CHAPTER – 1

1. Introduction

Arecaceae Bercht. & J. Presl (Palmae) is the oldest and early divergent monocotyledonous family and mostly extend in tropical and sub-tropical parts across the earth (Janssen and Bremer 2004; Dransfield *et al.* 2008). Palms family with its six sub-families (Coryphoideae, Calamoideae, Nypoideae, Ceroxyloideae, Arecoideae, and Phytelephantoideae) are relatively abundant in tropical and sub-tropical ecosystem and was evolved around 80 million year back (Pitman *et al.* 2001; Dransfield *et. al.* 2008; Morley 2000). Members of this family exhibit more than 2400 species and showing amazing geographical variation in species richness, phylogenetic composition and life forms (Govaerts and Dransfield 2005) and are quite adaptive with various climatic conditions and shows wide range of habit groups including climbers, shrubs and trees commonly known as Palm trees or Palms. Palms are one of the multi-use monocots confined to tropical regions of the world and are significant to rural communities for their various economical uses as building materials, food, fuel, medicine, fabric, ornamental and horticultural importance. They play a vital role, in some way or other, in everyday lives of people, especially in Asia and Africa (Renuka 2011). Various important products like food, oil, wax, fibre, dye, sago, sugar etc. are derived from palms and a large number of palms species are also widely used in beautification and landscaping (Basu 2013). For the world's food source three most important plant families are grass family (Poaceae), the legume family (Fabaceae) and the palm family (Palmae or Arecaceae). The utility of these three plant families are known to human kind since the ancient time (Basu *et. al.* 2014). Palms are undoubtedly the most attractive group among the angiosperms and draw better attention to both the botanists and horticulturists (Basu 1994). The beauty and elegance of palms are also no less important than their traditional and commercial values. The dried fruits, bracts, prophyll and leaves of some palms are also very decorative, therefore, used for vase decoration. The grandeur and elegance of palms would compel; anyone to agree with Carl Linnaeus who eulogized palms as the *Princes of the vegetable kingdom.*

Palms are characteristic by its woody appearance and grouped under monocotyledonous plants with distinctive features in their functional organs like root, stem, leaf, inflorescence, flower, fruit and seed and in their process of seed germination

(Basu *et. al.* 2013; Mondal *et al.* 2017). The Palmae (Arecaceae) is a botanical family of perennial climbers, shrubs and trees commonly known as palm trees includes 212 genera and 2779 species (Moore 1973). The number is changing rapidly as taxonomic studies have been progressed on this family. Govaerts and Dransfield (2005) estimated a revised list of Palms that includes 190 genera and 2364 species. Recently a new genus *Dransfieldia* was published by Baker *et al.* (2006).

1.1. Fossil Records

The fossil records of Arecaceae are both rich and widespread. Chronologically, the expanding and retracting distribution of fossil palms records in higher altitudes has been valuable indicator of global climate change, particularly cooling facts during the early Miocene. Entire Africa and the subcontinent of India possessed much richer fossil record of palm floras. Leaves, stems and pollen etc. are particularly abundant in the fossil bed, but there are also records of fruits and seeds, roots, rhizomes rarely, inflorescences rachillae or individual flowers (Madeline and Harley 2006).

All fossil records for the Arecaceae were extraordinarily rich and diverse and were present in late Cretaceous and from the earliest Tertiary (Palaeocene) until the cooling events of the Miocene. For the majority of palm fossils, the lack of distinctive morphological variation in organs frequently limits the possibility of inferring affinity to taxonomic units below the family level. Pollen records of palms were exceptionally numerous and problematic and over 50 fossil pollen genera with a clear or suspected affinity. The earliest palm fossils from the late Mid-Cretaceous to early upper Cretaceous with costa-palmate leaves were *Sabalites carolinensis* (Berry 1914) discovered from the late Coniacian–early Santonian of South Carolina to the Santonian in New Jersey (USA), *S. magothiensis* Berry, (1905, 1911) and *Sabalites longirhachis* Kvadek and Herman (2004) from the Lower Campanian of Austria. First palm fossils with pinnate leaves described from the Lower Campanian of Northern Montana was *Phoenicites brongniart* (Crabtree 1987).

At the other end of the geological time scale, almost all described fossil stems palm have been included in the single genus *Palmoxylon* (Madeline and Harley 2006). The primitive recorded stems palm fossil were *Palmoxylon andegavense* Crie and *P. ligerinum* Crie (1892) from France and *Palmoxylon cliffwoodensis* Berry from the Coniacian–Santonian of New Jersey (Berry 1916). *Palmocarpon luisii* was the first

recorded fruits fossil from the Upper Cretaceous in Brazil and the Early Palaeocene of Greenland (Maury 1930; Koch 1972). Records of *Nypa* fruits (*Nipadites*) were found in the Palaeocene of the Gulf Coast states, US and North-East Africa (Chandler 1954; Dolianiti 1955; Gregor and Hagn 1982). Rhizomes palm fossil *Rhizopalmoxylon huepaciense* Cevallos Ferriz and Ricalde–Moreno, *R. teguachachiense* Cevallos Ferriz and Ricalde–Moreno were discovered from Upper Cretaceous–Palaeocene (Ferriz and Ricalde-Moreno 1995) of Northern Mexico.

In India very few palm leaf fossil have been recorded from the various Karakoram mountain ranges of Himalaya of Ladakh part and most of those fossil formations were of middle – late ecocene. *Livistonia wadiai*, *Palmacites khariensis*, *P. tsokarensis*, *Trachycarpus sp* were some of the significant Indian palm fossil discovered from various strata of Jammu and Kashmir (Lakhanpal *et al.* 1983).

1.2. Morphology of Palms

Palms and rattans species are quite different in their morphological features from rest of the monocotyledonous species. Morphologically all the functional organs of these group are relatively distinctive in appearance and structure, therefore some explanation is necessary to aid in the understanding of the group. The structure of palms and its various parts (Fig.1) are described below.

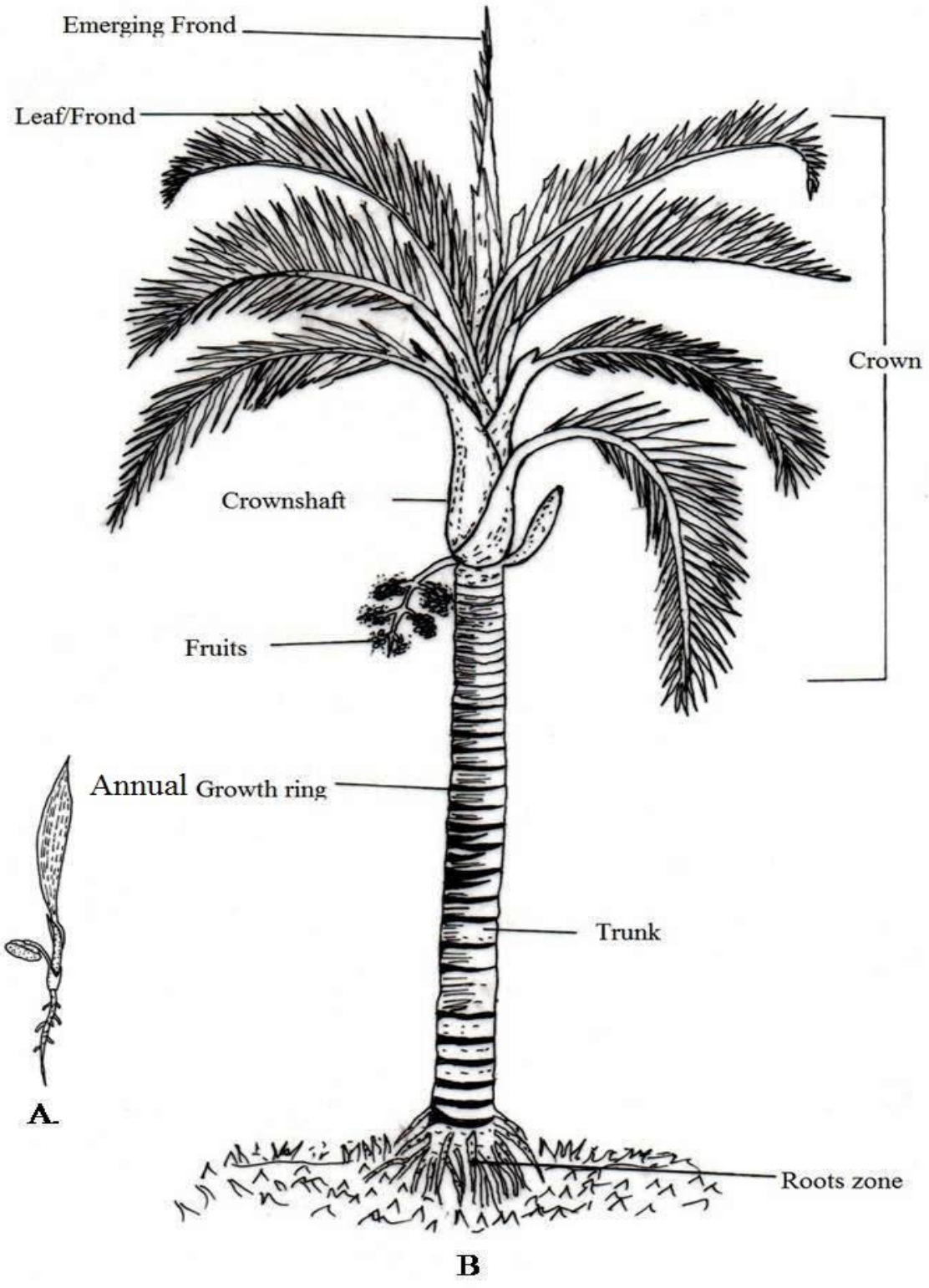


Fig. 1: A & B. Structure of palms with seedlings

1.2.1. *Roots of Palms*

The roots of palms originate from the base of the trunk and as in other plants perform the essential function of holding the plant to the soil and to absorb water and nutrients from the soil. In single stemmed palms primary root developing from seed. Secondary roots develop

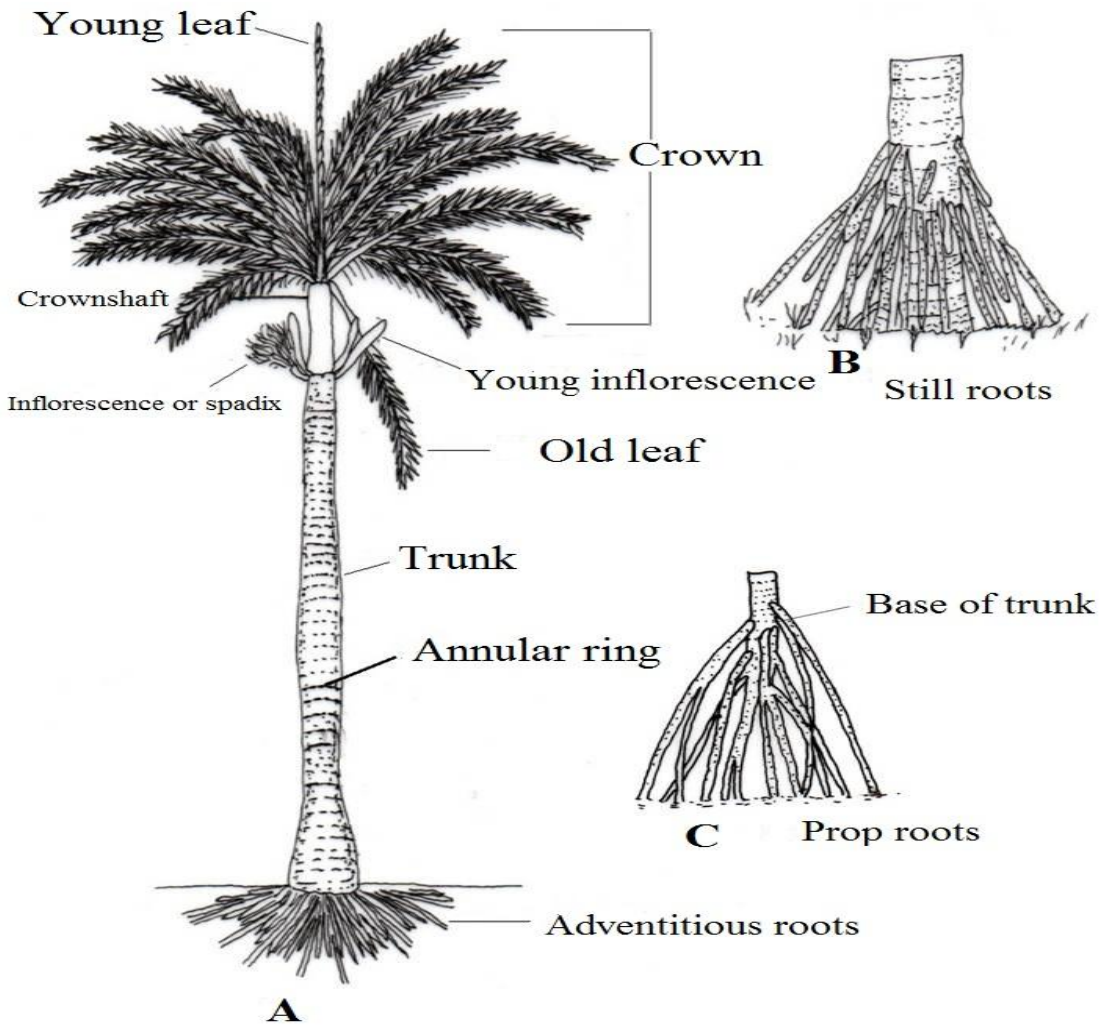


Fig. 2: A. B. & C. Root types of palms

from the base of the stem just near the soil surface and also termed as adventitious roots. In clump forming palms adventitious roots (Fig. 2) develop from each of the stem in a clump. The root system may be crowded or sparse, short and stubby or may wander for a considerable distance. In some palms roots may be visible at the base of the trunk above the soil surface. These aggregated roots above the soil make a big or small '*bole'*

at the base of the stem or trunk as seen in *Borassus flabellifer*, *Cocos nucifera, Areca catechu, Caryota obtusa, Caryota urens, Caryota maxima* etc. Some palms like *Vershaffeltia splendida* of Seychelles produce stilt roots. Adventitious roots may develop on stem high above the ground level by cracking the hard skin of the stem, a common feature seen in *Cocos nucifera.*

1.2.2. Habit form of palm's stem and Branching pattern

The trunk or stem is very important diagnostic part of the palm group for identification (Fig. 3). In all there are five groups of palms which can be recognized depending on their trunk, but of these two are of major significance and accommodate the majority of the species. These are palms with solitary stem and those which produce multiple stems in a clump forming habit. The other forms are branching trunk, and palms with underground stems and those which are climbers. Palms have a woody stem which gets taller as the palm gets old. The stem bears the terminal or apical meristem by which palm grows.

This apical actively growing zone is well protected within the growing zone by the very young developing leaves with their sheathing base. In palms, all tissues are formed by the activity of the terminal bud (meristem) and this is the reason why palm stem does not grow in length until it attains its maximum girth. In spite of no secondary meristemetic activity in the stem, a number of palm species increase their girth of the stem by the expansion of the ground tissue together with the expansion of the fibrous tissues which constitute the sheath of the conducting tissue. The single stemmed palm in some species after some growth branches aerially and appear as a multi headed tree *Hyphaene dichotoma* (Doum palms) as seen in the West coast of India. Aerial branching and adventitious development of roots are the most distinctive characteristic of *Plectocomia himalayana* an important cane species of West Bengal. The striking feature of this species is the formation of bulbils shoots at the proximal part of the lower internodes with the development of adventitious roots. Under abnormal condition a normally single stemmed palm may also produce several axillary shoots in place of inflorescences. These shoots may die in course of further growth or grow into axillary branches as seen in *Phoenix sylvestris, Cocos nucifera, Borassus flabellifer, Phoenix rupicola, Arenga pinnata* etc.

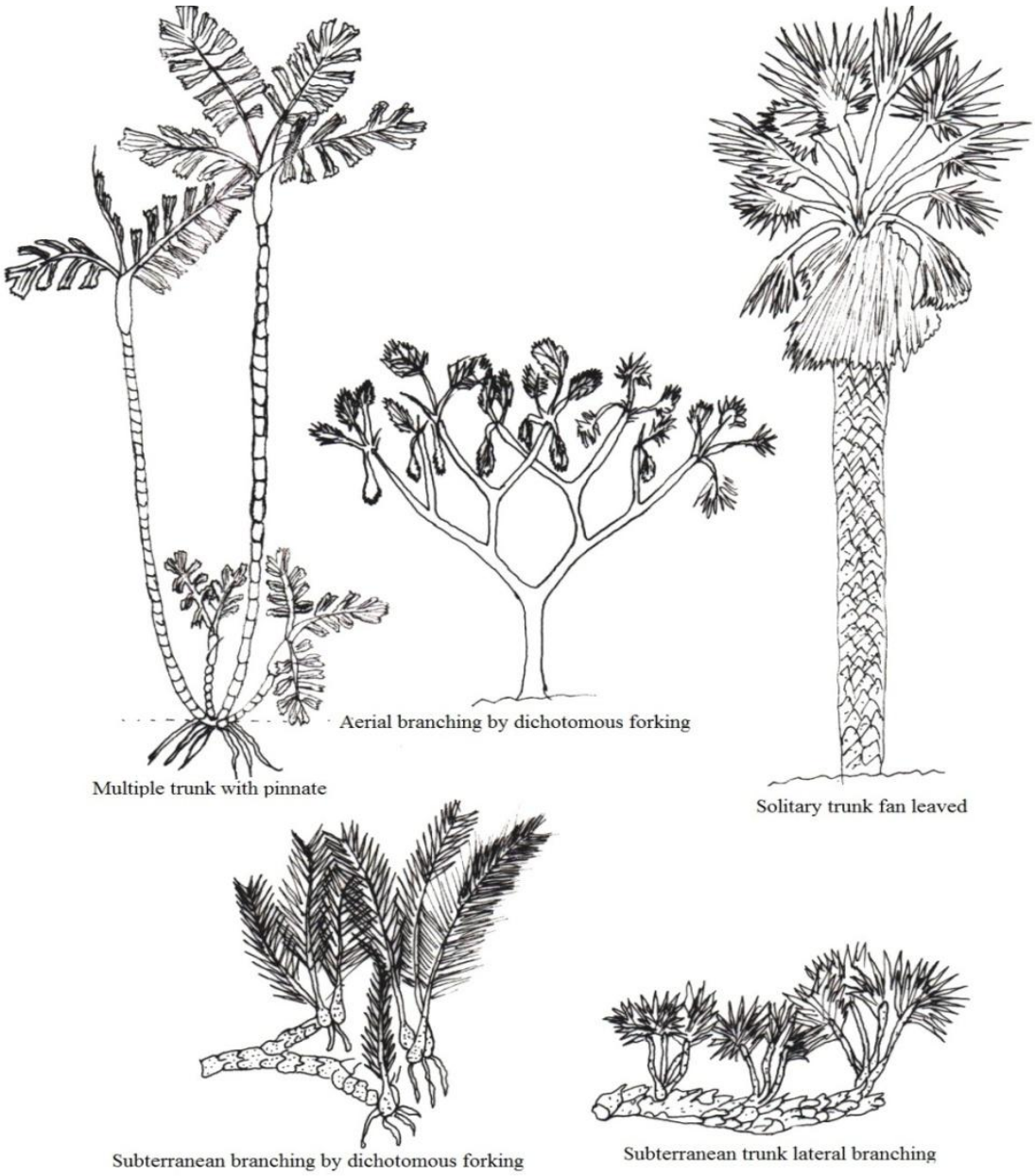


Fig. 3: Growth habit of palms

In rare situation external injury to the apical meristem by lighting or by other injury divide the apical meristem and that result in the development of branches. This unusual branching was reported from *Cocos nucifera* and *Borassus flabellifer* (Davis 1949). There are some palms whose stem grows underground and their leafy crown is visible above the soil thus the palm becomes acaulescent in appearance as seen in *Phoenix acaulis.* The underground stem in *Salacca* palm grows horizontally producing rosette shoots above the ground. In some palms the underground part of the stem throws out

aerial shoots from the dormant axillary buds and by the repeated development of axillary shoots from below the ground the palm appears tufted with multiple stems. In some palms the axillary shoots below the ground level do not come above the soil close to the main stem but grows away horizontally below the ground and appear at a distance as an erect shoot. This phenomenon was observed in the native palm *Pinanga disticha.*

1.2.3. Cirrus and flagellum

The climbing habit in palms (Fig. 4) is special adaptation for surviving in the tropical rain forests and seen in some groups of palms in the eastern and western tropics. All climbing

Fig. 4: Climbing habit of rattans

palms have long slender aerial stem with long rounded internodes. The cirrus and flagellum are special climbing organs by which climbing species of canes fix itself on a support (Fig. 5). Cirrus is a whip like extension of the leaf rachis and is armed with a series of spines, hooks and claws. All members of *Daemonorops* and *Plectocomia* and some species of *Calamus* are cirrate. A flagellum is the whip like appendage similar to cirrus,

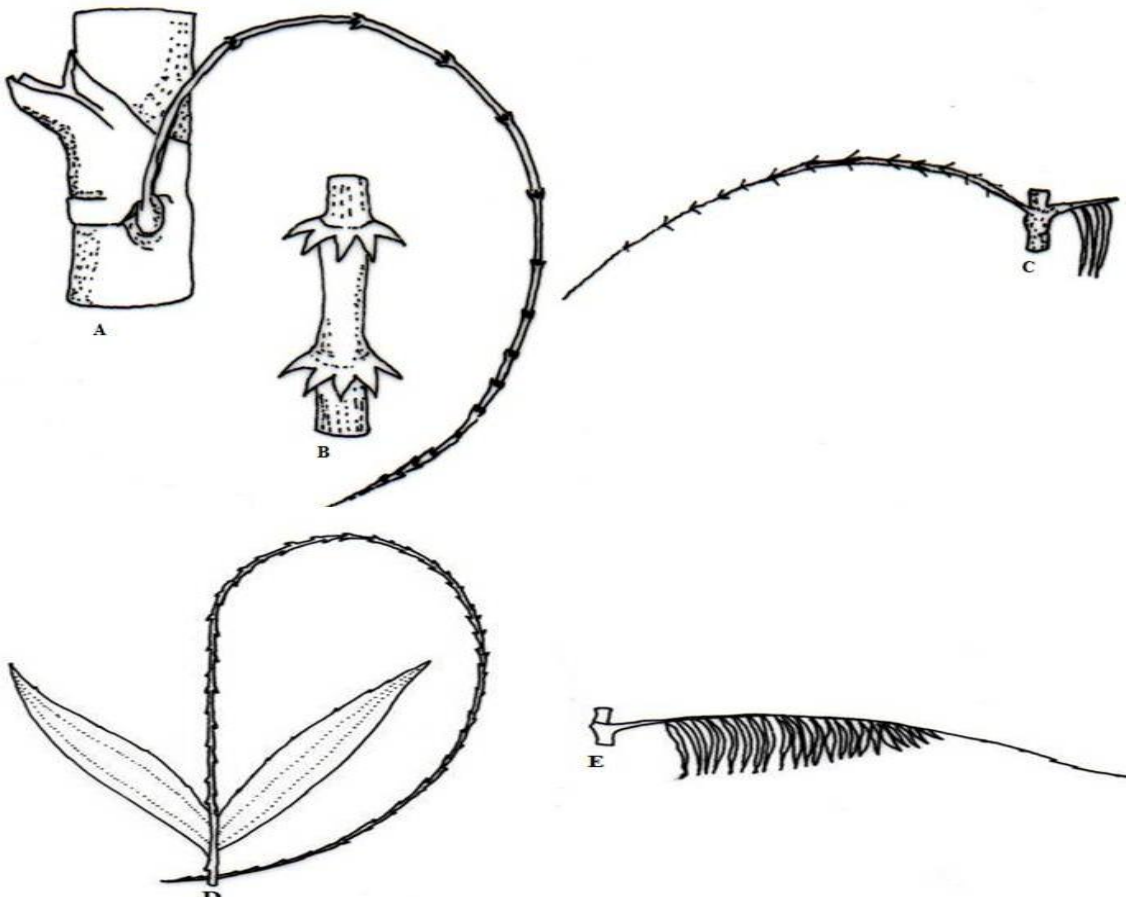


Fig. 5: A, B & C. Flagella; **D & E.** Cirrus

but originating from the uppermost part of leaf sheath. A flagellum is known only in some species of the genus *Calamus*. Morphologically a flagellum is a sterile inflorescence. Interestingly a leaf sheath does not produce both a flagellum and inflorescence. In *Calamus flagellum* of West Bengal, the flagellum is robust, very heavy and armed with hooks and claws and reaches to a length of seven meter or more. The non-climbing *Calamus erectus* and *Calamus pseudoerectus* of this region has no flagellum or cirrus. The two climbing organs, cirrus and flagellum do not occur in a species, however there is exception too. Apart from the cirrus and the flagellum, prickles and claws, hooks and spines on the axial portion of the inflorescence are also associated with the climbing. The cane species with erect habit like *Calamus erectus* does not have strong claws, hooks or definite organs for climbing. Its growth form could have multiple origins within the Calamoideae, appearing at least twice during

evolution (Baker *et. al.* 2000). It is still a matter of study how large bodied canes lacking secondary growth have adopted a climbing habit.

1.2.4. Shapes of palm leaves

Palm leaves have two basic forms, the pinnate form and palmate form (Fig.6 & 7). In some

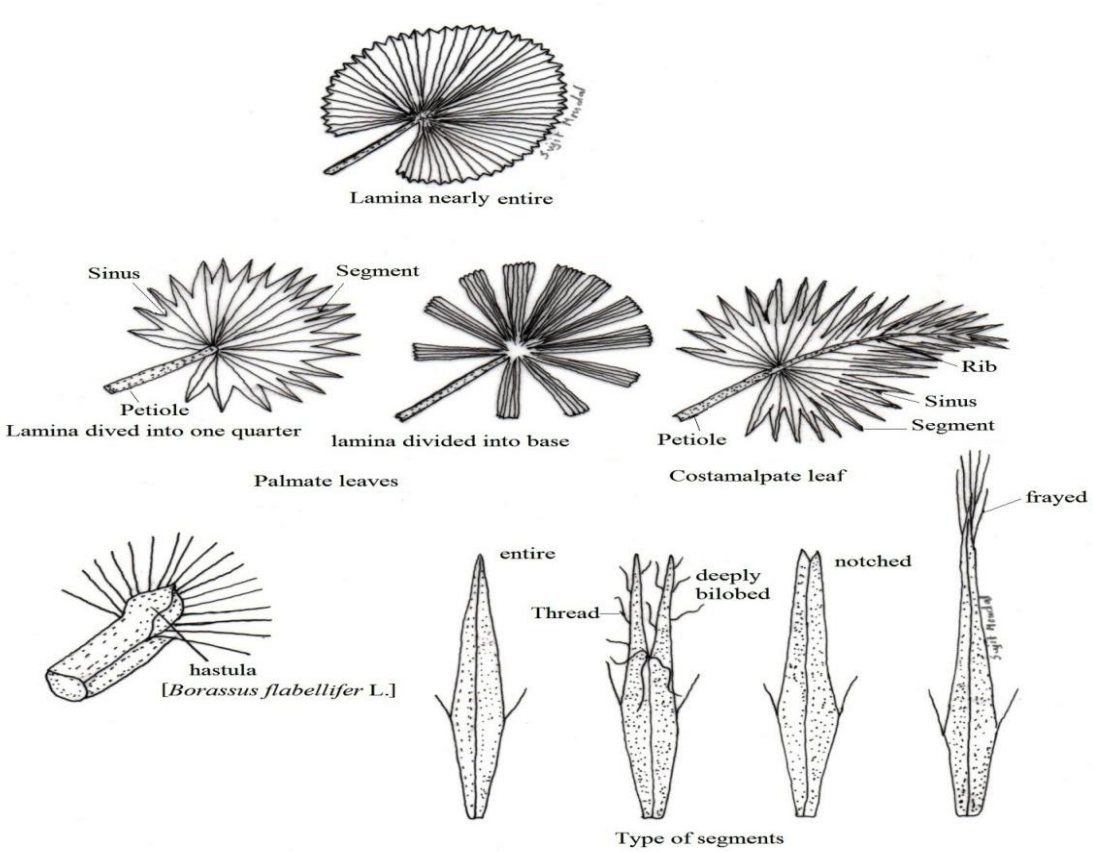


Fig. 6: Features of palms leaves

palmate leaves petiole axis extends into the leaf blade, thus the flat blade curves outside, this type of curved palmate leaves are termed as Costa palmate leaves. The lamina or the leaf blade of palmate leaved palms are half rounded or rounded and divided into many segments. The leaf division in palmate leaves is called segments. The leaf blade may be variously divided with some species being entire and barely notched along the margin as seen in *Licuala grandis* in other the leaf blades are variously divided to more than two third of the length of the blade as seen in *Livistona jenkinsiana*. A few fan leaved palms produce long thread from the junction of the segments and along the margins as seen in the leaf of *Borassus flabellifer*,

Washingtonia filifera etc. Rattans leaves are mainly pinnate, large and spirally arranged on the stem. The pinnate leaf is generally recognized into three or four parts *i.e.*, sheath, petiole, laminar and cirus. Bipinnate of fishtail palm (*Caryota sp.*) leaves are peculiar and very much characteristic of the genus *Caryota.* Here the leaves are twice pinnate and ultimate foliar units are wedge shaped.

1.2.5. Folding of palm leaves

Leaflets in pinnate leaves or leaf segments in palmate leaves are folded at their point of attachment with the rachis or at the tip of the petiole. This folding may be 'V' with the main nerve below (induplicate) or folded like a reverse 'V' reduplicate with the main nerve above. Induplicate folding is common in all Date palms and seen in almost all palmate leaves and partially in leaves of *Arenga, Caryota* and *Wallichia* palms (Fig. 7). Reduplicate folding with main nerve above is common in Arecoid and Cocosoid palms and seen in *Areca catechu, Areca triandra, Cocos nucifera* etc.

1.2.6. Eophyll

The first foliage leaf of a palm seedling is termed as "*eophyll*". Its shape is varied and consistent which on turns offers a good diagnostic character. The simple form of eophyll is elongated, tapering and entire, occurs mostly in Coryphoid palms and in some genera of Calamoid and Arecoid palms and some Royal Palm. Eophyll is bifid in most palms with reduplicately folded leaflets in adult leaves. Eophyll is pinnate in most genera of Cane species and in genera *Latania* of Borassoid group and *Rhopaloblaste* of Arecoid group of palms. In *Nypa fruticans* eophyll is imparipinnate.

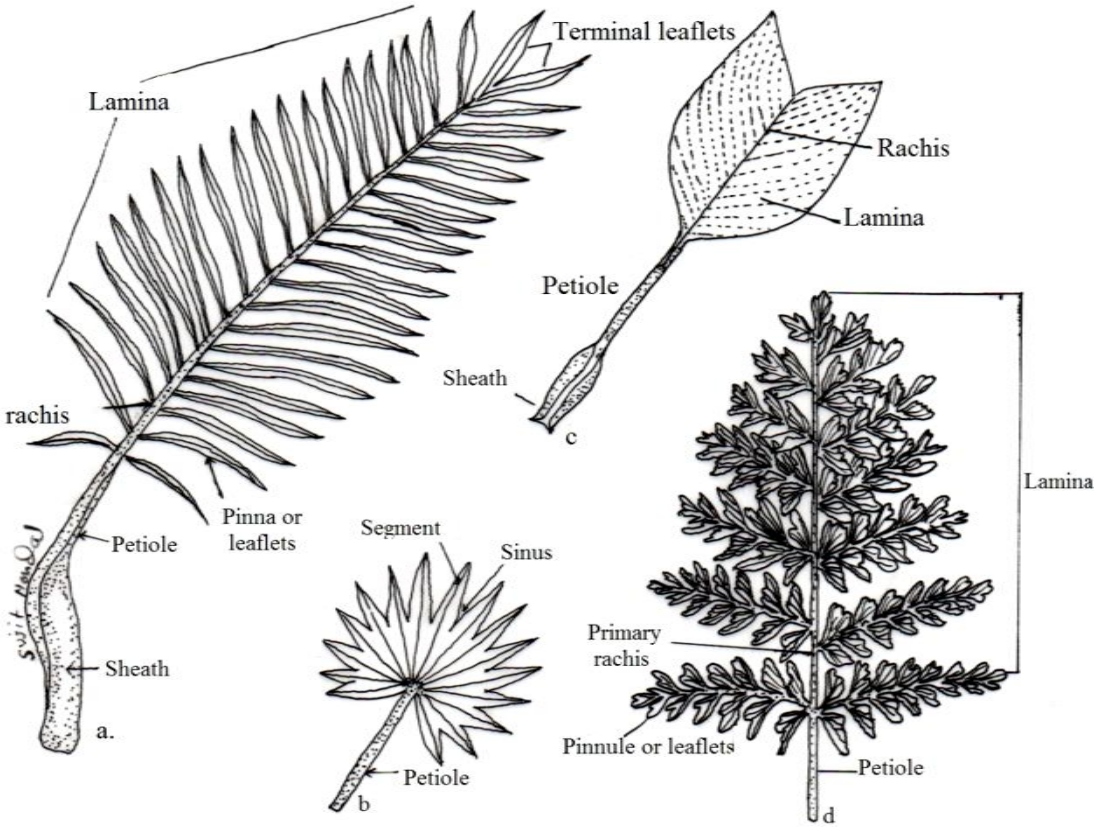


Fig. 7: Major type of palms leaves; **A.** Pinnate; **B.** Palmate; **C.** Entire; **D.** Bipinate

1.2.7. Inflorescence

Palm flowers are displayed on inflorescences that are considerably different from other plants. Unopened inflorescence in general is enclosed under one, two or many fleshy bracts. The outermost of these bracts is termed as "prophyll". The fleshy prophyll and fleshy bract or bracts on peduncle are sometimes collectively called as spathes and inflorescence is termed as "spadix". The first bract at the point of origin of flower branch in a compound inflorescence is also termed as "prophyll".

1.2.8. Emergence of palm's inflorescences and their position

The position of palm inflorescence in a palm tree is significant and characteristic during its emergence from the leaf axils and offers a good diagnostic character. Palm inflorescence may be axillary or terminal (Fig. 8 & 9). When a palm tree after attaining maturity starts producing axillary inflorescence in ascending order as the growth advances and the position of the inflorescence remain within the crown is termed as interfoliar or below the crown is called infrafoliar and their reproductive phenomenon

is termed as pleonanthic. This phenomenon is common in most palms excepting in a few genera of palms. In two genera of Coryphoideae and eleven genera of Calamoideae, the shoot after a long period of growth produces a compound terminal inflorescence that composed of much axillary reproductive branch system that terminates the shoot. The entire inflorescence dies after maturation of fruits along with the death of palm tree. This one time terminal flowering phenomenon is known as monocarpism. In some cluster forming species having this terminal flowering characters where only the flowering shoot withers after fruiting. The life process of the palm goes on through the development of other yet to flowering shoots in the cluster. This form of flowering is known as hapaxanthic. In almost all genera of Caryotoid palms the shoot after certain period of vegetative growth produces terminal inflorescence followed by the development of axillary inflorescences in the basipetal order and the tree or the shoot in cluster forming palm dies after the lowermost axillary inflorescence flowered. Under abnormal condition a pleonanthic palm may also flower terminally and dies afterward as happened in monocarpic palms. Extra axillary inflorescence is not a rigid character in palms but sometimes occur in palms. Normally each leaf axils of a palm leaf bears only one inflorescence. There is an exception noticed during field observation with emergence of two inflorescences in one tree of *Arenga pinnata.*

1.2.9. Characteristics in structure of Palm inflorescence

Palm inflorescences are basically axillary monopodial branch system with a strong or delicate peduncle and simple or simply branched flower branches that ultimate bear the flowering portion known as rachilla. The most simple type of palm inflorescence is an unbranched axis and on the other hand most complexes multi branched inflorescence is seen in Coryphoid, Arecoid, Calamoid and Nypoid palms and to some extent in Ceroxyloid palms. In some genera of Calamoid palms the long flagelliform inflorescence bear ramified axillary fertile branches known as partial inflorescence.

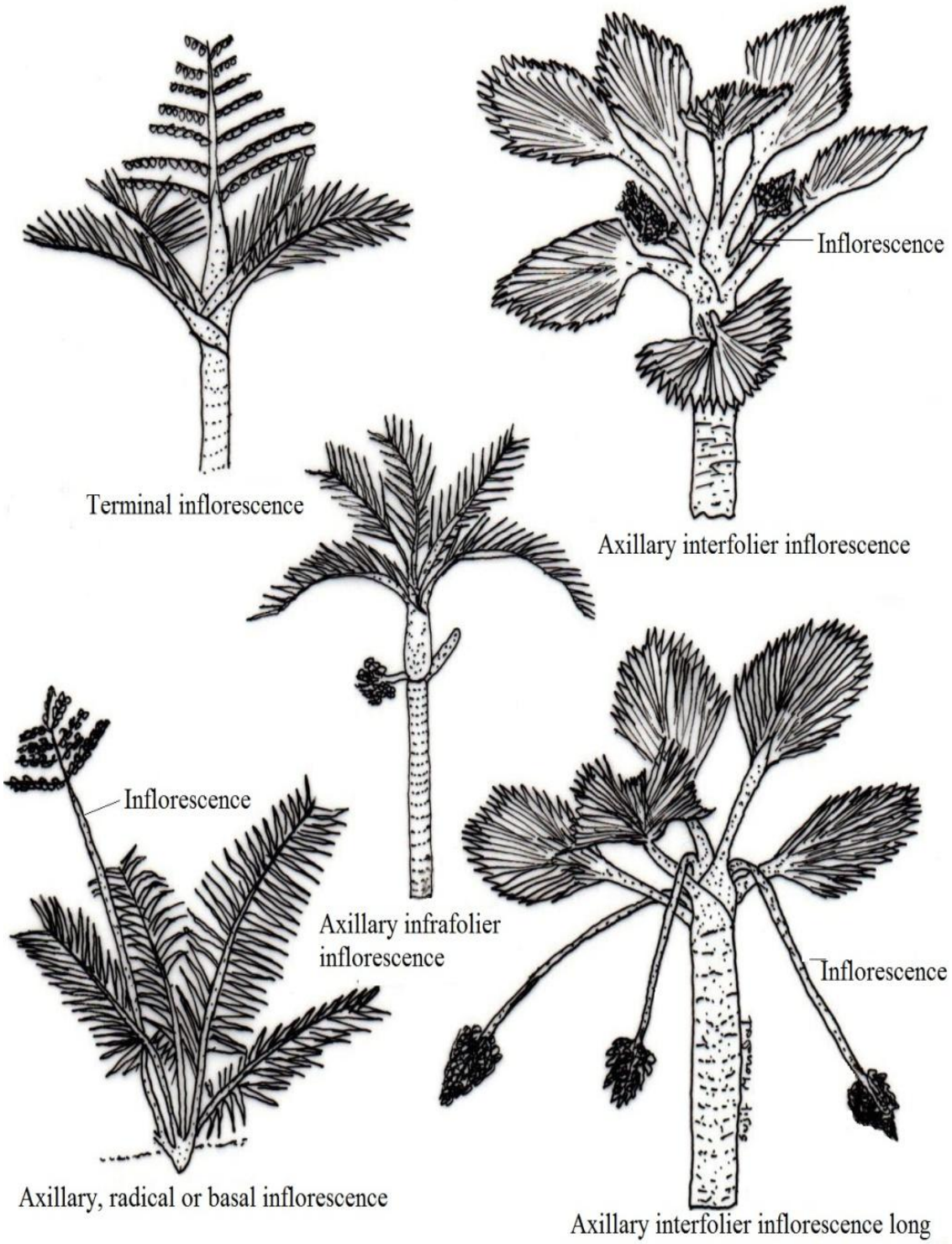


Fig. 8: Arrangement of palm inflorescence

1.2.10. Prophyll and Bracts in palm inflorescence

The term '*Prophyll'* was used by the well known palm taxonomist Late H.E. Moore (1963) who identifies and denote the primary bract on the peduncle or on the lateral branches of the inflorescence with other bracts. Prophyll or bracts are morphologically modified leaves. The shape and structure of prophylls are important characteristic features in some palms. In the genus *Phoenix* the solitary prophyll is thick and persistent and protects the young flower branches during development. The single prophyll opens by vertical split but never get detached. In the genus *Areca*, the solitary prophyll covers the entire inflorescence until it detaches from the peduncle for releasing the flower branches. In some genera of palms of Arecoid group the prophyll is large and encloses the inner peduncle bract which is also large and envelopes the flower branches.

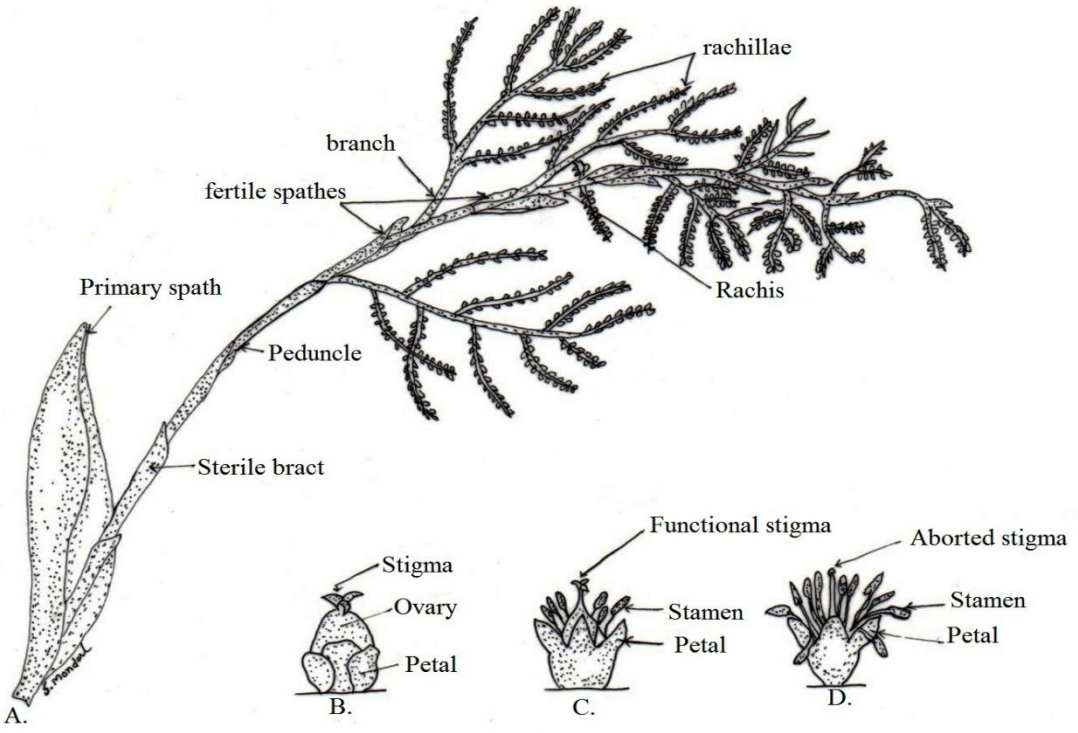


Fig. 9: **A.** Palm inflorescence; **B.** Female of pistillate flower; **C.** Bisexual or hermaphrodite flower; **D.** Male or staminate flower

At the opening the prophyll splits from the bottom and falls and the inner peduncle bract expands and gets detached from the peduncle by the push of the branches. This

type of prophyll is seen in all the species of the genus *Pinanga* found in the palm flora of North East India, *Bentinckia* of Nicobar Island and Peninsular India and other cultivated species of exotic palm genera like *Roystonea sp, Ptycosperma sp, Veitchia sp,* etc we commonly see around us in the Indian Flora. In *Dypsis lutescens* a common cultivated palm in this region, the prophyll is much shorter than the peduncle bract but fully encloses the flower branches at the very early stages of development. In the Cocosoid palms like Coconut the prophyll is small in comparison to the inner peduncle bract and remain hidden under the leaf sheath. During the emergence of flower branches, the peduncle bract pierces through the prophyll and grows to a great length enclosing the flower branches and opens by a longitudinal split on the inner side. In a multi bracteate inflorescence the peduncle bracts or bracts are sterile and the bracts on the rachis or the main axis of the inflorescence on the flower branches excepting the prophyll are fertile because each bract holds a flower branch of the next order. The genera *Arenga, Caryota* and *Wallichia* of Caryotoid group have only two or many sterile peduncle bracts.

1.2.11. Function and texture of prophyll and bracts in the palm inflorescence

The prophyll and the peduncle bracts are usually thin and papery in inflorescences that emerge by shedding of the corresponding leaves. The emerged inflorescence is automatic therefore the prophyll and bracts do not require to be strong enough, moreover, until emergence, the unopened inflorescence during its development gets extra support and protection from the corresponding leaf sheath. In interfoliar emergence of inflorescence, the growing inflorescence has to push out of the pressure of the leaf sheaths therefore for protecting the delicate flower branches and flower buds the prophyll and covering bracts need to be thicker and stronger and more fibrous in texture. Based on texture, prophyll and bracts palm inflorescence may be divided into the following categories:

1.2.11.1. Woody: As found in *Cocos nucifera, Corypha utan.*

1.2.11.2. Semi Woody to Woody: *Borassus flabellifer, Caryota urens, Caryota obtusa, Caryota maxima, Caryota mitis, Arenga pinnata, Arenga westerhoutii.*

1.2.11.3. Fibrous or matt: *Livistona jenkinsiana, Licuala peltata, Calamus sp, Daemonorops jenkinsianus, Plectocomia assamica, Salacca secunda, Trachycarpus martiana, Trachycarpus latisectus, Trachycarpus fortunei, Trachycarpus ukhrulensis*.

1.2.11.4. Papery: *Areca catechu, Areca triandra, Areca nagensis, Pinanga sp., Calamus sp*.

1.2.12. Flower cluster in palm inflorescence

Palm flowers are either solitary or in the form of clusters. The clusters are of several kinds. Solitary flowers may either be spirally arranged or closely crowded or irregularly disposed on the rachillae.

The cluster forming type may be Cincinnus where flowers are sympodial in development, when a second flower develops in the axils of the floral bract, the bract below the second flower then subtending the third flower and so on. In Dyad formation the cluster may consist of either of two hermaphrodite flowers or two male flowers or one female and one neuter flower as seen in *Calamus* a characteristic arrangement by which it is possible to identify the sex of dried herbarium specimens by examining the scars only. In the genus *Korthalsia* of Calamoid group the single bisexual flowers are reduced from Dyads. The Triad consists of two lateral male flowers and a middle female flower. It is the most common floral unit seen in *Arenga, Caryota, Areca, Pinanga* etc. By the suppression of the middle female flower a triad may appear as dyad and by suppression of one male flowers the cluster may appear with solitary female flower only.. This suppression of one sex from the triad is characteristic of the genera *Areca sp, Caryota sp* and *Wallichia sp*. Some flower clusters are formed in two lines on the rachillae, the proximal flower in the line becomes female and the distal are males. This type of clusters is known as acervulus and characteristic of the genus *Hyophorbe.*

Palm flowers are unisexual or bisexual, sessile or with pedicel and basically trimerous with 3 sepals and 3 petals with stamens 3 to six or many and ovary distinctly 3 carpellate with one ovule in each carpel.

1.2.13. *Perianth in palm flowers*

The perianth of palm flower is composed of similar or dissimilar sepals and petals sometimes uniseriate with variable number of lobes. Sepals are mostly 3 in number distinct, imbricate or connate or tubular. Petals are mostly 3 in number, imbricate or valvate or connate; mostly valvate in bisexual flowers or rarely united with free lobes and no distinct aestivation is recognized. In some genera the bisexual flowers do not have distinct petals or may be absent. The valvate aestivation of corolla in the male and bisexual flowers greatly facilitates the opening of the petals and simultaneous emergence of stamens. The unfolding of petals is caused by number of factors. The cumulative effect of the enlargement of anthers and lengthening of their filaments pushes the petals sideways when sufficient pressure develops. The tip of the petals moves outward and their base to tend in. This process is further facilitated by the free margins of the tangentially curved and imbricate sepals whose normal tendency is to converge. Thus the imbricate aestivation of calyx of the male flowers has a role to press open the petals apart. Such a lever mechanism can be more effective where the petals are much longer than the sepals as in the case with most palm species. There is a striking device which further helps in unfolding of the petals. A little above the base of the petals, a horizontal ridge of mass of large cells suddenly appears a few hours before the flowers blooms. The rapid enlargement of three ridges (one for each petal) within or otherwise packed up cavity, presses the petals towards the periphery. Such an enlarged ridge is clearly seen in some Arecoid species. In *Cocos nucifera* the ridge looks divided into two halves by the stout filament of the stamen that is placed opposite to the petals. The fleshy ridge thus, in function, resembles the lodicules of grasses. When young, the margins of the valvate petals are kept in a position by two rows of large cells which form the abscission layer. These large cells start withering when the anthers mature. The weakening of this binding abscission layer helps the petals to detach from each other easily.

1.2.14. *Androecium and Gynoecium*

Androecium in palm's flower consists of 3, 6, to many stamens, with distinct short or long filaments, variously connate or adnate or both with the petals. Anthers are basifixed or dorsifixed and pistillode may be present or absent in male flowers. The gynoecium is apocarpus with 1-3 carpels or syncarpus with 3 or more of 10 locules or

pseudomonomerous with 2 aborted and 1 fertile locule and ovule. Carpels are smooth or hairy or with imbricate scales as seen in Calamoid palms. Style is distinct, either connate or indistinguishable. Stigmas 3, in number erect or recurved or with slit in the carpel (*Nypa fruiticans*). Each locule has one ovule only. Staminodes may be present or absent.

1.2.15. *Palm fruits and seeds*

Palm fruits are botanically drupe which consist thin outer shell known as epicarp and a fleshy middle layer of variable thickness known as mesocarp and an inner hard layer which is attached to the seed known as endocarp. Most of the seeds consist of endosperm which is sometimes called as albumen. The embryo is embedded in the endosperm. The other form of fruit is berry with one seed where endocarp is absent, as found in *Phoenix.* Palm fruits may be conspicuous by their size (*Borassus sp., Cocos sp.*) and/or by their color (*Areca sp., Pinanga sp., Trachycarpus sp.*). The giant Double Coconut Palm botanically known as *Lodoicea maldivica* also known as *'Coco de mer'* is of the most famous palms in the world. The fruit of *Lodoicea maldivica* is about 45 Kg. and seed takes about a year to germinate and the palm takes about hundred years to attain some height to become sexually active. The ripe fruits in *Calamus sp., Daemonorops sp.* and *Plectocomia sp.* have a pericarp consisting of a scaly epicarp of overlapping scales and a fleshy seed coat known as sarcotesta. Fruits of rattans are easily recognized from other palm fruits by the presence of these scales. In *Daemonorops sp.* a red colored resinous liquid is excreted from the epicarp in between the scales. Surface of the fruit may be smooth or with symmetrical scales in *Calamus sp., Daemonorops sp.* and *Plectocomia sp.* and other Calamoid palms. Seeds of the calamoid palms have a fleshy layer which is considered as not part of the seed but a layer of fruit wall. This fleshy layer of fruits of *Calamus tenuis* and *Calamus longisetus* are edible. Some fruits of palms are built with flotation system. Many palm fruits are edible while a majority are not so. Pulp of some palm fruits contain poisonous or irritating substance as found in the fruits of *Arenga sp.* and *Caryota sp.* (Basu 2013).

1.2.16. *Palm seed germination*

When palm seed germinate the mode of germination may be remotive where cotyledonal sheath grows to a great length with the embryo and from there the root and shoot develop as seen in the germination mode of *Borassus flabellifer*. In adjacent type of germination seedling develops close to the germinating seed. The minute embryo in the seed grows and the single cotyledon works as hustoria to draw nourishment from the endosperm, this special function of the cotyledon continues till the seedling is capable of up taking nutrients from the soil by its roots.

1.3. Taxonomic treatments of Palmae (Arecaceae)

1.3.1. Bentham and Hooker (1862-1883) placed Arecaceae in their classification as follows:

Kingdom: Plantae
Subkingdom: Phanerogamia
Division: Angiospermae
Class: Monocotyledon
Series: Calycinae
Family: Arecaceae

1.3.2. Authur Cronquist (1981) placed Arecaceae in his classification as follows:

Division: Magnoliophyta
Class: Liliopsida
Subclass: Arecidae
Order: Arecales
Family: Arecaceae

1.3.3. Takhtajan (1997) placed Arecaceae in his classification as follows:

Division: Magnoliophyta
Class: Liliopsida
Subclass: Arecidae
Series: Arecanae
Family: Arecaceae

1.3.4. APG III (Chase and Reveal 2009) placed Arecaceae as follows:

Kingdom: Plantae

Clade: Angiosperms

Clade: Angiosperms

Clade: Commelinids

Order: Arecales

Family: Arecaceae

1.3.5. APG IV (2016) placed Arecaceae as follows:

Kingdom: Plantae

Clade: Angiosperms

Clade: Monocots

Clade: Commelinids

Order: Arecales

Family: Arecaceae

1.4. Major Classifications of Palms

For convenience, here in this dissertation, classification of family Palmae was followed according to (Uhl and Dransfield 1987) viz. subfamilies Coryphoideae, Calamoideae, Nypoideae, Ceroxyloideae, Arecoideae, and Phytelephantoideae. Palms of West Bengal are represented by four subfamilies only viz. Coryphoideae, Calamoideae, Nypoideae and Arecoideae. The subfamily Coryphoideae is further divided into tribes of Coryphae, Phoeneceae, and Borasseae. The subfamily Calamoideae is divided into tribes of Calameae and Lepidocaryeae. The subfamily Arecoideae is divided into tribes of Caryoteae, Areceae, Cocoeae, Iriarteae and Geonomeae. The tribes of Lepidocaryeae, Iriarteae and Geonomeae are not represented in the Palm flora of West Bengal. The subfamily Nypoideae is a monotypic.

1.4.1. Dransfield & Uhl (1986) Classification (Subfamilies and tribes)

Subfamily: Coryphoideae: Tribe: Coryphae, Phoeniceae, Borasseae

Subfamily: Calamoideae: Tribe: Calameae, Lepidocaryeae

Subfamily: Nypoideae

Subfamily: Ceroxyloideae: Tribe: Clyclospatheae, Ceroxyleae, Hyophorbeae

Subfamily: Arecoideae: Tribe: Caryoteae, Iriarteae, Podococceae, Areceae, Cocoeae, Geonomeae

Subfamily: Phytelephantoideae

1.4.2. Moore (1973) without rank

I. Coryphoid palms II. Phoenicoid palms III. Borassoid palms IV. Lepidocaryoid palms V. Nypoid palms VI. Pseudophenicoid palms VII. Ceroxyloid palms VIII. Chamaedorioid palms IX. Caryotoid palms X. Iriarteoid palms XI. Podococcoid palms XII. Arecoid palms XIII. Cocosoid palms XIV. Geonomoid palms XV. Phytelephantoid palms

1.4.3. Potztal (1964) as Subfamilies

Subfamily: Coryphoideae, Phoenicoideae, Borassoideae, Lepidocaryopideae, Nypoideae, Phytelephantoideae, Caryotoideae, Cocosoideae, Arecoideae

Tribe: Ceroxyleae, Chamaedoreae, Iriarteeae, Dypsideae, Geonomeae

1.4.4. Satake (1962) as Sub family

Subfamilies: Coryphoideae, Phoenicoideae, Borassoideae, Calamoideae, Lepidocaryopideae, Nypoideae

Subfamily: Arecoideae. Tribe: Ceroxyleae, Chamaedoreae, Iriarteeae, Dypsideae. Geonomeae.

Subfamily: Caryotoideae

Subfamily: Cocosoideae

Subfamily: Phytelephantoideae

1.4.5. Drude (1887)

I. Coryphinae tribe Phoeniceae
II. Borassinae
III. Lepicaryinae
IV. Ceroxylinae tribe Arecinae, Subtribe: Morenieae, Arecineae, Caryoteae, Iriarteae, Geonomae, Cocoineae
V. Phytelephantineae

1.4.6. Hooker (1883) as tribe

1. Tribe: Areceae Subtribe: Ceroxyleae, Chamaedoreae, Caryotideae, Iriarteeae, Wettinieae, Geonomiae and dubia affinitatis
2. Tribe: Phoeniceae
3. Tribe: Corypheae
4. Tribe: Lepidocaryeae
5. Tribe: Borasseae
6. Tribe: Cocoineae

1.5. Palmae (Arecaceae) characters

Small to large, solitary or cluster forming, armed or unarmed, hapaxanthic or pleonanthic, hermaphrodite, polygamaous, monoecious or dioecious palms or rattans. ***Stems*** arborescent to slender, delicate, short or very tall, creeping, subterrenian, climbing or erect, mostly unbranched, rarely dichotomously branched. ***Leaves*** alternate, spirally arranged, sometimes distichous or tristichous; leaf sheath thin, semi-woody or woody, loose or closely sheathing, tubular, armed or unarmed outside; petiole present or inconspicuous, usually terete or half terete, flat or channeled above with or without armature outside; hastula present or absent; leaf blade palmate, costapalmate, pinnate, bipinnate or bifid or entire or bipinnately veined, induplicate or reduplicate, tip of the leaf segments or leaflets acute, acuminate, truncate, oblique, bifid, praemorse or irregularly toothed or lobed; rachis sometimes prolonged into a whip-like spiny appendage. ***Inflorescence*** axillary, solitary or multiple, infrafoliar, interfoliar or suprafoliar, spicate or branched upto 6 order, sometimes inflorescence whip-like spiny appendage; prophyll usually 2-keeled, in different shape and size; peduncular bract present one to many or absent; rachillae short to long, slender filiform to massive. ***Flowers*** hermaphrodite or unisexual or dimorphic, sessile or stalked, borne single or in groups; ***perianth*** rarely of similar parts, usually clearly differentiated into sepals and petals; ***stamens*** 3, 6 or many, filaments erect, free variously connate and adnate, anthers basifixed or dorsifixed rarely didymous, staminodes from tooth-like to well developed, distinct, connate, sometimes adnate to petals or gynoecium; ***gynoecium*** apocarpus, 3- carpelled or variously syncarpus with usually 3 or rarely more locules or pseudomonomerous with 1 fertile locule, smooth, hairy or covered with scales, styles distinct or not clearly differentiated; stigmas erect or recurved, ovule solitary in each

locule, anatropous, hemianatropus, campylotropous or orthrotropous pistillode present or absent. ***Fruit*** usually 1- seeded, sometimes 2-3 to 10 seeded, small to very large, epicarp smooth, hairy, prickly, corky warted or covered with imbricate scales, mesocarp fleshy, fibrous or dry, endocarp thin or hard or not differentiated; ***seed*** with or without fleshy testa; endosperm homogeneous, ruminate, embryo apical, lateral, basal, germination adjacent ligular, remote ligular or remote tubular.

1.6. General Distribution of Palmae (Arecaceae)

Two genera of the tribe Corypheae such as *Sabal* and *Washingtonia* dominate the colder regions of Carolina and California, the genus *Trachycarpus* of the same tribe is also cold resistant palm, distributed northward from Himalaya to Upper China. *Raphis* is another cold resistant genus naturally occurring in Japan upto its northern limit. *Phoenix dactylifera* of the tribe Phoeniceae and *Nannorrhops ritchiana* of the tribe Corypheae grow wild in the desert. The genera common in Asia and Africa are *Phoenix* of the tribe Phoeniceae, *Hyphaene* and *Borassus* of the tribe Borasseae and *Calamus* of the tribe Calameae. The genera *Latania* and *Lodoicea* are the two Borassoid genera restricted to Mascarene and Seychelles Islands. The maximum diversity in the subfamily Calamoideae is noted in Southeast Asia. In Africa the typical Calamoid genus is *Ancistrophyllum,* while *Metroxylon,* one among the most economically important genera has natural distribution in the Pacific Islands. Among the tribe Areceae a large number of genera and species are found both in the eastern and western tropics. The important western tropical genera of the tribe Areceae are *Roystonea, Geonoma, Euterpe, Prestoa* and *Howeia* in the Pacific Islands.

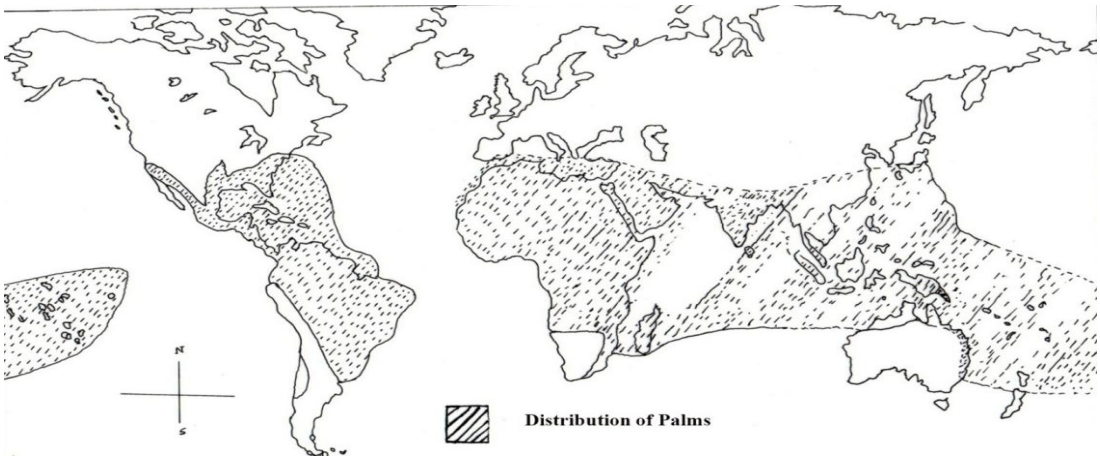


Fig. 10: World distribution of palms

The common eastern tropical genera of the tribe Areceae are *Areca, Bentinckia, Pinanga, Actinorhytis, Ptychosperma, Ropaloblaste, Dypsis, Veitchia, Archontophoenix, Hydriastele, Carpentaria, Normanbya, Heterospathe, Orania etc*. The tribe Caryoteae of subfamily Arecoideae comprises the genera *Arenga, Caryota* and *Wallichia,* all have their origin in Southern Asia, Indo China, Burma, extending to the Indian Subcontinent. Palms have their footing in the Southern Europe and across North India and China to Korea and Japan in the extreme north. In the south, they grow in New Zealand and South Africa (Fig. 10). The genus *Chamaeprops* is the only Corophoid palm dominates in the southern Europe. In the Southern hemisphere, the common extra-tropical palms are *Butia* and *Jubea* of the tribe Cocoeae and *Rhopalostylis* of the tribe Areceae, the former two genera are distributed in the southern part of South America while the latter in the New Zealand. With some exception most of the palm taxa have originated either from the old world or from the New World. The most economically important *Cocos nucifera* is although thought to be of Malesian origin and is pan tropic in distribution. Among the tribe Calameae, the genus *Raphia* has wide diversity in Africa but with only one species occurring in America. The genus *Podococcus* and *Sclerosperma* of tribe Areceae are endemic to tropical Africa. The Carribian Islands and the central part of America have large distribution of major genera like *Coccothrinax*, *Thrinax, Copernicia*, *Colpothrinax, Sabal, Acoelorraphe* etc of the tribe Coryphae. The genus *Corypha* is Indo-Malaysian and the genera *Livistona* and *Licuala* from the bulk of the Indo-Malayan species of the tribe Corypheae. The genus *Prichardia* is abundant in the specific islands. The important genera are *Bactria, Butia, Arecastrum, Syagrus, Aiphanes, Attalea*, *Orbygnia* etc of tribe Cocoeae is encountered in South America. The tribe Caryoteae is restricted in the eastern tropics only. The subfamily Nypoideae has only one genus *Nypa* is growing in eastern tropics only. The sub family Phytelephantoideae with its monotypic genus *Phytelephas* is restricted to the western tropics only. Our present knowledge on the distribution of the family Palmae took shape from the works of Corner (1966), Moore (1973), Beccari (1909, 1911, 1918 and 1933) and Uhl and Dransfield (1987). *Calamus* L. (Arecaceae: Palmae) is a largest genus with more than 600 species and is also the most widespread ranging across the Asia-Pacific region with one outlyer in Africa (Dransfield *et al*. 2008; Baker 2015; Baker and Dransfield 2016). The spiny climbing and non climbing rattans the Old World species and the source of commercial rattan cane, distributed from India to Fiji, tropical Africa, South China through Malay Archipelago to Northern

Australia and Fiji (Baker and Dransfield 2014). Initially from South and South East Asia, Dransfield (1979) described 104 species of rattans in his publication named *A Manual of the rattans of the Malay Peninsula*. Johns and Taurereko (1984–89) described the morphology of stem, roots, leaves and climbing organs of *Calamus* in their book *'A guide to the collection and field description of Calamus'*. Very important source of information *'Rattan –a bibliography'* and *'The state of rattan and bamboo trade'* were published by Kong-Ong and Manokaran (1986, 1990).

Calamus is most dominating and diversified genera in South East Asia where 190 species occurring across the Malay Peninsula, Philippines, Borneo, Sumatra and Java (Baker and Couvreur 2012; Govaerts *et al.* 2013; Henderson and Rustiami 2019) and 66 species were recognized from New Guinea (Baker and Dransfield 2006, 2014). The lower hills of Eastern Himalaya, terai parts are quite rich in *Calamus* species, 28 species were reported from China (Pei Shengji 1991), seven species from Bangladesh (Alam 1990), eight species recorded from Bhutan (Noltie 1994), 9 species from Nepal (Paudel and Chowdhary 2005).

1.7. Distribution of Palmae (Arecaceae) in India

About 106 species and 4 varieties of wild and semi wild palms representing 22 genera were reported from India (Renuka 2011). They are chiefly occurring in the three major geographical regions, *viz*. Peninsular India, Eastern and Northeastern India and Andaman & Nicobar Islands. A small number of palm taxa also occur in the rest of India, particularly in the sub-Himalayan valleys and plains of northern India, semi-arid parts of western India, Gangetic plains, estuarine mangrove forests of Ganga and Mahanadi delta, moist hilly tracts of Orissa, South and North Bihar. Apart from semi wild and wild palms, *Cocos nucifera* and *Areca catechu* are largely cultivated as commercial crops. Among the wild palms, the genera *Calamus, Daemonorops, Plectocomia, Korthalsia, Arenga, Wallichia, Nypa, Trachycarpus, Pinanga* and *Corypha* are poorly represented in cultivation.

In addition, some wild palms like *Borassus flabellifer, Phoenix sylvestris* and *Calamus erectus* and to some extent *Caryota urens* are dominated in different regions of India. *Areca catechu* and *Cocos nucifera* are used in wide commercial cultivation. During the last two centuries or more several species of exotic palms have been introduced in India

by various individuals, nurseries, different institutions and agencies for different purposes. Several species of exotic palms have become naturalized and semi-naturalized apart from their cultivation like *Trachycarpus fortunei*, *Dypsis lutescens* etc. Seeds of many palms are easily disseminated by birds assisting in their naturalization, and thereby enriching the palm wealth of India.

The beauty and elegance of palms are no less important than their traditional and commercial values. There is no substitute for the gracefulness that's palms offer, palms and tropics are thus synonymous. Palms are, therefore, cultivated not only for their economic reasons but introduced in the landscape for their value also. The dried fruits, prophyll, bract and leaves of various palms are also very decorative, so used for vase decoration. The hard endosperm of some palms like rattans are used as substitute of ivory and carved into for making attractive jewelleries (Basu 1994).

The earliest record of Indian palms appeared in *Hortus Malabaricus* where 9 palms were described with illustrations (Van Rheede 1678). Martius (1832-1853) described 15 Indian species in his book *Historia Naturalis Palmarum*. Griffith describes Indian palms in *Palms of British India* in 1850, followed by Beccari's (1906-1918, 1931) monographic series. Blatter published *Palms of British India and Ceylon* in 1926. After this not much taxonomic work was carried out on this group till 1982 when Kerala forest Research Institute initiated studies on rattans (Renuka *et al.* 1987) and after that a considerable amount of works were carried out on the taxonomy of Indian rattans. The detailed study on rattans in India was published by several authors from different part of the country (Anto *et al.* 2001; Joemon *et. al.* 2008; Basu 1992; Lakshmana 1993; Renuka 1992, 1995, 1999, 2011). Introduction and cultivation of exotic palms in India perhaps began at the early time of 18th Century when Arabian date palm (*Phoenix dactylifera*) was brought for cultivation in some parts of Western India (Blatter 1926). Cultivation of indigenous and exotic palms on a scientific basis was started after the establishment of East India Company's Garden in West Bengal in the year 1787, when Malayan Sogo palm (*Metroxylon sago*) was introduced in India. Later on various plams like (*Elaeis guineensis*) South American oil palm (*Orbignya cohune*) were also introduced in different periods. Three introduced palms cultivated in India as crash crops are coconut (*Cocos nucifera*), arecanut (*Areca catechu*) and African oil palm

(*Elaeis guineensis*). *Areca catechu* and *Cocos nucifera* are seen in the natural forest and coastal areas of Andaman and Nicobar Islands.

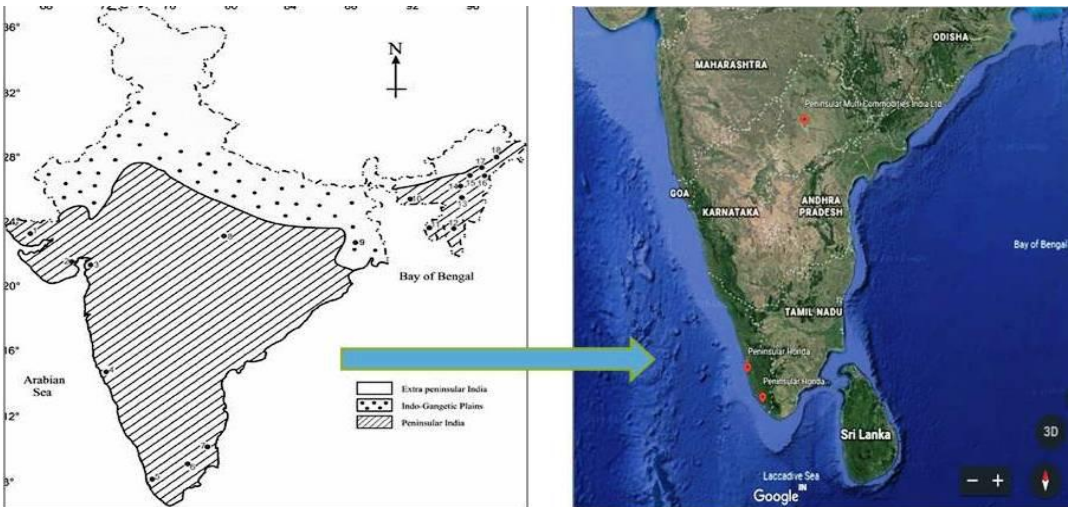
Beccari (1894) first time accounted 72 species of *Calamus* from undivided British India and presently around 36 species and 3 varieties of *Calamus* were recorded from various parts of Himalaya, Western Ghats and Andaman and Nicobar Islands (Basu and Basu 1987; Basu 1992; Renuka 1987).

It is not exactly known how many species of palms are at present cultivated in India as well as in West Bengal because quite a large number of them are the collections of the private growers, therefore, inaccessible to the others or in the possession of the nurserymen who mostly do not care to enlist their palm collections with proper identity. In many important public and Government gardens in India particularly in West Bengal (Acharya Jagadish Chandra Bose Indian Botanic Garden, Howrah; The Agri Horticultural Society of India, Alipore, Kolkata; Centre of Conservation and Utilization of Medicinal and Aromatic Plants, North Bengal University, Siliguri, Darjeeling) palms are seldom labeled and listed with their correct nomenclature and thus cause inconvenience to the palm lovers (Basu and Chakraverty 1994).

1.7.1. Peninsular India

The Peninsular India (Map 1) comprises the central highland with Satpure, Maikala, Vindya and Bundelkhand ranges (600-900 m), on the North and Western Ghats on the west. On the east, the Eastern Ghats, not continuous like Western Ghats with highest peak at Mahendra Giri (1680 m). The Eastern and Western Ghats meet at south Nilgiri of Karnataka. The regions west of Western Ghats and east of Eastern Ghats slope towards the coastal plains. The rest of the regions are either river valleys or coastal plains. On the western slopes of the Western Ghats comprises mostly tropical evergreen forest occurring in the state of Karnataka and Kerala. The Eastern slopes of Western Ghats consist mostly of moist deciduous forests. Palms are most frequent as evergreen forests component, frequent in the semi-evergreen and occasional in the moist decidouos forests. The conspicuous palm genera within the area are *Areca, Pinanga, Calamus, Bentinckia*, *Caryota* and *Corypha*. The dominant palm genus is *Calamus.* The genus *Phoenix* is extensive in the deciduous forest belts and along the coastal

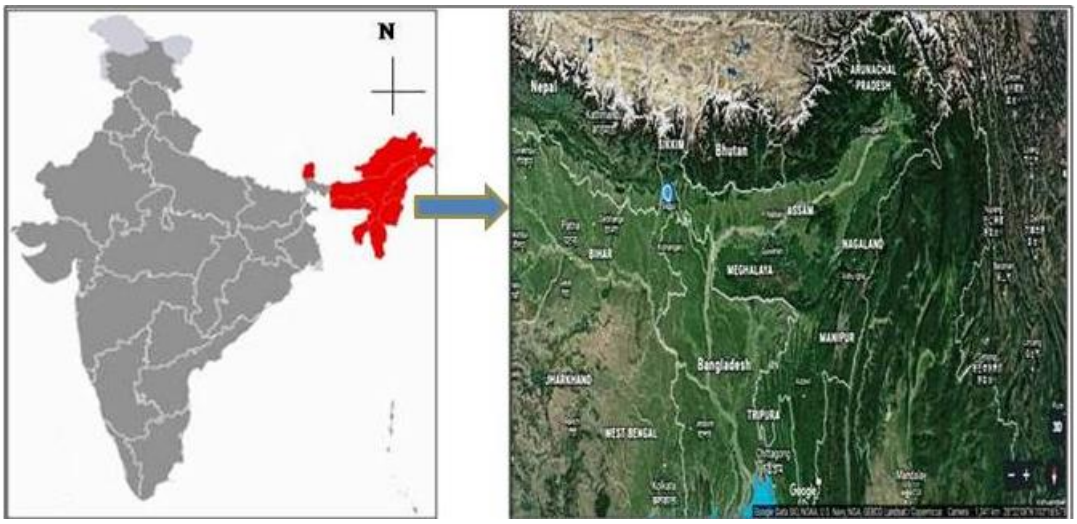
plains of Coromondal. *Borassus flabellifer* is the most conspicuous semi-wild palm all along the coastal plains of Andhra Pradesh and Tamil Nadu. More than half of the *Borassus* population of India is located in this region.



Map 1: Peninsular India (source: https://earth.google.com.)

1.7.2. Eastern and Northeastern India

This broad geographical region comprises Assam Valley, submontane regions of Assam, Arunachal Pradesh, Nagaland, Mizoram, Manipur, Tripura and Meghalaya (Map 2); lower mountain valleys and Teesta, Brahmaputra valleys of Sikkim, West Bengal and Assam. The natural vegetation of these composite regions are mostly tropical moist deciduous forests in the plains and tropical semi-evergreen to evergreen forests in the mountain valleys.



Map 2: Eastern & Northeastern India (source: https://earth.google.com.)

Palms are conspicuous in all the three types of forests. The most widespread rattans genera are *Calamus, Daemonorops* and *Plectocomia* and other palm genera are *Arenga, Areca, Wallichia, Caryota, Phoenix, Livistona, Licuala, Pinanga, Trachycarpus* and *Salacca. Cocos nucifera* and *Areca catechu* are cultivated in the plains. The semi wild palms, *Borassus flabellifer* and *Phoenix sylvestris* are also frequent in the plains.

1.7.3. Andaman and Nicobar islands

Andaman and Nicobar Islands are the summits of the submerged mountain range from an arcuate chain connecting western Burma and Sumatra, separated from each other by creeks, straits, passage having a coast line of 1962 km. The approximate land area of Andaman and Nicobar (Map 3.) is 1953 sq. km. The forests vegetation is still very rich though in many island it is greatly depleted due to biotic pressure. The main forest types are tropical evergreen, semi-evergreen and moist deciduous and extensive coastal mangroves. Palms are frequent in all types of forests representing the genera *Areca, Bentinckia, Calamus, Daemonorops, Korthalsia,*

Map 3: Andaman and Nicobar Islands (source: https://earth.google.com.)

Licuala, Corypha, Phoenix, Pinanga, Rhopaloblaste and *Nypa*. The genus *Korthalsia* is restricted to Andaman and Nicobar Islands only. In addition to indigenous species several exotic species of palms have been introduced as ornamental plants in the

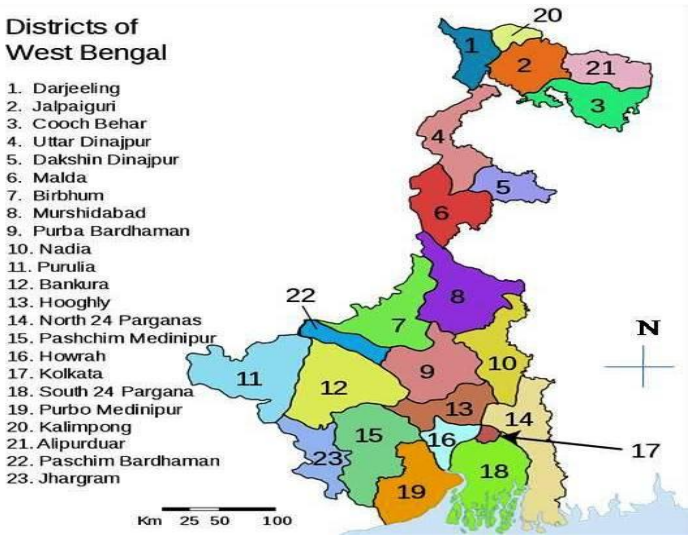
islands. Details works on rattans flora, their distribution and utilization in Andaman and Nicobar Island was published by Renuka 1995.

1.7.4. Other Region

Few palm species are also found in the moist tropical forests of sub- Himalayan valleys and plains of northern India. The semi- arid western parts of India have only one palm species, *Phoenix sylvestris* and its distribution extends through the Gangetic plains with occasional presence of *Borassus flabellifer*. In the estuarine mangrove forests of Sundarbans, *Nypa fruticans* and *Phoenix paludosa* occur as pure stands. The entire lower Bengal and coastal Orissa have extensive population of *Phoenix sylvestris* and *Borassus flabellifer* and isolated pure stands of *Phoenix paludosa* in the Mahanadi mangrove system. The two locally useful canes, *Calamus viminalis* and *C. tenuis* are common in this region. The beautiful fan–leaved *Licuala peltata* has a restricted distribution in some moist pockets of south Bihar plateau.

1.8. Palms in West Bengal

The broad geographical region of West Bengal comprises natural forests from sea level (Sundarbans) upto hill regions which support about the palm diversity of Indian flora (Map 4). In



Map 4: Palms distribution in West Bengal (source: www.google.co.in)

West Bengal plants of different groups have their different ecological niches and climatic requirements. It is of special interest for study of palms so far on their

distribution pattern, taxonomy, ecology, morphological structures, behavior, phenology, ethnobotanical and their commercial uses and potentials.

The Darjeeling-Kalimpong Himalaya, Terai–Duars regions, Western undulating highland and plateau, North and South Bengal plains and Gangetic delta as a whole, the entire regions constitute of varied terrains includes the river, plains to high mountains, gorges, deep valleys with rich natural vegetations. The boundary of West Bengal also have several in-situ conservatories that includes one Biosphere reserve (Sundarbans), six National Parks (Table 1 & Fig.11), fifteen Wildlife Sanctuaries (Table 2 and Fig.12) and many dense reserve forests with extremely rich biological entities. Most of the palm growing localities are inaccessible during the monsoon season due to heavy rains which made difficult for the plant collectors to explore palm and rattans specimens during their flowering and fruiting time. It is perhaps one of the reasons for non availability of adequate complete palm specimens particularly of canes and both tall and understory palms, in the different herbarium of the Botanical Survey of India of this region and other botanical institutions located here. Roxburgh (1814) first recorded palms among others in his catalogue of Indigenous and exotic plants recorded from undivided Bengal. Palm wealth of Bengal was explored by various authors in different times (Beccari 1894; Voight 1845; Prain 1903; Gages 1911; Sen and Naskar 1965). The recent work of Basu and Chakravorty (1994) gave a detail account of cultivated palms found in West Bengal. Mondal and Chowdhury (2018) reported 18 species of rattan found in different five broad geographical regions of West Bengal. In Addition to these earlier record of palms, references of palms is also available in district floras of West Bengal published by the Botanical Survey of India and other agencies.

Table 1: National Parks (NP) of West Bengal

Sl. No.	National Parks	Year of Notification	Area (km^2)	District
1	Buxa National Park	1992	117.1	Alipurduar
2	Gorumara National Park	1992	79.45	Jalpaiguri
3	Neora Valley National Park	1986	159.89	Darjeeling
4	Singalila National Park	1986	78.6	Darjeeling
5	Sunderban National Park	1984	1330.1	S 24 Parganas
6	Jaldapara National Park	2014	216.51	Alipurduar

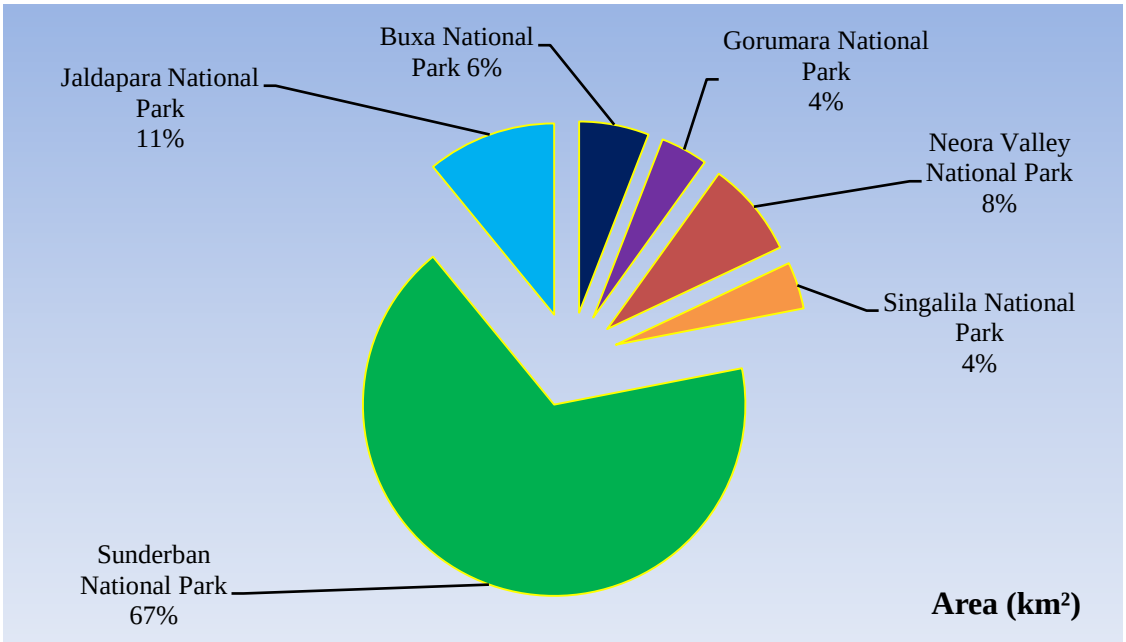


Fig. 11: Graphical representation of areas percentage of different National Parks of W.B

Table 2: Wildlife Sanctuary (WLS) of West Bengal

Sl. No.	Wildlife Sanctuary	Established Year	Area (km²)	District
1	Ballavpur WLS	1977	2.02	Birbhum
2	Bethuadahari WLS	1980	0.67	Nadia
3	Bibhuti Bhusan WLS	1980	0.64	S 24 Parganas
4	Buxa WLS	1986	267.92	Alipurduar
5	Chapramari WLS	1976	9.6	Jalpaiguri
6	Chintamani Kar Bird Sanctuary	1982	0.07	S 24 Parganas
7	Haliday Island WLS	1976	5.95	S 24 Parganas
8	Jorepokhri Salamander WLS	1985	0.04	Darjeeling
9	Lothian Island WLS	1976	38	S 24 Parganas
10	Mahananda WLS	1976	158.04	Darjeeling
11	Raiganj WLS	1985	1.3	U Dinajpur
12	Ramnabagan WLS	1981	0.14	Burdwan
13	Sajnakhali WLS	1976	362.4	S 24 Parganas
14	Senchal WLS	1976	38.88	Darjeeling
15	West Sunderban WLS	2013	556.45	S 24 Parganas

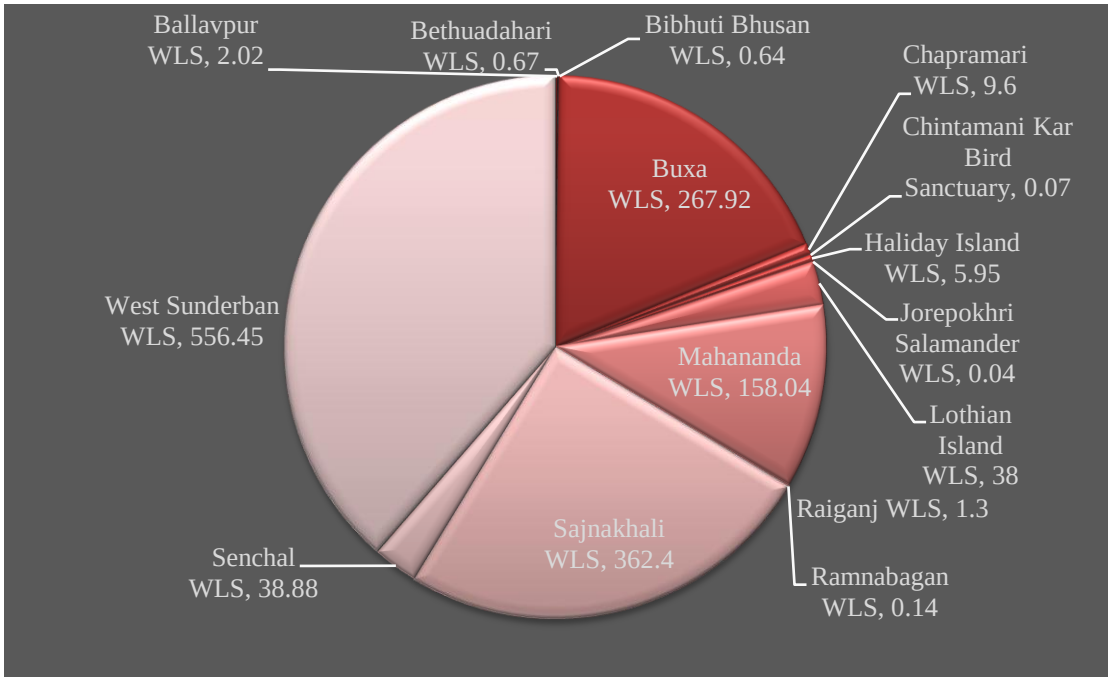


Fig.12: Percentage of Area (km²) shared by different Wild Life Sanctuary of W.B

1.9. Importance of Palms and Canes

Palms are among the most frequently harvested plant species in the tropics (Mc Currach 1960). Palms provide a wide range of economic products necessary for daily life. Stems and leaves of many palms are used extensively as construction materials. Leaf sheath fibers and stem fibers are used as cordage and for making brushes. Leaves are used as writing materials as well as for making hats, brooms, baskets etc. Foliage of several palms is used for as fodder. The apical bud of several palms, commonly known as 'palm hearts' are edible and is a rich source of starch. Toddy is starchy sap extracted from the inflorescence and phloem of *Cocos*, *Borassus*, *Phoenix, Arenga sp.* and *Caryota sp*. Rattan shoots are also famous because of rich in proteins (Renuka and James 2006). Many palms are used by various ethnic and local people in their different rituals and religious festivals.

Canes play an important role in the rural economy in West Bengal as well as in India. A significant proportion of the rural population and forest dwellers earn their living through extraction and cleaning of canes. A large number of cottage and small scale industries in West Bengal are involved in the manufacture of cane furniture, walking sticks, hockey sticks and handicraft items. Mature nuts of several species of palms

(*Areca triandra, Pinanga sp.*) are used as substitutes for betel nuts in North eastern region of India. *Cocos nucifera, Areca catechu*, *Borassus flabellifer* and *Elaesis guineensis* are extensively cultivated and they play important role in the economy of our country. Palms also figure prominently in the life cycles of a variety of insects and are important food sources to rodents, bats, ungulates and primates etc.

Majority of the species has tremendous importance to local commerce as sources of food, thatch, fiber, wax, oil, timber, sugar, salt, alcoholic beverages, masticatories and stimulants. Some are symbolic in several cultures. They have considerable aesthetic value, are used in magic and folk- medicine, and are an essential ecological associate of many primitive tribes. They have become increasingly important in commercial horticulture because of their elegant and predictable shapes.

1.10. Threat and Conservation of Wild Palms

Most of the West Bengal palms exhibit highly restricted distribution to ecological niches within various biogeographic regions where they exist. In all these biogeographic regions distribution of palms are subjected to extensive habitat loss to anthropogenic factors as well as environmental catastrophe like earthquake, cyclons, flood, draught etc. Aila, Bud Bud, Fani, Bul bul etc. Species of the genera *Borassus sp.*, *Calamus sp.*, *Corypha sp.* etc. are threatened palm populations in the wild where these palms are decreasing because of their constant and increasing utilization. Some inherent characteristics of palms such a monocarpic flowering, poor germination of seeds and poor establishment of seedlings etc. have also contributed to retard natural regeneration of palm population (Renuka 2011). Over exploitation is one of the major threats to the survival of many wild palm species. Although increased used of palms may provide economic benefits to rural people (Anderson 1988; Peters *et al.* 1989), some species particularly those with high market potential, are being depleted by unscientific harvesting (Vasquez and Gentry 1989).

Many anthropogenic activities has posed threat to palm diversity globally resulting in extensive habitat loss and decrease in palm populations such as land clearing for human settlements, huge developmental works, exploitation of palms for making household items, furniture and other purposes to meet their pleasure, in addition to which they are

also used for daily chores for fuel, food, fodder etc., Palm also forms one of the good raw materials for industries and has a increasing day to day demand over the globe.

Due to increasing demand many tribal communities to run their lifestyle they meet the industrial demand and destroy the palms even affecting immature palm population which has greater impact in habitat loss. Extension of tea garden has destroyed natural wild habitat affecting their regeneration and growth patterns. The tender shoots and young leaves of rattans and other palms such as *Trachycarpus, Livistona, Pinanga* etc. are very good food for wild animals as well as domesticated cattle, thus habit loss has been occurring due to grazing.

The climate is changing globally at a faster rate as compared to past many decades. The main reason for the drastic climate change is mainly due to increasing human population followed by their activities such as grazing, destructive lumbering, logging, pollution due to industrialization, transport road extensions etc. Because of drastic climatic change, the soil is also polluted and degrading its quality on account of which the growth pattern and habitats of palms are affected adversely. Closed canopy nature forms important feature of rainforests where openings and canopy gaps formed by branch fall, crownfall, treefall etc. determines the forest structure. These canopy gaps retard the regeneration of palms population to a certain extent.

Conservation and sustainable utilization of this resource assumes great importance in the context when forest wealth of the state as a whole has been decline. In absence of concrete efforts towards their replacement, some of these wild palms are likely to face the threat of extinction.

Removal of forest resources at a large scale has degraded vegetation in India which resulted huge loss of flora and faunal diversity and the climate change is no less adverse result. Most of the indigenous species of global palms and rattans are recently enlisted under various threatened category by IUCN Red list. Many conservation measures are to be taken to deal with the circumstances. Conservation measures do not pose complete ban on palm utilization but more focus to be done on the sustainable use of palm resources. For conserving the palm species, some important steps has to be taken such as establishment of Palmatum in plant conservatories, growing in Horticultural institutes, commercial cultivation, planting as roadside trees and avenues

also can be grown as ornamentals. Greater awareness among the ethnic community in this regard should be made as they are the pioneer group of people utilizing the palm resources since long back.

1.11. Research objectives

Following are the research objectives of present dissertation:

a. Preparation of the exhaustive list of wild and exotic palm and canes flora with their taxonomic revision from West Bengal.
b. Understanding the phenology and reproductive potentials of rare and indigenous species under study.
c. Record of traditional knowledge and economic utility of different species of palms and canes.
d. To understand the physical Threats and Conservation status of indigenous palms and canes of West Bengal.