 6-nerved in *Calamus latifolius* Roxb. Bristle spines are present on the surface 21 ts of all species except *Calamus latifolius* Roxb. in which smooth leaflets lack bristle spir

In all the species studied thorns are found scattered on leafsheaths except in *Calamus latifolius* they are arranged in whorl on the leafsheath. They are densely in *Calamus longisetus* Griff. Knee on leafsheath of all species is inconspicuous except *Calamus latifolius* Roxb of which knee is conspicuous. The fruits of *Calamus longisetus* Griff. and *Calamus latifolius* are

ellipsoid and those of *Calamus viminalis* Willd., *Calamus erectus* Roxb.and *Calamus guruba* Ham.are globose in shape. Prominent beak is found in fruits of *Calamus longisetus* Griff and *Calamus guruba* Ham but not found in other species.

The anatomical variation such as epidermal cell shape the size of vascular bundles, metaxylem vessel diameter, number of protoxylem element can be used as supporting features in species differtiation. (Bhat et.al,1993). Furthermore the central cylinder of *calamus* species is distinguished from that of most palms by the relatively uniform density of its vascular bundles and wide metaxylem vessel as stated by Tomlinson et al, 2001. He also revealed that these features contribute to the texture of canes. As shown in table 6. 2, the variation in the promising features mentioned above which help to distinguish species level and influence on texture of canes found encountered in this study are given in table 6.2.

Table 6. 2. The promising features of five rattan species to distinguish at species level

Species	**Epidermal cell shape**	**Size of vascular bundle (inner portion)**		**Metaxylem diameter (µm)** In (inner portion)	**Number of protoxylem element** in (inner portion)
		Radial length (µm)	**Tangential width (µm)**		
Calamus viminalis Willd.	Rectangular	405.80	390.79	144.15	1-12
Calamus guruba Ham.	Quandrilateral	385.39	312.99	157.27	1-12
Calamus longisetus Griff.	Radially elongated	511.87	399.69	184.57	2-13
Calamus erectus Roxb.	Rectangular	641.77	464.78	216.84	1-15
Calamus latifolius Roxb	Radially elongated	648.79	537.38	296.56	2-16

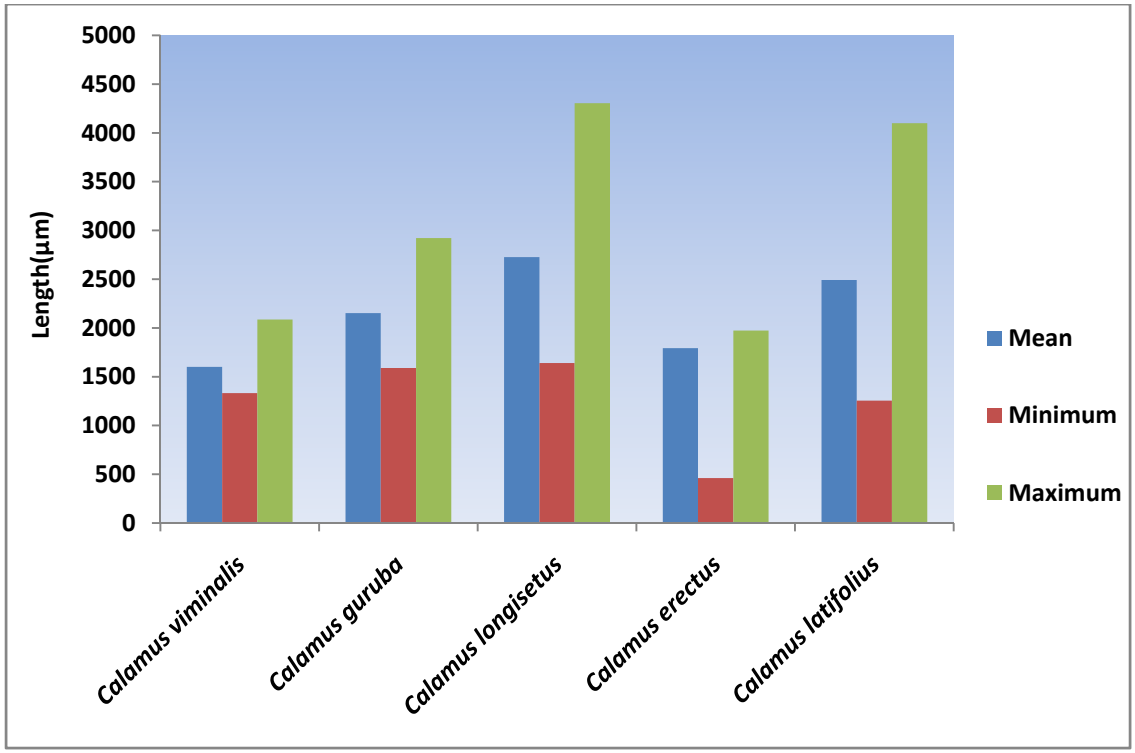
In all species observed cortex tissues comprises of rounded and oval shaped and thin walled parenchyma cells which are agreed with Bhat et al, 1998 and Tomlinson et al 2001. Weiner & Liesen (1990) suggested that at species level many anatomical characters are similar among the species. Bhat et.al (1993) also mentioned that more than one type of ground parenchyma was seen within the same species. Similarly, in the present investigation, A and B type of ground tissue is found in *Calamus longisetus* Griff., *Calamus erectus* Roxb.and *Calamus latifolius* Roxb and C type in *Calamus viminalis* Willd.and *Calamus guruba* Ham.. Ground

tissues of *Calamus viminalis* Willd.and *Calamus erectus* Roxb. include raphide sacs with short clusters of raphide crystals at wide intercellular spaces which agreed with Tomlinson et al 2001.

The general structure and distribution of vascular bundles are similar in all species observed. In transverse section, the stem contains vascular bundles of various sizes with the largest in central region. The largest bundles usually have one wide metaxylem vessel, several narrow metaxylem vessel and protoxylem elements. The number of protoxylem elements varies from species to species as shown in table 6. 2. Phloem field is usually divided into separate strands in each bundle. The narrow vascular bundles infrequently scattered throughout ground tissue have single narrow metaxylem vessel with two phloem strands. The narrowest vascular bundles have no protoxylem but a single narrow metaxylem. Incomplete vascular bundles without well developed narrow metaxylem are found often scatter throughout cortex in periphery portion of stem. These findings are in accord with those of Tomlison et al 2001 and Fisher et al 2002.

Protoxylem of all species examined consists of tracheal elements only, with taper ends, the wall sculpturing helical thickening which is similar to findings of Tomlinson et al, 2001. Protoxylem elements are longer than in metaxylem vessel and found wide vascular bundles located in inner portion of stem. Narrowest vascular bundles located in periphery portion totally lack protoxylem elements. The longest mean tracheids are found in *Calamus longisetus* Griff. whereas shortest in *Calamus viminalis* Willd. as shown in figure 6.1.

Figure. 6.1. Variation in length of protoxylem elements (tracheal elements) among the species



Bhat et al, 2001 stated that in *Calamus* species phloem tissue or phloem field is divided into two strands of sieve tubes distributed on two lateral side of the solitary metaxylem vessel. Moreover uniseriate sieve tubes are found in some species and rarely biseriate in some species. As he mentioned phloem tissue or phloem field consisting of two strands of sieve tubes located on two lateral side of the single metaxylem vessel are found in all species observed and sometimes biseriate sieve tubes in *Calamus erectus*.

In all species examined metaxylem diameter increase from periphery to center as well as from bottom to top. The increasing in metaxylum diameter is smaller in longitudinally than radially which is confirmed by Bhat et al 2001. Metaxylem diameter is related with the durability properties of rattan. If the size of pores is large, rattan is less durable because it is easy to attack by insect (Titi Kalima and Jasni, 2004). Among tested species smallest diameter of metaxylem located in inner portion is found in *Calamus viminalis* and largest in *Calamus latifolius* Roxb. whereas smallest of periphery in *Calamus guruba* Ham. and largest also in *Calamus latifolius* Roxb. as shown in figure 6.2.

Fiber bundles are found to occur generally scatter within cortex and they are found to be a cap on the one side of vascular bundle in the center. However, fiber bundles are found scattered within ground tissues in *Calamus guruba* Ham. As shown in figure 6.3 fiber length and width vary relatively little both within the stem and among the species which is accord to Bhat et al.

Figure 6.2 Variation in diameter of metaxylem vessel among five tested species

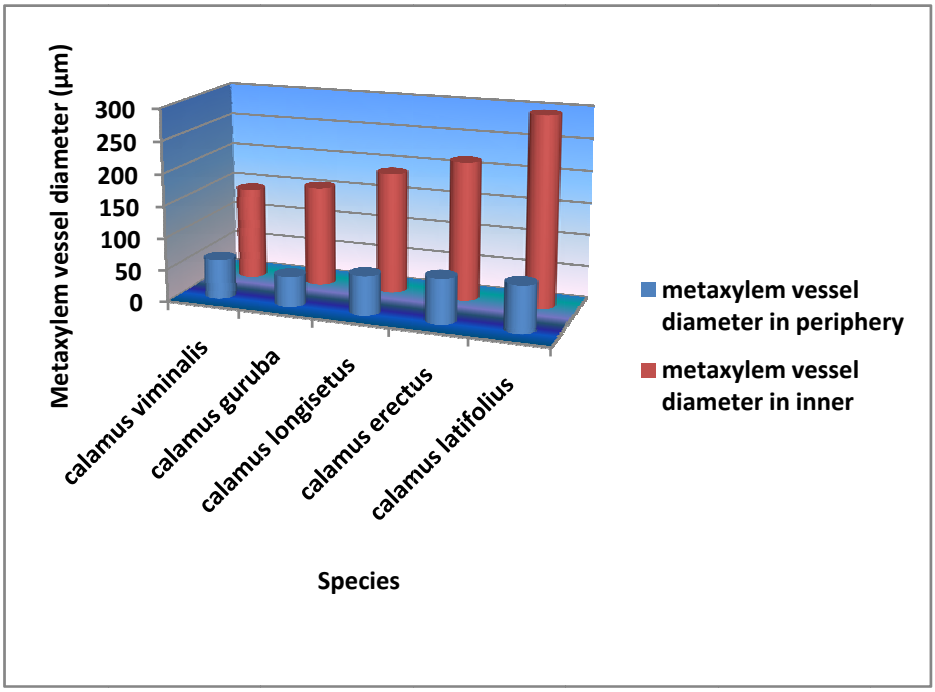
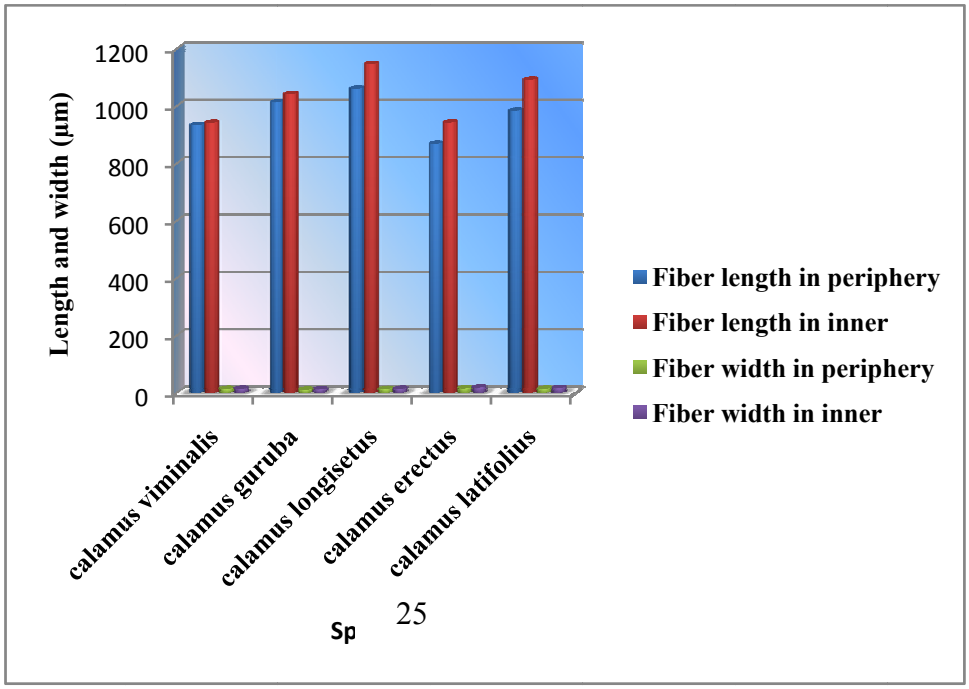
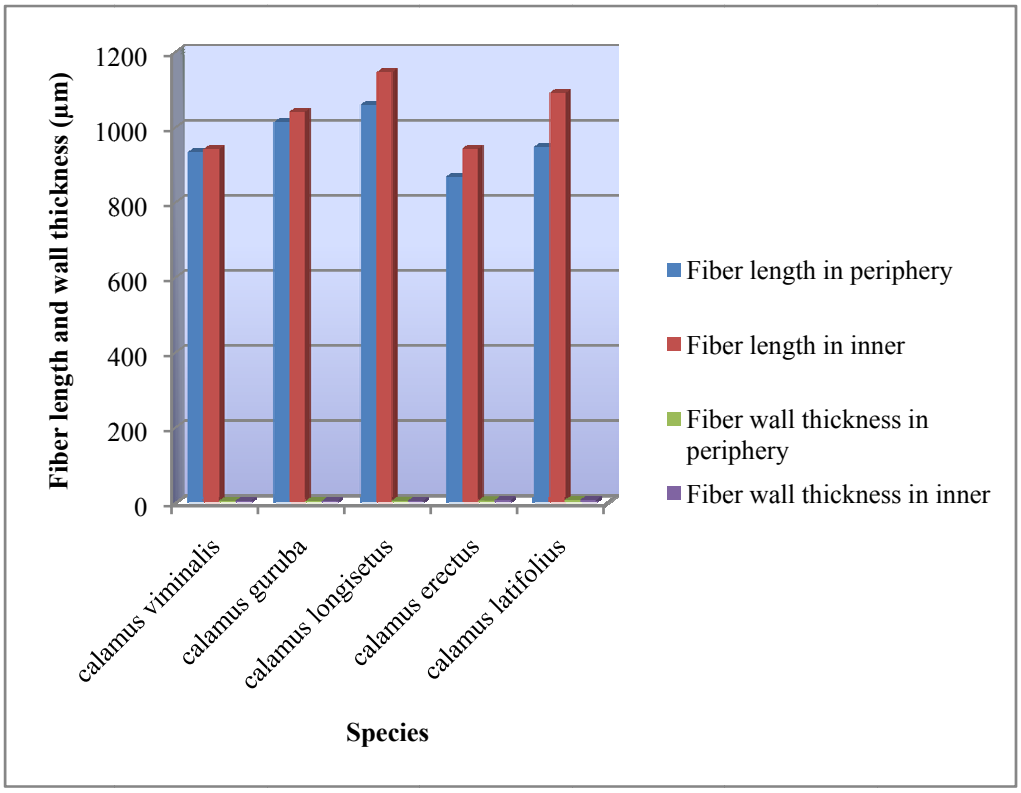


Figure 6.3 Variation in fiber length and width both within stem and among the species



Furthermore, according to Titi Kalima and Jasni, 2004 the fiber length and wall thickness are the most important parameter in determining the strength of rattan and the longer the fiber and thicker the fiber wall, the higher its strength and the heavier the rattan. In the present study fiber wall thickness is less variable among species studied and fiber length is longest in *Calamus longisetus* as shown in figure 6.4. According to survey on local utilization *Calamus longisetus* is found to be widely used for frame of furniture. Thus the findings in this research are found to be the same as those of Titi kalmia and Jasni, 2004.

Figure 6.4 Variation in fiber length and wall thickness both within stem and among species



7. Conclusion

In order to identify the right species of rattan for conservation, management and sustainable use it must rely on systematic taxonomic identification. In taxonomic identification, a morphological features are key points. In this study the morphological features of five rattan species growing in Pathein Township, Ayeyarwady Region found out. The investigated features such as stem growing habit, leaves, climbing organs like cirrus and flagellum, leafsheath, infructescence are promising parameters for taxonomic identification.

The processing and utilization of rattan are influenced by to a great extent on anatomical characters of stem which exhibits considerable variation along the stem length (Liese 2005). Some of important anatomical characters like fiber length, fiber wall thickness, metaxylem diameter and vascular bundle distribution and density determine the strength, durability and texture of cane.

However, more detail investigations are necessary on morphological and anatomical structure of rattan species to be authenticated and to find out the develop commercially and utilization properties through qualitative and quantitative anatomical characters investigation.

Acknowledgements

We are grateful to U Zaw Win Myint, Director, Forest Research Institute, Yezin, for his allowing us to undertake this research paper. Our thanks are due to Assistant Director, staff officer and forest staff, Forest Department from Pathein Township, Ayeyarwady Region, for their kindly assistance during our trip.

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