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STRUCTURAL CHARACTERISATION OF 18TH CENTURY INDIAN PALM LEAF MANUSCRIPTS OF INDIA

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Abstract

This paper's aim to characterise the 18th CE Palm leaf manuscript of India`s southern and eastern part based on its structural elements. Investigative studies were carried using polarised light microscope and stereomicroscope for the samples drawn from Indian states of Kerala, Tamil Nadu and Odisha. From the data, it is observed that the palm leaf species of Borassus and Corypha mostly drawn from southern and eastern states of India were extensively exploited for manuscript writing in whole of India. The microscopic observation also showed the weak zones present in the palm leaf manuscripts for suitable conservation measures.

Keywords*: Palm tree; Corypha, Borassus; Palm leaf manuscripts; Anatomy; Deterioration; PLM; Isolateral; Dorsiventral.*

Introduction

Palms are an unbranched evergreen tree which belongs to tropical and warm regions. The characteristic feature of this tree is that it is crowned with a long feathered or fan-shaped leaves. They typically have old leaf scars forming regular pattern on the trunk and belong to Arecaceae or Palmae family. Arecaceae are a botanical family of perennial lianas, shrubs and trees commonly known as palm trees [1].

Palm trees are flowering plants and are a family in the monocot order Arecales. Currently 181 genera with around 2600 species are known [2], most of them restricted to tropical, sub-tropical and warm temperate climates. Palms are distinguished by their large, compound, evergreen leaves, arranged at the top of an unbranched stem.

For identification purpose, palms can be divided into two major groups:

- Palmate or fan-shaped leaves
- Pinnate, or feather shaped leaves.

They both are different from each other. Palm species are characterized by a leafy structure in which all leaf segments arise from a single point whereas pinnate leaves are characterized by leaves along both side of a central axis.

The leaves of the palms are either arranged at more or less distant intervals along the stem, as in the canes, or are approximated in tufts at the end of the stem, thus forming noble crowns of foliage which are so closely associated with the general idea of a palm. In the young

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condition, while still unfolding, these palm leaves with the succulent end of the stem from which they arise; form "the cabbage" which in some palm species is highly esteemed as an article of food [3].

Leaves in the Palmae have a characteristic aspect but are diverse in size, shape and division. Most have a sheath, petiole or leaf stalk and blade. Sheaths sometimes are elongated or tubular and when they appear to form a continuation of the stem, they are referred as crownshaft [4]. The petiole is discernible above the sheath as a supporting axis devoid of leaflets. The terminal portion or blade of the palm leaf is always plicate and may be either pinnate (feather like) or palmate (fan like). It is also noticed that leaves are sometimes armed with spines or marginal teeth on sheath, petiole, or blade or all parts. The leaf axis in a palm is divided into 3 components: a basal sheath which is always a closed tube; a longer or shorter petiole; the combination of the axis as the rachis into the segmented blade [5].

Hence, the sheath can be seen as a barrel which supports the distal part of the leaf by clasping the stem, accommodating the considerable expansion of enclosed leaves while long petiole is a flexible tapered cantilever that extends the blade away from the axis in order to reduce drag and mutual shading. Leaf bases in palms are initially hollow. The leaf sheath in the beginning is a closed tube but in due course of time, it normally thickened on the Doral side (corresponding to the side below petiole) and thinner on the ventral side (the side opposite the petiole) [6, 7].

Epidermal cells are distributed in longitudinal files. Unlike hypodermis, epidermis is always shallow and flat, and the outer wall is sometimes papillose. It is also considered as a protective layer against water loss and infestation against insects. The epidermis of the palm leaf is protected by outer deposits of polymerized lipids (fatty) substances, which have hydrophobic properties. Two distinct layers are present:

- Epicuticular waxes which are secreted through the outer wall of the epidermis and form a distinct outer loose layer which is easily detachable.
- A Cuticle: Cutin is secreted into the outer epidermis where it accumulates to form the cuticle but cannot be detached as it impregnates the cellulose wall layers [7, 8].

Another important feature in anatomy of palm lamina is Mesophyll. It is primarily the photosynthetic tissue of the palm lamina. It is also the ground tissue that supports veins and fibre bundles.

Another crucial feature is vascular bundle. The function of vascular bundle is to transport the substances every day. It has further partition, i.e., Xylem, which is a thicker cell walls and it helps in transporting water to other parts. The second part is phloem whose task is to transport sugar from photosynthesis to other parts. These two parts are covered by bundle sheath in a circular form, followed by on both upper and lower side of vascular bundle, there is a bundle sheath extension [6]. There is a strip of ground tissue between vascular bundles and epidermis in leaf which can be hypodermal and consist of parenchyma, collenchyma and sclerenchyma. Their role laid in the stabilisation of tissue and protection of substances [9].

Origin and Nature of Samples Collected

Palm leaves have been one of the medium of writing in India since several centuries ago. Our forefathers have used various traditional methods, materials and techniques in processing and preserving these leaves in the form of writing medium which we called as 'Palm leaf Manuscripts.' Writing on Palm leaf manuscripts differ with region to region. Northern India has particular method of writing whereas in Southern India; people adapt a different technique which is similarly practiced in Southeast Asian countries. In general, there are two major techniques used for writing on palm leaf manuscripts [10]. One by brush and other by incising with iron stylus and later on enhancing the colour by rubbing the charcoal powder or any other required pigments. Hence, along with the prepared palm leaves, a complete writing kit consisted of a stylus, a knife and the scribing compass for cutting the holes. These tools were usually kept together in a metal sheath like holder [10].

From previous studies (Agrawal, 1986) it has been identified that India has two kinds of Palm genera which are extensively found, they are, *Coryphae* and *Borassus* [12]. It was also observed that both occur in few pockets of southern and eastern India respectively. The aim of structural characterisation of these two genera is to scientifically prove their origin as per the earlier studies.

To fulfil the above-mentioned objective, few sets of samples were collected from various parts of India. Some samples were collected from Odisha (illustrated) whereas some were collected from Kerala and Tamil Nadu (Non-illustrated). The samples were collected from various institutes like state archives, Bhubaneshwar, Odisha, State Archives and Oriental Research University, Trivandrum, Kerala, and from other private individuals. Among these set of samples, some were original and old, whereas rest of them were new and treated as reference sample. The condition of few samples was unstable. It showed signs of deterioration like adherence of dust and dirt, insect attack possibly biscuit beetle, loss of edges, cracks, stains, holes, brittleness and blackening of the surface [13]. These samples were thoroughly documented after collecting from various organisations and individuals. While documenting these manuscripts, it was found that the name of the artist and date of origin were unknown to the respective owners or organisations.

The leaves in form of samples were collected from various parts of India with a motive to find how these species look like. Does the anatomy play an important role in the strengthening or weakening of these leaves? How does the anatomy look in both cases of *Corypha* and *Borassus*? Do they differ from each other? Does this anatomy help in identifying the recipients of deteriorating agent? The answer to these questions can exclusively be found in the structural characterisation of the leaves.

Experimental

The samples, as above mentioned were collected from various parts/ repositories in India. The collections were at first documented through photographs and stereomicroscope images. The next course was to examine the palm leaf for structural characterisation. The experiments for structural characterization were carried both at the laboratories of National Museum Institute, New Delhi, India and University of Applied Arts Vienna, Austria. Experimental procedure of thin section was planned and laboratory protocols were developed in order to produce reference material and compare it with samples under Polarised Light Microscope (PLM). Hence, thin sections were planned to be prepared for supporting the further examination.

The details of the samples collected and their origin is shown in Table 1. The reason for marking in such format is to characterise and examine them as per their region so that the results and interpretation of the same can be prepared accordingly.

Table 1. Details of the samples and their origin

Sl. No	Sample No.	Origin
1.	KP1, KP2, KP3	Kerala
2.	TP1, TP2, TP3	Tamil Nadu
3.	OP1, OP2, OP3	Odisha

To commence the analysis, a strip of almost 2x3cm was taken from all samples and the strip was soaked in 50:50 mixture of Ethanol and Distilled water for more than 24h.

The thin sections were prepared in the laboratory of University of Applied Arts Vienna, Austria:

a. As palm tissues are heterogeneous in nature, the prepared sections are easily crumbled. Therefore, a strip was taken from water and alcohol solution leading to freehand sectioning. It included the process which corresponds to the cutting of material with

razor blades. This process can be liberal because it can yield best results. Many transversal sections were prepared which was immersed in water.

b. The sections were bleached in Sodium hypochlorite (10% NaOCl) for 3-5 minutes until it becomes yellowish in colour. This process helped in removing the pigmentation, unwanted cell contents and clarifies tissue distribution.
c. The sections were washed with several changes of water so that the remains of the bleaching agent get wash.
d. The Sections were stained by immersing in a mixture of one litre staining agent (which constitutes 20mL acetic acid, 0.1g Fuchsin, 0.143 g Chrysoidin and 1.25g Astra blue per litre of aqueous solution) [14] for 4- 5 minutes. he staining agent was used to contrast different constituents of the plant tissue i.e. for cellulose content change the colour to blue, lignin turned to purple whereas for all lipophilic substances like suberin, cuticle waxes, etc, turned yellow.
e. This was followed by rinsing of the thin sections in water.
f. Mounting was done in 2:1 glycerol to water under a cover glass that can be stored for a longer period.
g. For observation of structure of leaf, an Olympus microscope (Nikon Eclipse ME600 with Fluorescent attachment- Nikon Y-FL 078252) with polarised light was used. Macroscopic images were taken by using well-fitted Nikon D 200 camera at the laboratory of National Museum Institute, New Delhi, India.
h. Few sets of frames were recorded from the specimens for clear and comparative study of both the genera.

Results and Discussions

As previously discussed, there are several sub-families of palm but for this particular study, the concentration is on the two genus of palms i.e, *Corypha* and *Borassus*. There are two types of leaves based on the manner of their orientation, as under [7, 14]:

a. Dorsi-ventral leaves which usually orient at an angle to the main axis and held perpendicular (normal) to the direction of sunlight (e.g. - Leaves of dicots). The upper or dorsal face is adaxial and has a thicker cuticle.
b. Iso-bilateral leaves which usually orient parallel to the main axis and held parallel to the direction of the sunlight. (E.g. leaves of monocots). An Iso-bilateral leaf is unusually vertically oriented to expose both surfaces to the sun. They have equal numbers of stomata in matching quantities and surface qualities of cuticle on both faces of the leaf.

The former is quite common as compared to the latter one. The accurate illustration and interpretation can be achieved from transverse sections rather than longitudinal sections. In Dorsi ventral symmetry, upper (adaxial) and lower surface (abaxial) are unequal with stomata largely restricted to the abaxial surface with the upper and lower mesophyll layers dissimilar. In Iso- lateral symmetry, stomata are equally distributed on upper and lower surfaces and upper and lower mesophyll layers are also similar [7].

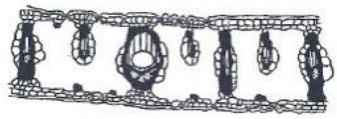
As per the literature, *Corypha* is dorsi-ventral in nature whereas *Borassus* is both Iso-bilateral as well as infrequently dorsi-ventral in nature [7]. To proof it further, the samples from various regions were taken and anatomical structural analysis carried out.

Under Polarised Light Microscope (PLM) examination of palm leaf thin sections, it clearly showed that the anatomical structure of the leaf is Iso-bilateral in nature. It has been further confirmed that the major difference between two species is the manner of orientation [7]. While examining under PLM, it is quite easy to identify a *Corypha* species because they have one sided orientation whereas *Borassus* species are quite confusing because they can have both sided orientation i.e., Iso-bilateral as well as Dorsi-Ventral form. On the other hand, the anatomy was being referred to the reference images from two books. One by *P.B. Tomlinson*

on the "*Anatomy of the Monocotyledons*" published in 1961 and other one was by *Jack B. Fisher, James W. Horn and P.B. Tomlinson* titled "The Anatomy of Palms: Arecaceae-Palmae published in 2011 [8]. The sample specimen collected from Odisha and Kerala were observed that they belong to the *genus Borassus*.

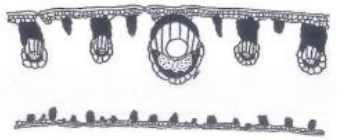
To further confirm the result of the above-mentioned analysis, it was needed to cross-refer it with similar kind of species**.** Therefore, similar specimens were made available by an artist from Kolkata, India. Further observing the reference sample under PLM, it has been found and interpreted that this structure belongs to the genus *Borassus*, i.e. *Borassusflabellifer* (Table 2).

Table. 2. Thin sections of samples from Kerala and Orissa, India [15] and reference image from the herbarium of Vienna University

Category Observations Sections	Lamina Almost Isolateral Transverse
Ref images of Borassus from Tomilinson (1961) [16] Page 386	
Ref images of Borassus from Tomilinson (2011) [5] Page 163	
Ref sample images from Kerala, India	
Ref sample images from Odisha, India	
Ref sample images from Freshly prepared manuscripts from Kolkata, India	

On the other hand, the samples from Tamil Nadu examined under PLM had a transversal stained section which was found dorsi-ventral in nature. The cross-section showed one-sided orientation. Hence it has been concluded that this specimen belongs to the genus *Corypha* (Table 3).

Table. 3. Thin sections of samples from Tamil Nadu, India [10]

Category Observations Sections	Lamina Dorsiventral Transverse
Ref images of *Corypha* from Tomilinson (1961) [11] Page 419	
Ref images of *Corypha* from Tomilinson (2011) [8] Page 155	
Ref sample images from Tamil Nadu, India	

On the other hand, under Polarised Light Microscope it has been found that few fibres were broken from few areas. The possibility of broken edges on the leaf probably may be due to the usage of iron stylus for writing. As mentioned earlier iron stylus has been used as one of the medium for writing. As the palm leaf has been etched during writing there is a great possibility that layer beneath gets affected and fibres slowly loosened. Therefore, this practice of writing somewhere affects the strength of the medium of writing.

Conclusion

The anatomical data played an important role in taxonomic identification of the Palm leaf manuscript. This study helped in taxonomic identification of palm leaf manuscripts collected from various parts/repositories of India. The study revealed that the *Borassus genus* has both Iso-bilateral as well as Dorsi-ventral anatomical structure, same observed in the Palm leaf samples collected from Kerala and Orissa, while *Corypha genus* having Dorsi-ventral anatomical structure as seen in the samples collected from Tamil Nadu respectively. Through this research work, one can easily distinguish between palm species available in India through structural characterisation. Another finding was that the usage of Iron stylus on the leaves somewhere affects the fibres of the leaves and further weakened it.

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