ANATOMICAL CHARACTERISATION OF *MONOON LONGIFOLIUM* (Sonn.) B. Xue & R.M.K. Saunders FROM FOUR DISTINCT LOCATIONS

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Abstract

This study explores the internal wood structure and anatomical characteristics of four wood samples of *Monoon longifoliu*m (Sonn.) B. Xue & R.M.K. Saunders , which is an important evergreen tree of the family Annonaceae with ornamental, ecological, and medicinal significance. In the present study physical properties and anatomical characteristics of wood samples were studied from four wood samples, collected from four different locations in North Bengaluru, Karnataka. The physical properties like colour, odor, texture, luster, hardness, etc. were examined using a hand-lens (10X). Wood samples were macerated, softened, sectioned, mounted and examined to study the anatomical characteristics of vessels, fibres, axial parenchyma, rays, mineral inclusions, etc. Wood anatomical analysis revealed consistent structural characteristics across all samples, including diffuse-porous wood, indistinct growth rings, simple perforation plates, alternate minute intervessel pits, heterocellular multiseriate rays, diffuse-in-aggregate axial parenchyma, and abundant non-septate fibres. All samples exhibited reddish-brown tanniferous tubes, whereas crystal composition showed inter-sample variation, characterized by acicular crystals in ML-1 and ML-2 and mixed crystal types in ML-3 and ML-4, highlighting anatomical differences among the samples. Specific gravity ranged from 0.451 to 0.614, reflecting moderate variation in wood density. Inter-population variation was evident in quantitative wood anatomical traits, including vessel dimensions, fibre characteristics, ray width, crystal diversity, and specific gravity, whereas qualitative anatomical features (tanniferous tubes) remained conserved across all samples, demonstrating overall structural consistency, thus provides baseline information for wood identification, taxonomy and for better wood utilization of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders.

INTRODUCTION:

Monoon longifolium (Sonn.) B. Xue & R.M.K. Saunders, formerly known as *Polyalthia longifolia* (Sonn.) Thwaites, is an evergreen tropical tree belonging to the family Annonaceae. This species is native to the Indian subcontinent and Sri Lanka and is widely cultivated throughout tropical and subtropical regions as an ornamental avenue tree due to its attractive columnar growth habit, pendulous branches, and evergreen foliage. Commonly referred to as the False Ashoka or Mast Tree, it is frequently planted in urban landscapes, gardens, educational institutions, and roadside plantations for its aesthetic value and environmental benefits (Lemmens & Bunyapraphatsara, 2003; Jothy *et al.*, 2013). The family Annonaceae Juss. comprises approximately 130 genera and 2,400 species distributed predominantly in tropical regions of the world. Members of this family are known

for their economic, ecological, and medicinal significance, with many species possessing diverse bioactive compounds (Mitra, 1993; Katkar *et al.*, 2010).

Anatomically, *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders exhibits typical dicotyledonous features with distinct epidermal, cortical, vascular and pith regions. The stem shows a single-layered epidermis covered by a cuticle, followed by cortex composed of parenchymatous cells. The vascular bundles are arranged in a ring and are collateral, open, and endarch in nature. Secondary growth occurs through the activity of the vascular cambium, resulting in the formation of secondary xylem and phloem. The xylem contains vessels, fibres, tracheids, and xylem parenchyma, while the phloem consists of sieve tubes, companion cells, and phloem parenchyma (Ogunsanwo *et al.*, 2014). The leaf is dorsiventral with a distinct upper and lower epidermis. The mesophyll is differentiated into palisade and spongy parenchyma. Stomata are predominantly present on the lower epidermis, making the leaf hypostomatic. The vascular bundles are surrounded by supporting tissues that provide mechanical strength and efficient conduction (Metcalfe & Chalk, 1983). The root possesses a typical dicot structure with an outer epiblema, cortex, endodermis, pericycle and a central vascular cylinder. Secondary growth leads to the development of secondary vascular tissues and periderm formation, contributing to increased support and transport efficiency (Esau, 1977).

Anatomical studies of *Monoon longifolium* (Sonn.) B.Xue & R.M.K.Saunders are important for taxonomic identification, pharmacogenetic characterization and understanding its adaptation to diverse environmental conditions. The presence of sclerenchymatous tissues, oil cells and well-developed vascular elements contributes to its mechanical strength and economic significance (Ogunsanwo *et al.*, 2014; Jothy *et al.*, 2013). *Polyalthia longifolia* (Sonn.) Thwaites, was reclassified as *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, due to advancements in molecular phylogenetics (DNA-based studies) and revised botanical taxonomy, which demonstrated that the species is more appropriately placed within the genus *Monoon* rather than *Polyalthia* (Xue *et al.*, 2012; Saunders *et al.*, 2020). This case study aims to investigate the comparative study of anatomical characterization of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, from four distinct locations within a range of 15 kms and understanding their adaptation to diverse environmental conditions. The presence of parenchyma tissues and xylem elements.

MATERIALS AND METHODS

Sampling sites: The wood samples of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, were collected from four distinct locations around KR Puram area of Bengaluru, Karnataka, during May 2026. At each sampling site, *in situ* morphological observations were carried out to facilitate preliminary taxonomic identification of the species. In addition to the wood samples (Fig-D), fresh twigs (Fig-E) bearing vegetative characters were collected for species authentication. All collected materials were properly preserved and transported to the laboratory for detailed macroscopic and microscopic anatomical studies.

1) **ML-1 sample** was collected from Harmony Grooves, a Residential area located in KR Puram, Bengaluru North-560036, its geographical latitude is 13.017329ºN and longitude is 77.726701ºE - Fig(A)
2) **ML-2 sample** was collected from ITI housing colony located in Dooravaninagar Bengaluru North-560016 - its geographical latitude is 13.00902ºN and longitude is 77.688862ºE - Fig(B)
3) **ML-3 sample** was collected from Silicon city college grounds located in TC Palya, Bengaluru – 560049, its geographical latitude is 13.010958ºN, longitude is 77.701294ºE – Fig(C)
4) **ML-4 sample** was collected from the place called Bidarahalli, Bengaluru – 562114. Its geographical latitude 13.070000ºN and longitude is 77.80003ºE - Fig(D)

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Fig (A) – Fig (E) *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders
A – ML1 sample tree, B – ML2 sample tree, C – ML3 sample tree, D – ML4 sample tree, E – collected wood sample, F – fruiting twig

Determination of Physical Properties:

Samples were examined for physical properties such as colour, odor, texture, luster, hardness, etc. after debarking the wood and making fresh cuts on end- and longitudinal- faces using a sharp blade. The specimens were then examined using a hand-lens (10x). After exposure to air at room temperature for approximately two weeks, the physical characteristics were re-examined and recorded.

Determination of Density and specific gravity:

Density is the weight of a substance (mass) per unit volume; specific gravity is the ratio of the density of a material to the density of water and, consequently, specific gravity does not have units. Wood density and specific gravity were determined following the methods described in the IAWA Bulletin (1989). Initial weight (W_i) and oven-dry weight (W_o) were measured, and both parameters were calculated as the ratio of wood mass to volume (V).

The wood samples were prepared as blocks. First, the initial weight (W_i) of each sample was recorded. The samples were completely immersed in mercury to determine their volume. The weight of the displaced mercury (W_{Hg}) was recorded and the volume of wood samples (V) determined using the mathematical expression of Archimedes' Principle, $F_b = \rho Vg$ (given that the density of mercury (ρ) is 13.55 g/cm^3). Then the samples were

placed in a hot air oven for 24 hours at 100° C. Finally, the oven-dry weight (W_o) was measured, and the density and specific gravity are calculated using the appropriate formulas:

$$\text{Density} = \frac{initial\ weight\ (\text{Wi})}{volume\ (V)} \qquad \text{Specific Gravity} = \frac{oven\ dry\ weight\ (\text{Wo})}{volume\ (V)}$$

Softening of wood samples, sectioning and mounting:
The wood samples of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders were collected from four distinct locations and labelled sequentially as ML-1, ML-2, ML-3, and ML-4. Small wood blocks measuring 1.5 × 1.5 × 1.5 cm were prepared by carefully marking and cutting each sample to the required dimensions. To facilitate sectioning, the wood blocks were boiled in water for 4–5 days, with the duration adjusted according to the hardness of each sample. After softening, transverse, tangential longitudinal, and radial longitudinal sections were prepared using a MICROM HM 430 microtome (Germany). For each sample, three anatomical planes were obtained: Cross Section (CS) (Fig. 1), Tangential Longitudinal Section (TLS) (Fig. 2), and Radial Longitudinal Section (RLS) (Fig. 3). Temporary sections were mounted in glycerol for preliminary observation. For permanent slide preparation, the sections were mordanted with 3% iron alum**,** stained sequentially with 1% hematoxylin and safranin**,** dehydrated through a graded ethanol series, cleared in acetone and xylene, and permanently mounted in DPX mounting medium. The prepared slides were examined under a Nikon Eclipse C*i* POL polarizing microscope to systematically observe, analyze, and document the wood anatomical characteristics.

Maceration of wood samples:
For the isolation and cellular characterization of individual xylem elements, tissue maceration was performed following Jain (1979) method. The process began with sample preparation, during which harvested wood segments collected, *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, specimen was carefully reduced into small radial slivers measuring approximately 1-2 cm in length and 1-2 mm in thickness. These slivers were thoroughly washed with distilled water to remove extraneous dust and surface impurities, and subsequently air-dried prior to chemical processing.

To initiate the maceration procedure, radial slivers were chipped off, with a higher volume of slivers selected from samples containing lower vessel densities to ensure adequate data collection. These slivers were placed into test tubes and boiled in a water-containing beaker until the tissue segments settled to the bottom, after which the water was decanted. Chemical digestion was achieved by adding a pinch of potassium chlorate alongside a volume of 30% nitric acid to each test tube, taking strict care to avoid excess $KClO_3$ which can cause artifactual fibre breakage. The mixtures were boiled within a water bath until the wood slivers became entirely colorless or slightly yellowish. Following digestion, the maceration fluid was carefully decanted and the liberated cellular tissue was washed two to three times with distilled water before being shaken thoroughly to separate the individual components. Finally, a droplet of the macerated tissue suspension was transferred onto a clean glass slide, secured with a coverslip and examined under a Nikon Eclipse C*i* POL polarizing microscope to measure and analyze fibre and vessel dimensions.

Microscopy:
The macerated samples and permanent sections were observed under a Nikon Eclipse *Ci POL* polarizing microscope (Japan) for the assessment of fibre and vessel dimensions and other anatomical features. Both qualitative and quantitative data were collected and analyzed using NIS-Elements BR 5.21.03 software.

RESULTS AND DISCUSSION

The analysis of the collected wood samples yielded comprehensive qualitative and quantitative data (Table 01) on their physical, structural, and microscopic anatomical traits which are presented below:

Table 1: Anatomical properties of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, in numbers (min – max)

Characteristic	ML-1	ML-2	ML-3	ML-4
Mean vessel lumina diameter (µm)	46.55 - 108.88 µm	53.62 – 89.55 µm	56.03 – 107 µm	28.72 - 351.11 µm
Vessel frequency (Nos./mm^2)	12 – 19	17 – 34	12 – 52	11 – 22
Vessel element length (µm)	318.16 - 531.21 µm	203.79 - 587.45 µm	231.24 - 512.15 µm	251.42 - 634.47 µm
Ray frequency (µm)	3 - 6	4 - 7	3 – 6	3 - 7
Ray Cell count	7 - 91	10 - 58	11 – 46	9 - 71
Ray height (µm)	109.9 - 2091.88 µm	85.71 - 1834.16 µm	72.02 - 998.52 µm	78.87 - 1518.72 µm
Ray width (µm)	9.1 - 197.38 µm	11.05 – 200.34 µm	7.81 – 147.61 µm	10.61 - 228.37 µm
Fibre length (µm)	410.59 - 1235.7 µm	540.65 - 1085.7 µm	391.49 - 1050.61 µm	702.69 - 1251.96 µm
Fibre diameter (µm)	4.62 - 37.97 µm	11.58 - 23.6 µm	11.09 - 22.66 µm	10.44 - 26.06 µm

Physical characters:
All the four wood samples were creamish -white colour when freshly cut and on exposure to air it turns into light brown color. The wood is soft, straight-grained, medium coarse-textured and it is non lustrous. The pith is persistent.

Growth rings:
The growth rings are indistinct or poorly defined.

Vessels:
All four *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders wood samples (ML-1 to ML-4) exhibited diffuse-porous wood, with vessels uniformly distributed throughout the transverse section, although small vessel clusters were occasionally observed. Vessel grouping was predominantly in radial multiples, while solitary vessels occurred less frequently. The solitary vessels were circular to oval in outline (Fig. 1). All vessel elements possessed simple perforation plates, that facilitates efficient water conduction. Intervessel pits were alternate, polygonal, and minute in size across all samples. The mean intervessel pit diameter varied among samples, ranging from 2.58 ± 0.49 µm in ML-2 to 4.46 ± 0.74 µm in ML-3. Vessel–ray pits possessed distinct borders and were similar in size and shape to the intervessel pits, occurring throughout the ray cells. Vestured pits and helical thickenings were absent in all four samples, indicating uniform qualitative vessel characteristics irrespective of sampling location.

Variation was observed in quantitative vessel traits. The tangential vessel diameter ranged from 46.55–108.88 µm (ML-1), 53.62–89.55 µm (ML-2), 56.03–107.00 µm (ML-3), and 28.72–351.11 µm (ML-4), with ML-4 exhibiting the widest range due to the occurrence of exceptionally large vessels. Vessel frequency varied from

12–19 vessels mm^{-2} in ML-1**,** 17–34 vessels mm^{-2} in ML-2, 12–52 vessels mm^{-2} in ML-3, and 11–22 vessels mm^{-2} in ML-4. Similarly, vessel element length ranged from 318.16–531.21 µm (ML-1), 203.79–587.45 µm (ML-2), 231.24–512.15 µm (ML-3), and 251.42–634.47 µm (ML-4) (Fig. 9). Tyloses and other vessel deposits were absent in all samples, indicating unobstructed vessel lumina and suggesting efficient conductive pathways.

Fibres:
Ground tissue fibres in all four *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders wood samples possessed simple to minutely bordered pits, were non-septate, and ranged from thin- to thick-walled. These qualitative anatomical features were consistent across all populations. Fibre length (Fig. 7) ranged from 410.59–1235.70 µm in ML-1, 540.65–1085.70 µm in ML-2, 391.49–1050.61 µm in ML-3, and 702.69–1251.96 µm in ML-4, indicating the occurrence of predominantly short- to medium-length fibres. The mean fibre diameter (Fig. 8) was 4.62–37.97 µm in ML-1, 11.58–23.60 µm in ML-2, 11.09–22.66 µm in ML-3, and 10.44–26.06 µm in ML-4.

Axial parenchyma:
Axial parenchyma was well developed and present throughout the wood. The apotracheal axial parenchyma was diffuse-in-aggregate, whereas paratracheal axial parenchyma was absent. Scalariform banded axial parenchyma was observed in all the four wood samples. The axial parenchyma strands consisted of 5–8 cells per strand in the samples of ML-1, ML-2, and ML-3, whereas in ML-4 sample axial parenchyma strands consisted of 3–4 and 5–8 cells per strand and crystals were wanting.

Rays:
The wood rays in all four *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders wood samples are broader, predominantly multiseriate, commonly 4–10 cells wide, with occasional uniseriate rays. ML-1 has 3 – 6 rays per mm, ML-2 has 4 -7 rays per mm, ML-3 has 3 – 6 rays per mm and ML-4 has 3 – 7 rays per mm and are clearly visible to naked eyes. Aggregate rays were absent, and the majority of the rays exceeded 1 mm in height (Fig. 2). Rays of two distinct size classes were not observed. All samples exhibited heterocellular rays composed primarily of procumbent body cells. In ML-1, the rays possessed 2–4 rows of upright and square marginal cells, whereas ML-2, ML-3, and ML-4 exhibited only a single row of upright and square marginal cells (Fig. 3). Sheath cells, tile cells, and perforated ray cells were absent in all four samples. The maximum ray height varied among the samples, reaching 2092 µm (91 cells) in ML-1, 1834 µm (58 cells) in ML-2, 999 µm (46 cells) in ML-3, and 1519 µm (71 cells) in ML-4. Ray width ranged from 9.10–197.38 µm in ML-1, 11.05–200.34 µm in ML-2, 7.81–147.61 µm in ML-3, and 10.61–228.37 µm in ML-4. Tubes containing characteristic reddish-brown deposits resembling tanniferous tubes were consistently observed in all four samples (Fig. 6).

Mineral inclusions:
In ML-1 and ML-2 wood samples the rays were observed with acicular crystals (Fig:4). In ML-3 and ML-4 wood samples, the rays were observed with acicular crystals and crystals of different shapes (Fig:5).

The present study explored the wood anatomical characteristics of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders collected from four different locations in Bengaluru, Karnataka. Despite originating from different geographical locations, all samples exhibited highly similar qualitative anatomical features, indicating that the fundamental wood structure of the species is well conserved across populations. The diffuse-porous nature of the wood and the absence of distinct growth rings observed in all samples are characteristic of tropical evergreen tree species growing under relatively uniform climatic conditions. Similar observations have been reported by Ogunsanwo *et al.* (2014), who described diffuse-porous wood with indistinct growth rings as a characteristic feature of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders. The vessel elements consistently possessed simple perforation plates, alternate minute non-vestured intervessel pits, and vessel-ray pits similar in size and shape to the intervessel pits. These anatomical features are typical of advanced dicotyledonous hardwoods and contribute to efficient water conduction. The absence of helical thickenings and tyloses suggests unobstructed conductive pathways, which may enhance hydraulic efficiency. Although the qualitative vessel characteristics

remained constant among the samples, variation was observed in vessel frequency, with ML-2 and ML-4 showing relatively higher frequencies than ML-1 and ML-3. Such variation is likely influenced by environmental factors, including moisture availability, soil conditions, and growth rate, and reflects ecological adaptation rather than taxonomic differences. Similar vessel characteristics have also been reported for members of the Annonaceae by Metcalfe and Chalk (1983).

The axial parenchyma exhibited a highly consistent pattern among all samples. Diffuse and diffuse-in-aggregate apotracheal parenchyma and scalariformed parenchyma occurred throughout the wood, whereas scanty paratracheal parenchyma was absent only in ML-1. Likewise, the rays were predominantly multiseriate, heterogeneous, and composed of procumbent, upright, and square cells, agreeing well with the diagnostic wood anatomical features described for the family Annonaceae. The absence of aggregate rays, tile cells, sheath cells, perforated ray cells, and rays of two distinct sizes further confirms the anatomical stability of the species. These observations indicate that ray and parenchyma characteristics are reliable taxonomic features for identifying *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders.

Variation was evident in the occurrence of calcium oxalate crystals among the four samples. ML-1 and ML-2 contained only acicular crystals, whereas ML-3 and ML-4 possessed acicular, and other crystal forms, indicating greater crystal diversity with increase in girth of the samples. The increased crystal diversity observed in the larger-girth samples may be associated with stem maturity, suggesting that crystal deposition becomes more complex during secondary growth. Since calcium oxalate crystals are involved in storage, detoxification, and defence against herbivores, their variation is more likely related to developmental and environmental factors than to inherent anatomical differences.

The consistent occurrence of reddish-brown tanniferous tubes which resemble in all samples indicates that this feature is stable trait and is not significantly influenced by site conditions. Tanniferous tubes serve as specialized secretory structures that store tannins and other phenolic compounds involved in plant defence against insects, pathogens, and herbivores. Their uniform presence across all sampling locations supports their value as an important diagnostic character for *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders and is consistent with reports describing secretory structures as characteristic features of Annonaceae woods.

The physical properties of the wood also varied among the samples. Specific gravity ranged from 0.451 to 0.614, while wood density ranged from 0.609 to 0.906 g cm^{-3}. The comparatively higher values recorded in ML-2 and ML-3 are likely associated with thicker fibre walls and a greater proportion of supporting tissues, resulting in a more compact wood structure. In contrast, ML-1 and ML-4 exhibited relatively lower density and specific gravity, indicating wood porosity to be high in. These quantitative differences suggest that local environmental conditions influence wood formation and physical properties without altering the fundamental anatomical characteristics of the species. As wood density and specific gravity are closely related to strength, durability, and dimensional stability, the observed variation may influence the suitability of wood for different end uses.

Overall, the results demonstrate that *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, possesses highly stable qualitative wood anatomical characteristics across different geographical locations, confirming the reliability of these features for species identification and taxonomic classification. In contrast, quantitative variations in vessel frequency, crystal diversity, wood density, and specific gravity indicate that environmental conditions influence wood development and quality. These findings provide valuable baseline information for wood identification, taxonomy and ecological studies. Furthermore, the favourable anatomical characteristics and moderate-to-high wood density suggest that *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders has good potential for small furniture, interior joinery, decorative wood products, and other value-added timber applications.

Micrographic description of wood *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders

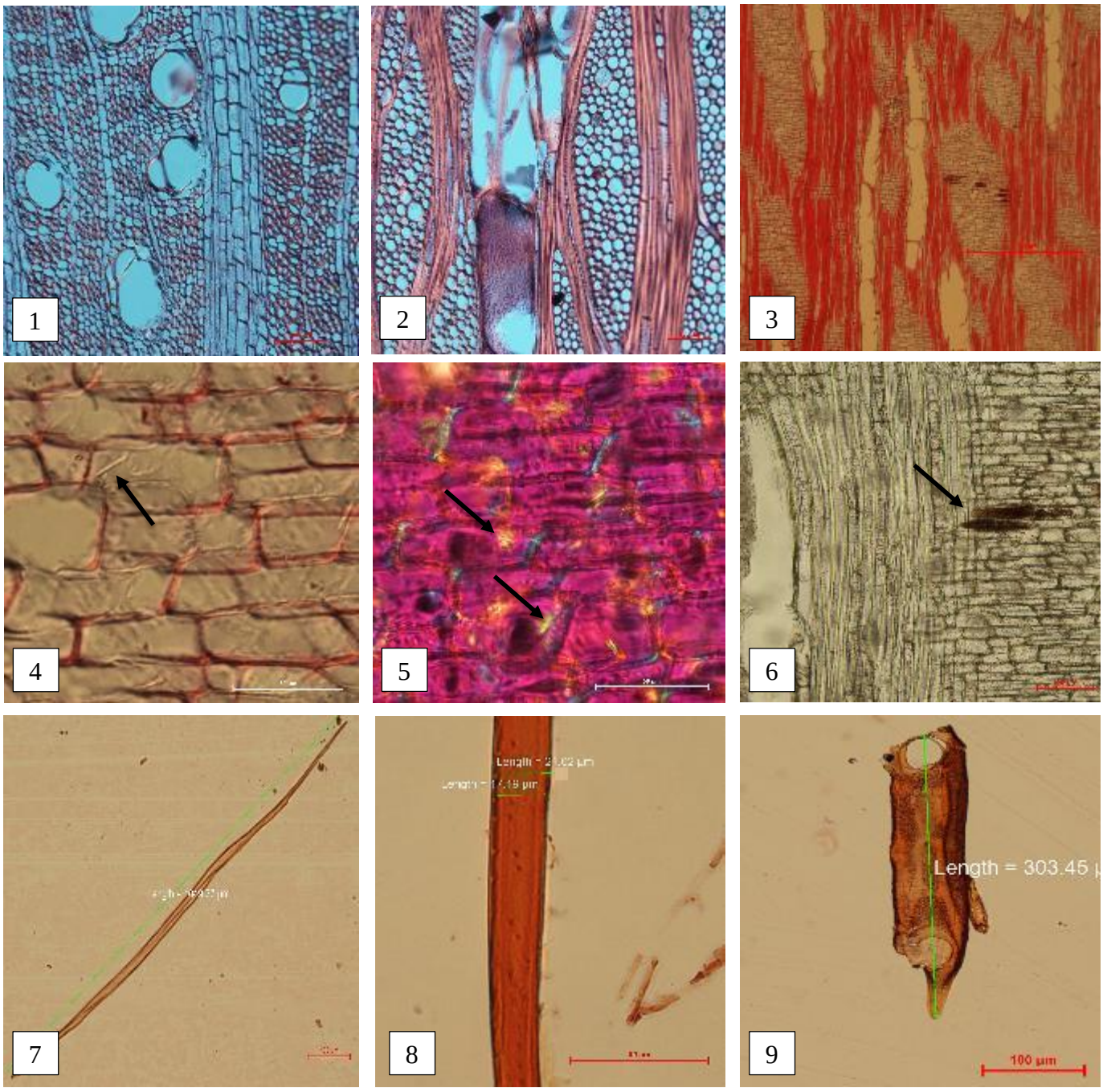

Plate 1: Fig (1) – Fig (9) *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders

(1) cross section (10x), (2) tangential-longitudinal section (10x), (3) radial-longitudinal section (10x), (4) acicular crystal in ray cells (50x), (5) crystals of other shapes in ray cells (50x), (6) suspected tanniferous tubes in ray cells (20x), (7) fibre (10x), (8) widest portion of fibre (50x), (9) vessel element (10x).

Density and Specific gravity of wood samples:

Table 2: Data of density and specific gravity calculation for the samples of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunder

SAMPLES	W_i (g)	W_{Hg} (g)	W_o (g)	Volume (V)	Density (g/cm^3)	Specific Gravity (S.G.)
ML – 1	5.57	124.12	4.13	9.146	0.609	0.451
ML – 2	7.18	132.28	5.96	9.747	0.736	0.611
ML – 3	10.95	163.40	7.40	12.04	0.906	0.614
ML – 4	9.79	203.39	7.66	14.98	0.653	0.511

CONCLUSION

The present study shows that *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, exhibits a uniform wood anatomical structure across different geographical locations despite minor variations in quantitative anatomical and physical characteristics. The observed differences in traits such as vessel dimensions, fibre characteristics, crystal composition, density, and specific gravity indicate the influence of local environmental conditions on wood development, while the stability of the qualitative anatomical features reflects unique identification character. These findings confirm the reliability on wood anatomical characters for accurate species identification and taxonomic classification. Furthermore, the study provides a valuable anatomical database that can support wood authentication and future comparative studies within the family Annonaceae. The information generated also contributes to a better understanding of intraspecific wood variation and may assist in the sustainable utilization and scientific management of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders, as an economically and ecologically important tree species.

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