PHENOLOGY–6

6.1. Introduction

Phenology is a branch of science that deals with the relationship between periodic biological phenomena of organisms with their seasonal and climatic variations including habitat factors. More elaborately, the word Phenology, derived from the Greek word *'phaino'* which means to show or appear, of periodic plant life cycle events that are influenced by environmental changes, especially seasonal variations in temperature, rainfall and precipitation driven by weather and climate. The Belgian biologist Charles Morren (1853) first coined the term Phenology. Study of Phenology means the detailed records of life cycle of annual and perennial plants throughout the year. It can also be defined as relationship between climatic and biological phenomena (Lieth 1974). The climatic variables that affect the periodic phenological methods that includes temperature (Ashton *et al.* 1988), insulation (Van Schaik *et al.* 1993; Stevenson *et al.* 2008), rainfall (Opler *et al.* 1976; Yadav and Yadav 2008, Dutta and Mouplea *et al.* 2014; Devi 2015;), and water stress (Borchert 1983).

In a simpler way, phenology means the study of complete life cycle of plants including its germination, fertile form and death phase relating to month of particular season. The periodical climate change of a particular area directly affects the plant's life cycle. Phenological study helps to understand the rhythm of changes in life cycle of plants that indicates the proper time of sowing, flowering, fruiting and death especially for the agricultural crops.

The proper periodical record bears scientific value which greatly helps to understand the interactions between the organisms and their environment and also to assess the impacts of climate change. The phenogical study of any vegetation is very much useful tool for understanding the nature of that particular vegetation in a better way. There are several authors who studied the detailed phenology of different species of palms in different corners of the World (Ihne 1884; Harper 1906; Koelmyer 1959; Caprio 1966; Wang 1967; Leith 1970; Frankie *et al.* 1974; Croat 1975; Putz 1979; Basu, 1994).

Several workers had great contribution in the field of phenological study on different weeds and other important plant species in India. Some such remarkable works were performed by Hara *et al.* (1966, 1971), Bhoj and Ramkrishnan (1981), Sivaraj and Krishnamurthy (1989), Sundriyal (1990) on different plant species growing on Eastern Ghats and Himalayas. Some notable Phenological study on various rice field weeds and wetland angiosperms of West Bengal provides very good information to understand the life cycle of plant species with their surrounding environmental factors (Acharya 1998; Chowdhury 2009; Chowdhury 2017).

6.2. Flowering behavior of some palms

The emergence of inflorescence in pleonanthic palms is either seasonal or perennial round the year. In hapaxanthic palms like *Arenga, Caryota* and *Wallichia* no distinct flowering season were recorded. In almost all the species among these genera flowering starts once in their lifetime after attaining maturity. Among the pleonanthic palms, *Phoenix* flowering season commences from December and continues up to February when both the staminate and pistillate palms produce inflorescences. In one or two exceptional cases, late emergence of inflorescence has also been noticed. For instance, *Phoenix rupicola,* one of the most beautiful palms of Himalayan region, the flowering period commences from late March to April or sometimes in May (Fig. 70,71). The staminate and pistillate inflorescences in all other species of *Phoenix* emerge in quick succession from the leaf axil and appear as whorl of inflorescences. Anthesis in male and female flowers in the respective inflorescences occurs almost immediately with the unfurling of the solitary prophyll. The flowering season and emergence of inflorescence in *Borassus flabellifer* commences from March and continues up to July. The staminate and pistillate inflorescences in this palm also emerge in quick succession similar to that of *Phoenix*. Very late emergence of inflorescences however is not uncommon in *Borassus flabellifer* where, the flower branches being axillary to bracts, they take some time to emerge out of the respective bracts. In most cases only the fertile portion of the rachilla gets exposed and the sterile base remains hidden within the sheathing bract. The flower buds once exposed rapidly develop and commence anthesis in the male flower of male rachilla that takes place in besipetal sequence and in characteristic spiral fashion. It takes 4–5 days for completion of anthesis in males. The exact period of receptivity in the female flowers could not be ascertained due to unapproachable height of the tree. However, a few periodic collections from young palms showed that almost all the female flowers in a rachilla open during the early hours of the day. The late evening collection in *Borassus flabellifer* showed drying of the stigma. Movement of ant and the presence of aphids on the female flowers are conspicuous. It could not be determined whether these creatures play any part with the floral biology as *Borassus flabellifer* palm is reported to be anemophilous. *Areca catechu* is a monoecious palm with male and female flowers occurring on the same inflorescence. Every year 3–4 inflorescences are produced. The first inflorescence on the young palms may produce only male flowers. The male flowers open for a few hours, shedding the pollens mostly in the morning; honey bees and other insects were found to visit the flowers. The average period for male flowering is 2–3 weeks. After the male anthesis, the stigma in the female flowers mostly positioned at the proximal part of the rachilla become receptive for 3–4 days. Although male flowers are visited by bees probably by the attraction of nectar, they do not visit female flowers, may be as reported to be wind pollinated. Among the Coryphoids, the most common cultivated palm is *Livistona chinensis* whose emergence of inflorescence takes place in colder month of December and continue normally to the end of January or rarely up to February. In exception, *Livistiona jenkinsiana*, most popular native palm of north east, emergence of inflorescence takes place during September to October and fruits mature during March to April. Fruits that drop from the infrutescences and the seeds are germinated spontaneously after some rains at the onset of hotter months from March – April. Birds and other small animals eat the fruits that help in dispersal of the seeds to the distant places. In *Licuala peltata*, another wild palm of this region emergence of inflorescence takes place in September to November and fruits mature in April and May (Fig. 69). In this species 4–6 inflorescences develop almost simultaneously in one flowering season. In a peculiar mode all the inflorescences rise from the respective leaf axils by the extension of the petiole and the rachis and reach high above the canopy of the crown of leaves. Solitary rachilla from each of the axis of the bracts remains pendulous and the main axis of the inflorescence remains erect till the fruits mature. Among Calamoids, excepting the genus *Korthalsia* in all other genera such as *Calamus, Daemonorops* and *Plectocomia* of these region male and female flowers are borne on different plants. The mode of flowering is either hapaxanthic or pleonanthic. In hapaxanthic flowering, inflorescence emerge from the uppermost node of the mature stem after cessation of vegetative growth and the stem dies after flowering and maturation of fruits. In the suckering form the plant do not die because the immature shoots from the base do not die and continue to grow until maturity. The genus *Plectocomia* is the best example of hapaxanthic flowering among canes of Darjeeling-Kalimpong Himalaya. In pleonanthic mode of flowering in canes, the growing stem at maturity produces axillary inflorescences in each flowering season and the cane do not die after maturation of fruits. All indigenous species of *Calamus* and *Daemonorops* are pleonanthic and their flowering starts in colder season and continued to spring and fruiting takes place just before or during monsoon. The number of staminate and pistillate inflorescences in these two genera vary from 3–5. In *Calamus* and *Daemonorops,* fusion of peduncle and the stem is more pronounced. At maturity, inflorescences emerge from the leaf axils or from a position obliquely opposite to the petiole of the next higher leaf. Peduncle is free in *Plectocomia* and its flowering is terminal depending on the maturity of the shoot. In almost all cirrate canes like *Plectocomia,* the axial portion of the inflorescence is very long and armed with claws, hooks etc. The fertile portions are usually compact and shorter than leaves. The branching pattern of inflorescences of all the canes of this region may not be visually identical but they follow a basic morphological design. *Cocos nucifera* has the most prolonged flowering season, which produces one inflorescence almost every month. In *Areca catechu*, *Areca triandra, Areca nagensis, Pinanga gracilis* the position of the inflorescence always remain infrafoliar at emergence. Inflorescence buds in these palms grow to a great extent while still enclosed within the leaf sheath and exposed only by the shedding of the corresponding leaves. Therefore, in these palms the number of inflorescences that emerge in a flowering season depends entirely on the number of leaves shed in consequence of the new leaves unfurled during the growing season. As most of the Caryotoid palms are hapaxanthic, there is no distinct flowering season. The terminal or the first inflorescence in hapaxanthic species of *Arenga pinnata, Arenga westerhoutii, Caryota urens, Caryota obtusa, Caryota maxima, Wallichia disticha, Wallichia densiflora, Wallichia triandra* emerge in continuation of the main axis which depends on the maturity of the tree as a whole irrespective of seasonal influence. However, it has been observed that the subsequent emergence of axillary inflorescences is mostly governed by seasonal influence. The dormant axillary inflorescence buds tend to develop more in hotter months than in the colder. Female flowers in pistillate inflorescence are generally active only from the early hours till evening whereas male flowers are highly deciduous and start dropping from midday. In *Arenga micrantha,* the primary inflorescence which is invariably terminal shows almost female expression. A maximum number of large fruits develop on this inflorescence. As the emergence of inflorescence in this species is besipetal, the bunch younger to the terminal one comes out of the axils of the leaf immediately below the terminal inflorescence. The second inflorescence also produces only female flowers. In the next one or two inflorescences, rudimentary male flowers may be seen, two bordering a female flower. At a still lower level, the size of female flowers gets reduced and male flowers become more and more defined. At a further lower level, female flowers are absent and each flower cluster has only two males. In some cases a cluster is left with a single male flower only. Thus coming down from the terminus of the palm, and with the time, female expression steadily gives place to male expressions.

Towards the last stage of the tree, even the male inflorescence does not produce fully developed male flowers. In *Caryota urens* the terminal inflorescence develops on maturation of the tree, the subsequent inflorescences are interfoliar or infrafoliar, developing from the lower leaf axils. Normally 8 – 10 inflorescences develop in a single tree within a span of 12 months. Those inflorescences developing in higher leaf axils and the terminal one bear fruits. Flower clusters in triads are spirally arranged on flowering spike that hang in bunch from the peduncle like horse tail. In a triad the female flower takes the central position and the two males on both sides. Anthesis takes place first in the male flowers followed by the female flower. Thus an inflorescence always remains as functionally unisexual. Flowers of *Corypha* (talipot) palms are bisexual, *i.e.* they have the male (staminate) and female (pistillate) organs in the same plant. Fruits and seeds are developed from the pistillate flowers after successful fertilization through pollination by insect and birds. The genus *Corypha* locally called suicide palms because it produces terminal inflorescence once in a life time and after the maturity of fruits the plants dies.

The staminate and pistillate inflorescences in *Wallichia disticha* and *Wallichia densiflora* are borne in the same plant at different position. *Wallichia disticha* which is tall and has arborescent habit where flowering on terminal inflorescence emerge first that bears predominantly female flowers followed by the axillary inflorescences in basipetal order like all other palms of this group. Though in *Wallichia* there is no specific flowering season but the emergence of inflorescences occur mostly during summer or in spring. Unlike *Arenga* and *Caryota*, in *Wallichia* the terminal female inflorescence and axillary male flower bearing inflorescences are different in shape. In *Wallichia densiflora* the axillary male inflorescences have larger bracts aggregated in a bell form with a narrow opening enclosing the filiform male flower bearing branches. Male flowers are highly caducous at anthesis.

However, for better understanding of the flora and vegetation of the palms of West Bengal, the phenological study for selected species were under taken. During present investigation it was taken as an important aspect for observation on various phenological phases and then aggregated and analyzed.

6.3. Result and Discussion

The phenology of various indigenous palms and rattans species that are growing in the Darjeeling – Kalimpong Himalaya, Terai – Duars, Western undulating highland and plateau, North and South Bengal plains and Gangetic Delta of West Bengal have been attempted in this dissertation work. As much as 49 species of indigenous and 40 species of introduced palms were chosen and observation has been made during full period of 2013–2018. During the study a huge data have been collected regarding the growth and different successive stages of their life cycle *in vivo*.

6.3.1. Habit groups

After the comprehensive phenological survey, it has been noted that palms could be classified into 3 major categories on the basis of their habit groups, namely: **(i)** ***Cluster forming palms*** (*Borassus flabellifer, Cocos nucifera, Phoenix sylvestris, Livistona jenkinsiana* etc.) **(ii)** ***Underground palms*** (*Phoenix acaulis, Phoenix paludosa, Chamaedorea elegans, Raphis humilis, Raphis excelsa* etc.) **(iii)** ***Climbing palms*** (*Calamus, Daemonorops jenkinsiana, Daemonorops teraiensis, Plectocomia himalayana* etc.)

6.3.2. Stem Architecture

The palms can be classified into four basic architectural models (Halle and Oldeman 1970).

a. Unbranched monocarpic palms (Holtrum's model): These groups of palms are characterized by means of single erect stem without any branches which gives flower once in a lifetime and bear monocarpic fruits. *Wallichia caryotoides, W. disticha, W. oblongifolia, Corypha utan, C. tailera, C. umbraculifera, Caryota obtusa, C. urens* and

Caryota mitis are the unbranched monocarpic palms have been recorded from the study area.

b. Unbranched polycarpic palms (Corner's model): This group of palms are characterized by means of bearing single branchless erect stem where flowering occurs several times in a lifetime and bear polycarpic fruits. *Cocos nucifera, Areca catechu, A. triandra, Elaesis guinensis* are the unbranched polycarpic palms recorded from the study area.

c. Branched palms (Tomlinson's model**)**: These are pleonanthic and characterized by means of many erect stem with branches. *e.g. Ptychosperma macarthurii, P. waitaianum, P. sanderianum Dypsis lutescence* or hapaxanthic *e.g. Pinanga gracilis, P. griffithii, Arenga micrantha* and *Metroxylon sagu.*

d. Dichotomously branched palms (Schoute's model**):** These groups of palms are characterized by means of dichotomously branch stems. *e.g., Hyphaene thebaica* and *Nypa fruticans*.

6.3.3. Growth phase, Growth Strategy and Habitat

6.3.3.1. Growth phases:

Growth strategies are the morphological and physiological response in a plant species to ecological constraints (Corner 1966; Dransfield 1978; Granville 1992; Basu 1992, 1994 and Henderson 2002). Various growth strategies of recorded palms and rattans species of West Bengal are elaborated below.

6.3.3.1. A. Single Stemmed palms:

Tall single stemmed palms of forest in West Bengal grow slowly as long as the palm reaches its canopy. As the growth occurs, the successive internode gets wider as the primary thickening meristem becomes progressively much massive. Through these phase gradient of light intensity is needed. *e.g. Phoenix sylvestris, Borassus flabellifer, Livistona jenkinsiana, Chamaedorea elegans, Livistona rotundifolia, Livistona jenkinsiana, Trachycarpus fortunei*.

6.3.3.1.B. Multi stemmed palms:

Palms with multiple stem having same growth strategy as single stemmed palms are *Nypa fruticans* and *Hyphaene thebaica.* However, it has been seen that *Phoenix sylvestris* and *Borassus flabellifer* also produce multi stemmed branches.

6.3.3.2. Vertical and Horizontal growth strategies

6.3.3.2. A. Single stemmed palm

Because of the constant size of the palm crown during the elaboration or elongation of the stem, the volume of the ecotope (Oldeman 1974; Wittaker 1973) during vertical growth of single stemmed palms fits a cylinder *e.g. Caryota urens, Caryota obtusa, Phoenix sylvestris, Corypha taliera, Borassus flabellifer*. On the contrary, the growth of the trees which constantly increase in diameter has volumes which are more or less a reserved cone. As a result, tall solitary stemmed palms are better adapted to fill thin gaps in the forests canopy than dicotyledons.

6.3.3.2.B. Multi stemmed palms

Palms with multiple stems have a vertical and horizontal growth strategy. Every individual stem is similar to single stemmed palm. The production of new stem on the same clump provides palm with the possibility to spread horizontally in rhizomatous and stoloniferous species. The most efficient palms are with rhizomes that spread and colonize the new places. An unusual sucker found to occur in *Pinanga gracilis, Raphis excelsa, Raphis humilis* etc. In those species, the largest stem of the clump bend under the ground and new clump are produced from the sucker which develop and roots form axillary buds (Granvillee 1978).

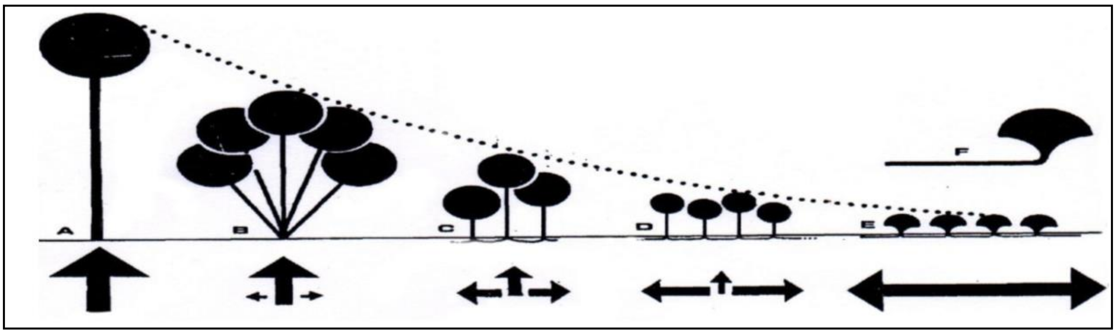

Fig. 66: Growth strategies of palms from vertical growth to horizontal growth **A.** Single stemmed palms with erect trunk **B.** Cespitose multi stemmed palms **C.** Medium sized rhizomatous palms **D.** Small rhizomatous palms **E.** Grasses and creeping **F.** Rhizomatous palms **G.** Procumbent single stemmed palms (Orastom 1991)

6.4. Habitat:

6.4.1. *Himalaya:* Darjeeling and Kalimpong Himalaya are the parts of Himalayan hotspot which varies from place to place mainly due to the altitude, aspects, exposure to plains. *Calamus guruba, C. tenuis, C. flagellum, C. acanthapathus, Daemonorops jenkinsianus, D. teraiensis, Phoenix rupicola, P. loureirii, Pinanga gracilis* commonly grows in sub-tropical and tropical forests of hill slops, riverine forest of lower hills of Darjeeling and Kalimpong districts in between the altitudinal ranges from 200 – 1000 m. The most palm and cane species rich area includes the Lower Neora valley National parks, Bindu, Jaldhaka, Gorubathan, Malli of Kalimpong Himalaya and upper hilly areas of Mahananda Wildlife Sanctuary, Latpanchar, Mirik, Kalijhora, Muktikhola, Dudhiha, Panighata, Teesta bazaar and various Tea garden adjoining areas of an altitude upto 1000 m of Darjeeling Himalaya. *Trachycarpus fortunei, T. martiana, Phoenix rupicla, Wallichia densiflora, Caryota, urens, Caryota obtusa* are the large tall - Stemmed Palm found in the areas of Sevok, Latpanchor, Darjeeling and upper middle hill forests upto 2000 m of altitude. *Caryota urens* and *Caryota obtusa* have been found in cold temperate forests of an altitude up to 3000m.

6.4.2. *Terai & Duars:* Terai and Duars are spreading through the districts of Jalpaiguri, Alipurduar, and upper region of Cooch Behar and plains of Darjeeling Himalaya. *Jaldhaka, Murti, Sankosh, Torsha, Dyna, Karatowa, Kaljani* and *Raidak* are some of the rivers crossing the Dooars. *Calamus guruba, C. tenuis, C. flagellum, Daemonorops jenkinsianus D. teraiensis, Phoenix sylvestris, Borassus flabellifer, Pinanga gracilis Caryota obtusa, Caryota Urens* are the common species found in foot hill forests of Terai and Duars from 80 m upto 100 m.

6.4.3. *Open scrubs and forests of plains:* The river Ganga divides the West Bengal plain into North and South Bengal plains. North Bengal plains include Uttar and Dakshin Dinajpur and Maldah districts. On the other hand, South Bengal plains include Murshidabad, Nadia, Birbhum, Hooghly, Howrah and some parts of Burdwan, Bankura, E & W Medinipur, N & S 24-Parganas districts. *Phoenix sylvestris, Phoenix acualis, Areca catechu, Borassus flabellifer, Cocos nucifera, Corypha utan, Calamus tenuis* are found in this region

6.4.4. *Plateau and lower hills:* The entire Purulia district and western part of Bardhaman, Bankura and E & W Medinipur districts constitute the western undulating uplands and plateaus. This area is the extension of Chotonagpur plateau. Among the hills rising above the general level of plateau Ayodhya, Panchet, Bagmundi of Purulia district and Susunia and Biharinath of Bankura district are worth mentioning. Gargaburu of Ayodhya hills is the highest peak (677 m) of this region. *Phoenix sylvestris, P. acaulis, Areca catechu, Borassus flabellifer, Cocos nucifera, Calamus tenuis* are the dominant palm species mainly found in these region.

6.4.5. *Mangroves:* The Gangetic delta includes Sundarban area in North and South 24 Parganas district. The area has many creeks and tracts of lowland, marshy places and wide river openings. Soil is usually saline. Sandy soil predominates on islands, river beds and on the bay coast. *Phoenix paludosa* and *Nypa fruticans* are common palms found in sundarban. The bushes of *Phoenix paludosa* is a suitable places for birthing and hunting of Royal Bengal Tiger. Apart from these two species, *P. sylvestris, P. dactylifera, Areca catechu, Borassus flabellifer, Cocos nucifera* are also found upto lower Bengal as well as outer part of mangrove forest.

6.5. Growth Forms: Growth forms are the morphological and physiological characters of plant species (Corner 1966; Dransfield 1978; Granville 1992). In the present study eight types of growth forms were recorded in 50 indigenous and 48 cultivated palm and rattan taxa (Fig 66 & Table.17, 18).

Table 17: Various growth forms in recorded taxa

Sl. No	Growth Forms	Genus
1.	Large Tall–Stemmed Palms	*Caryota, Trachycarpus, Borassus, Cocos, Calamus, Pritchardia, Sabal* and *Roystonea*
2.	Large–Leaved Medium Short–Stemmed Palms	*Licuala, Phoenix, Pinanga*
3.	Medium–Size Palms	*Areca, Phoenix, Livistona, Dypsis*
4.	Medium/Small Palms with stout stems	*Arenga, Wallichia, Sabal, Butia*
5.	Small Palms	*Phoenix, Pinanga, Chamaedorea, Raphis*
6.	Large Acaulescent Palms	*Wallichia*
7.	Small Acaulescent Palms	*Nypa fruticans*
8.	Climbing Palms	*Calamus, Daemonorops, Plectocomia*

Each growth form, the palms species were classified as either solitary or cespitose. Further division is largely based on maximum size of the leaves, absence or presence of an aerial stem, length and diameter of the aerial stem.

Table 18: Growth forms of palms in West Bengal

Palm Growth form	Stem height (m)	Stem diam. (cm)	Leaf size (m)	Stem development	Self-supporting/ Climbing
Large Tall-stemmed	20 – 35	18 – 100	2.6 – 12	Caulescent	Self supporting
Large-leaved Medium	1 – 20	14 – 26	3 – 12	Caulescent / Acaulescent	Self supporting
Medium-sized	6 – 16	12 – 15	2 – 4	Caulescent	Self supporting
Medium/small with stout stems	1 – 20	25 – 65	2 – 5	Caulescent	Self supporting
Small	0.6 – 8	0.3 – 12	0.2 – 2.8	Caulescent	Self supporting
Large Acaulescent	0.15 – 0.4	0.3 – 0.5	3 – 3	Acaulescent	Self supporting
Small Acaulescent	0 – 0.3	0 – 0.1	1 – 3	Acaulescent	Self supporting
Climbing	3 – 32	0.5 – 6	1 – 3	Acaulescent	Climbing

6.5.1. Large Tall - Stemmed Palm

This group of palms has tall stems about 25 – 40 m long and 15 – 91 cm in diameter. Large tall- stemmed palms are identified by their height and stem diameter, leaf size varies greatly from one group to another. Some species like *Caryota urens, C. obtusa, C. mitis, Trachycarpus fortune, T. martianus, Prichardia pacifica, Royastonea regia, Sabal mauritiformis* etc. are Large tall stemmed Palm and were usually found in gaps between large trees. *Trachycarpus fortunei, T. martiana, Caryota urens* and other species of *Caryota obtusa, C. urens* and *C. maxima* found in the forests on terai regions and hill slopes of Kalimpong and Darjeeling district.

6.2.2. Large – Leaved Medium – Short – Stemmed Palms

Palms of this group have medium-short stems with about 1 – 25 m long and usually 16 – 26 cm in diameter. Short - stemmed palms may be sub-acaulesent with the stems not more than 1 – 2 m long and entirely covered with the sheaths of dead leaves and leaves were 2 – 12 m long in adult plants. *Licuala peltata, Phoenix acaulis, Pinanga gracilis* and *P. griffithi* were the large leaved medium short stemmed palms. The leaf of the *Phoenix acaulis* is 1 – 2.8 m long whereas *Pinanga gracilis* is 2 – 2.5 m. *Licuala peltata* is a sub-acaulescent palm which has large leaved with short stem.

6.5.3. Medium – Sized Palms

This group of palms have medium sized stem with about 7 – 9 m long, 10 – 14 cm in diameter, leaves 2 – 6 m long. *Areca triandra, Phoenix loureirii, Pinanga gracilis, P. griffithii, P. hookeriana, Livistona jenkinsiana* and few naturalised species like *Dypsis decary, Livistona saribus, Elaesis guineensis, Licuala spinosa, L. grandis etc.* are medium sized palms.

6.5.4. Medium/Small Palms with stout Stems

These palms have stems, 30 – 65 cm in diameter which significantly enlarged by persistent skirt of dead leaf. *Arenga nana, Arenga pinata, Wallichia disticha, Sabal paletto Butia capitata, Bismarkia nobilis* are the medium/small palms with stout stems.

6.5.5. Small Palms

These palms have small stems, 0.1 – 10 m long, 0.6 – 15 cm in diameter. In West Bengal *Pinanga gracilis* are the small palms which grow in Jalpaiguri, Darjeeling and Kalimpong districts, similarly *Phoenix acaulis* mainly found in Birbhum and Bankura districts of Western highland and plateau. *Chamaedorea elegans, Raphis excels, R. humilis* are the cultivated small palms which are used in landscape purpose in various parks and public gardens.

6.5.6. Large Acaulescent Palms

Large Acaulescent palms have sub-terrian stem that never grows above the ground and bears large leaves of 5 – 10 m long. *Wallichia densiflora* and *Wallichia carytoides* are the acaulescent palms common in Kurseong and Darjeeling Himalaya of West Bengal

6.5.7. Small Acaulescent Palms

Stems of *small acaulescent* palms were apparently absent and subterranean or much short to conspicuous, leaves more than 2 – 5 m long. These palms were found in understory of estuarine mangrove forest and understory of lowland forest. *Nypa fruticans* is a small acaulescent palm which grows in Gangetic delta region of West Bengal.

6.5.8. Climbing Palms

Stem of climbing palms and canes are unable to grow vertically without support, except seedling and juvenile stages. In West Bengal climbing rattans includes 23 species representing three genera. *Calamus* with 17 species whereas *Daemonorops* and *Plectocomia* having two and three species respectively and *Salacca* with one species. Maximum climbing cane species recorded from Darjeeling-Kalimpong Himalaya and terai – duars region of Northern West Bengal. *Calamus acanthospathus, C. arborescens, C. flagellum, C. floribundus, C. gracilis, C. guruba, C. tenuis, C. viminalis* are the ecirrate climbing palms of tarai and duars of West Bengal. *Calamus acanthospathus* known as *gouri bet* is a strong climbing cane found in lower and middle hill forests upto 600m height. *Calamus tenuis* was the cirrate climbing cane locally known as *pulti* or *phekri bet*, which is common and widely spread from lower hills of terai – duars to Western undulating highland and Plateau. *Calamus leptospadix* locally called *danger bet* is common in the valleys of lower hills forests, especially in very damp places along the rivers. *Calamus inermis*, *C. latifolius, Daemonorops jenkinsiana, Plectocomia himalayana, P. bractealis* are the cirrate climbing palms of West Bengal. *Daemonorops jenkinsiana* and D. *teraiensis* are locally called *duhia, boro, danger bet* and *Kanra bet* mainly found in the mixed forest of terai and lower hill forests upto 700m of altitude. *Plectocomia himalayana* and *P. bractealis* are locally called *tokri bet* which are very common scandent rattans of middle and upper hills forests (700–1500 m).

6.6. Phenophases of studied palms and canes

The following phenological parameters were studied during the survey:

1. Period of seedling appearance or sprouting
2. Period of Flowering
3. Pollination method
4. Period of Fruit ripening and seed dispersal
5. Period of death or rest

Month wise, all the above mentioned phenophases for palm and canes were observed from different habitats in the entire study area. Sometimes, little variation has been observed in different location for same species and the total period has been considered in such cases. The pollination patterns of palms were found very interesting. Two major pollination modes have been found to be recognized among the West Bengal palms, namely anemophily and anemo – entomophily.

The nature and time of seedling appearance is somehow different from terrestrial plants. During phenological study of palms it was noted that maximum number of palms seedling appear during April to December. Those species, which appear from bulb, rhizome, rootstalk etc., the phenomenon of new flash or new shoot appearance is considered as the start of new life cycle.

Phenology covers different stages in the life of a plant. It starts from germination or sprouting after a resting period and ending with the death or entering into the next rest period (Table 23). It is true for almost all plants and is directly related with the set of total environmental conditions. The result of the present investigation is presented below considering such stages separately.

6.7. Flowering

The vegetative phases are ending or interrupted by the initiation of the indigenous palms reproductive state *i.e.* flowering. It has been recorded that the most interesting periods are March – January when highest number of palms (rattans) found in blooming to fruiting stage. The peak month is March to April when 19 palms were recorded in their flowering and fruiting condition followed by July to November (09 species) and January to May (11 species). There are 6 species like *Caryota urens, Caryota mitis* and *Caryota obtusa, Wallichia densiflora, Wallichia disticha* , and *Wallichia caryotoides* those extend their flowering phase once in a lifetime. Phenology, life forms, habit groups and modes of pollination of 89 species have been recorded (Table 22).

6.8. Pollination

Pollination is one of the important phases towards the reproduction of palms like other plants. Pollination leads to successful fertilization that is essential for production of proper mature seeds. The two major pollination types *i.e.*, Entomophily and Anemo –

Entomophily (Table 19) are common for palms. From the direct field observation of 89 species (49 indigenous and 40 introduced) of palms, it has been recorded that 31 (34.83%) species are *Entomophilous* (Fig. 67) followed by 58 species (65.16%) *Aanemo–entomophilous* (Table 20).

Table 19: Numerical distribution of different categories of palms pollination

Sl. No.	Pollination type	Species	Percentage (%)
1.	Entomophilous	31	34.83
2.	Anemo – Entomophilous	58	65.16

Table 20: Pollination Type of indigenous and introduced palms in West Bengal

Sl. No.	Taxa	Pollination Type	Sl. No.	Taxa	Pollination Type
1.	*Areca catechu*	Entomophily	46	*Plectocomia bractealis*	Entomophily
2.	*Areca triandra*	Entomophily	47	*Plectocomia himalayana*	Entomophily
3.	*Arenga micrantha*	Entomophily	48	*Salacca sacunda*	Entomophily
4.	*Archontophoenix alexandrae*	Entomophily	49	*Trachycarpus fortunei*	Animo-entomophily
5.	*Archontophoenix cunninghamiana*	Entomophily	50	*Dypsis adagascariensis*	Animo-entomophily
6.	*Areca concinna*	Entomophily	51	*Dictyosperma album*	Animo-entomophily
7.	*Areca macrocalyx*	Entomophily	52	*Trachycarpus martianus*	Animo-entomophily
8.	*Arenga caudata*	Animo-entomophily	53	*Dypsis lutescens*	Animo-entomophily
9.	*Arenga engleri*	Animo-entomophily	54	*Elaeis guineensis*	Animo-entomophily
10.	*Arenga obtusifolia*	Animo-entomophily	55	*Heterospathe elata*	Animo-entomophily
11.	*Arenga undulatifolia*	Animo-entomophily	56	*Hydriastele microspadix*	Animo-entomophily
12.	*Acoelorraphe wrightii*	Animo-entomophily	57	*Hyphorbe lagenicaulis*	Animo-entomophily
13.	*Borassus flabellifer*	Entomophily	58	*Hyphorbe vershaffeltii*	Animo-entomophily
14.	*Bactris major*	Entomophily	59	*Hyphaene bussei*	Animo-entomophily
15.	*Bismarckia nobilis*	Animo-entomophily	60	*Hyphaene thebaica*	Animo-entomophily
16.	*Calamus erectus*	Entomophily	61	*Latania loddigesii*	Animo-entomophily
17.	*Calamus flagellum*	Entomophily	62	*Licuala grandis*	Animo-entomophily
18.	*Calamus gracilis*	Entomophily	63	*Livistona chinensis*	Animo-

					entomophily
19.	*Calamus guruba*	Entomophily	64	*Livistona rotundifilia*	Animo-entomophily
20.	*Calamus leptospadis*	Entomophily	65	*Livistona saribus*	Animo-entomophily
21.	*Calamus leptospadix*	Entomophily	66	*Lodoicea maldivica*	Animo-entomophily
22.	*Calamus longisetus*	Entomophily	67	*Normanbya normanbyi*	Animo-entomophily
23.	*Calamus nambariensis*	Entomophily	68	*Phoenix reclinata*	Animo-entomophily
24.	*Calamus pseudoerectus*	Entomophily	69	*Phoenix roebelenii*	Animo-entomophily
25.	*Calamus tenuis*	Entomophily	70	*Phoenix pusilla*	Animo-entomophily
26.	*Calamus viminalis*	Entomophily	71	*Pritchardia pacifica*	Animo-entomophily
27.	*Caryota mitis*	Entomophily	72	*Ptychosperma elegans*	Animo-entomophily
28.	*Caryota obtusa*	Entomophily	73	*Ptychosperma macarthurii*	Animo-entomophily
29.	*Caryota urens*	Entomophily	74	*Ptychosperma waitianum*	Animo-entomophily
30.	*Cocos nucifera*	Entomophily	75	*Raphis excelsa*	Animo-entomophily
31.	*Chamaedorea elegans*	Entomophily	76	*Raphis humilis*	Animo-entomophily
32.	*Daemonorops jenkinsianus*	Entomophily	77	*Roystonea borinquena*	Animo-entomophily
33.	*Daemonorops teraiensis*	Entomophily	78	*Roystonea oleracea*	Animo-entomophily
34.	*Latania loddigesii*	Animo-entomophily	79	*Roystonea regia*	Animo-entomophily
35.	*Licuala peltata*	Animo-entomophily	80	*Sabal mauritiformis*	Animo-entomophily
36.	*Livistona jenkinsiana*	Animo-entomophily	81	*Thrinax parviflora*	Animo-entomophily
37.	*Nypa fruticans*	Animo-entomophily	82	*Trachycarpus fortunei*	Animo-entomophily
38.	*Phoenix acaulis*	Animo-entomophily	83	*Veitchia merrillii*	Animo-entomophily
39.	*phoenix loureirii*	Animo-entomophily	84	*Washingtonia filifera*	Animo-entomophily
40.	*Phoenix paludosa*	Animo-entomophily	85	*Washingtonia robusta*	Animo-entomophily
41.	*Phoenix rupicola*	Animo-entomophily	86	*Wallichia caryotoides*	Animo-entomophily
42.	*Phoenix sylvestris*	Animo-entomophily	87	*Wallichia oblongifolia*	Animo-entomophily
43.	*Pinanga gracilis*	Animo-entomophily	88	*Wallichia disticha*	Animo-entomophily
44.	*Pinanga griffithi*	Animo-entomophily	89	*Wallichia triandra*	Animo-entomophily
45.	*Plectocomia assamica*	Entomophily			

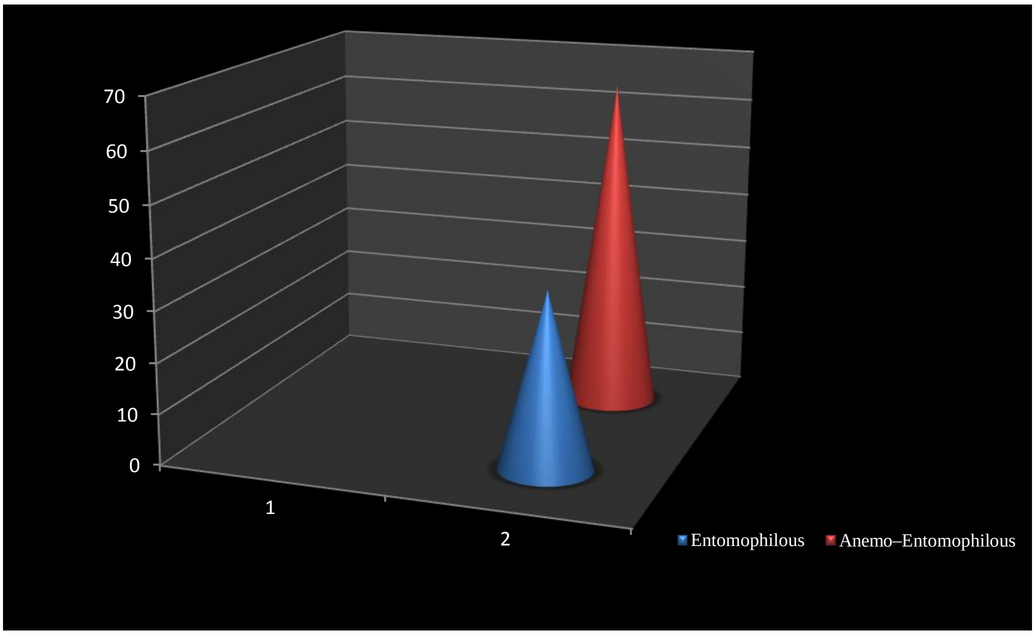

Fig. 67: Graphical representation shows % of the pollination of palms

6.9. Pollen morphological study of some members of Arecaceae

Pollen morphology is potentially informative in the systematic of monocotyledons as well as Arecaceae (Palmae). The pollen morphology of palms including rattans species mainly shows the qualitative pollen characters like exine ornamentation, aperture, and shape. These are found to be taxonomically highly valuable as compared to the quantitative characters like exine thickness and size of pollen grain. The pollen grains of selected 23 species belonging to 18 genera under 8 tribes of 4 sub-families were investigated to understand their unique ultra-morphology. On the basis of aperture type, 2 distinct types of grains were observed, monosulcate and disulcate. All the grains were monad. Majority of the grains were monocolpate (16 taxa) and only 5 species were disulcate viz., *Wallichia densiflora, Dypsis lutescens, Daemonorops jenkinsiana, Licuala peltata* and *Calamus guruba.*

The pollen grains of 23 species of Arecaceae were investigated to understand their unique micromorphology. The greatest variation occurs in exine ornamentation that range from psilate (most primitive type) to verrucate (the most advance type). Intraspecific variations in pollen morphology were noticed among the grains. This involved shape and ornamentation of individual grains e.g. *Areca catechu* and *Areca* *triandra*, *Caryota urens* and *Caryota obtusa*, *Calamus guruba* and *Calamus arborescens*.

Pollen grains are generally isopolar (12 taxa), heteropolar (3 taxa), para-isopolar (2 taxa) except in *Areca catechu* and *Chamaedorea elegans*, where both are apolar type.

The grain also shows variations in symmetry, majority of the grains are bilaterally symmetrical (13 taxa). Radially symmetrical (3 taxa) and asymmetric grains (6 taxa) are also found in the family. The grain shows various shapes in their equatorial view such as elliptic (12 taxa), prolate (4 taxa), sub-prolate (2 taxa) spherical (1 taxa) and oblate (4 taxa) as well as in polar view such as circular (5 taxa), triangular (2 taxa), elliptical (1 taxa), bean-shaped (2 taxa), sub-circula (2 taxa) and spheroidal (3 taxa).

The pollen grains examined are usually thick in exine texture. Psilate (9 taxa), regulate (3 taxa), reticulate (5 taxa), echinate (2 taxa), faveolate (1 taxa), striate (2 taxa) and annulate (1 taxa) are recorded from the study. However based on aperture type, 2 distinct types of grains are recognized. Majority of the grains are monosulcate (17 taxa) and remaining 6 grains have disulcate type of pollen (Fig. 73,74).

From the current study it can be concluded that Arecaceae is a more or less stenopalynous family. Significant variation in pollen aperture and exine ornamentation has been observed. In addition most of the grains were isopolar, bilaterally symmetric, monosulcate which are globally distributed with various shape and size in both equatorial and polar view. All these characters indicate the family to be evolutionary primitive. The common characteristics of most of the grains of the family are similar with those found in Dasypogonaceae , another family placed in the order Arecales (according to APG-III system of classification of flowering plants,2009). Hence the study supports the latest system of classification of flowering plants and the family Arecaceae is closely related with Dasypogonaceae. So, the present pollen-morphological study of 23 species of Arecaceae proved that pollen grain shows wide range of characters those can be easily used for their characterization, identification and also for phylogenetic analysis.

6.9.1. Key to the species

1 a. Pollen grains disulcate……………………………………….………………..2

1 b. Pollen grains monosulcate .... *Areca catechu*

2 a. Pollen grains asymmetric 4

2 b. Pollen grains symmetric 3

3 a. Exine striate ....*Dypsis lutescens*

3 b. Exine psilate ....……….*Calamus arborescens*

4 a. Pollen grains heteropolar...................................…………. *Calamus guruba*

4 b. Pollen grains isopolar

(i) Exine striate ....………………… *Wallichia densiflora*

(ii) Exine psilate .... *Daemonorops jenkinsiana*

(iii) Exine regulate.............................. ……………………… ………….....5

5 a. Pollen grains asymmetric……………. .... ………………7

5 b. Pollen grains symmetric .... ……………....6

6 a. Pollen grains apolar……... *Chamaedorea elegans*

6 b. Pollen grains heteropolar

(i) Exine psilate……………. .... *Cocos nucifera*

(ii) Exine reticulate….............. ……………………………. *Roystonea regia*

7 a. Pollen grains isopolar

(i) Exine regulate………………………………………*Ptychosperma macarthuri*

(ii) Exine psilate………………………………….……. *Arenga porphyrocarpa*

7 b. Pollen apolar.. 8

8 a. Pollen para-isopolar

(i) Exine annulate ....*Pinanga gracilis*

(ii) Exine reticulate.. *Livistona australis*

8 b. Pollen isopolar

(i) Exine verrucate..*Borassus flabellifer*

(ii) Exine echinate ....*Nypa fruticans*

(iii) Exine faveolate...*Pritchardia pacifica*

(iv) Exine regulate..*Latania loddigessi*

(v) Exine psilate

(a) Pollen prolate in equatorial view .... *Caryota urens*

(b) Pollen elliptic in equatorial view............................... *Adonidia merrilii*

(vi) Exine reticulate

(a) Pollen elliptic to oval .... *Phoenix sylvestris*

(b) Pollen prolate to spheroidal...................................... ………………9

9 a. Pollen radially symmetrical..*Phoenix roebelenii*

9 b. Pollen bilaterally symmetrical...*Caryota obtusa*

6.9.2. DESCRIPTION OF POLLEN

6.9.2.a. Wallichia densiflora Mart.

Pollen is disulcate, isopolar, bilaterally symmetrical, EV: Elliptic; PV: Circular,sulci long, extending almost pole to pole; exine striate. Polar axis: 23.27µm; Equitorial diameter: 17.48µm; length of sulci: 19.22µm.

6.9.2.b. Nypa fruticans Wurmb

Monosulcate grains, isopolar, radially symmetrical, EV: Prolate; PV: Circular, sulci long, narrow, almost extending end to end; exine echinate. Polar axis: 39.78µm; Equitorial diameter: 30.15µm; length of sulci: 22.49µm.

6.9.2.c. Roystonea regia (Kunth) O. F. Cook

Monosulcate grains; monad, hetropolar, asymmetric, EV: Sub-prolate, sulci long, broad, extending almost end to end, narrow tapering ends; exine: reticulate; Equitorial diameter: 19.28µm; length of sulci: 27.11µm.

6.9.2.d. Latania loddigessi Mart.

Grain is monad, monosulcate grains, isopolar, radially symmetrical, EV: Ellipsoidal, sulci long, extending end to end. Exine regulate; Equitorial diameter: 22.02µm; polar axis: 27.55µm; length of sulci: 25.91µm; exine thickness: 1.85µm.

6.9.2.e. Livistona australis (R. Br.) Mart.

Monosulcate grains, para-isopolar; bilaterally symmetrical, EV: Spheroidal; sulci long; spirally coiled, exine reticulate. Equatorial diameter: 22.79µm; length of sulci: 28.72 µm; thickness of exine: 2.06µm

6.9.2.f. Phoenix roebelenii P.R. O'Brien

Pollen is monosulcate; isopolar, bilaterally symmetrical; EV: Prolate to spheroidal; sulci long extending pole to pole; broad in the middle; narrow towards the end. Exine reticulate; Equitorial diameter: 30.75µm; exine thickness: 2.70µm.

6.9.2.g. Caryota urens L.

Monosulcate grains, isopolar, radially symmetrical. EV: Prolate; PV: Circular; sulci long, narrow, extending pole to pole; exine: psilate: Equitorial diameter 13.83µm; Polar axis: 22.77µm, length of sulci: 11.41µm.

6.9.2.h. Daemonorops jenkinsiana (Griff.) Mart.

Grain is disulcate; monad; isopolar; bilaterally symmetrical; EV: Ellipsoidal; exine regulate; sulci long, extending pole to pole; Equitorial diameter: 14.45µm; Polar axis: length of sulci: 15.04µm; exine thickness: 1.55µm.

6.9.2.i. Areca triandra Roxb. *ex* Buch.-Ham

Monad, monosulcate, para-isopolar; bilaterally symmetrical; EV: Elliptical: PV: Sub-circular; sulci long, broad, extending almost end to end; exine: annulate; Equitorial diameter: 20.27 µm; Polar axis: 41.83µm; length of sulci: 33.35µm; exine thickness: 1.83µm.

6.9.2.j. Ptychosperma macarthurii H.Wendel

Monosulcate grains; monad; isopolar; asymmetric; EV: Elliptic; PV: Spheroid; sulci long, extending end to end, broad; exine: regulate; Equitorial diameter: 29.75µm; Polar axis: 32.27µm; length of sulci: 38.36µm; exine thickness: 2.41µm.

6.9.2. k. Pritchardia pacifica Seem & H.Wendel

Monosulcate grains; isopolar; bilaterally symmetrical; EV: Oblate: PV: Bean shaped; sulci long, narrow; exine: faveolate; Equitorial diameter: 26.35µm; Polar axis: 31.36µm; length of sulci: 38.36µm; exine thickness: 1.12µm.

6.9.2.l. Licula peltata Roxb. *ex* Buch.-Ham.

Disulcate grains; monad; isopolar; bilaterally symmetrical; EV: Elliptical; PV: Triangular; sulci long; exine: regulate; Equitorial diameter: 13.81µm; length of sulci: 33.98µm; exine thickness: 1.17µm.

6.9.2. m. Cocos nucifera L.

Monosulcate grains; heteropolar; asymmetric; EV: Oblate; PV: Spheroidal to triangular; sulci long, extending almost pole to pole; broad in the middle, gradually tapering towards the end; exine: psilate; Equitorial diameter: 29.24µm; Polar axis: 33.78µm; length of sulci: 36.63µm; exine thickness: 2.19µm.

6.9.2.n. Dypsis lutescens (H. Wendl.) Bentje & J. Dransf.

Disulcate grains; isopolar; asymmetric; EV: Oblate; PV: Circular o spheroidal; sulci long; extending end to end; exine striate; Equitorial diameter: 21.84µm; Polar axis: 35.53µm; length of sulci: 36.44µm; exine thickness: 1.02µm.

6.9.2.o. Areca catechu L.

Monosulcate grains; apolar; radially symmetric; EV: Oblate; PV: Circular to spheroidal; sulci long; broad; exine: echinate; Equitorial diameter: 26.19µm; Polar axis: 31.69µm; length of sulci: 24.19µm; exine thickness: 1.05µm.

6.9.2.p. Phoenix sylvestris (L.) Roxb.

Monosulcate grains; isopolar; bilaterally symmetrical; EV: Elliptic to oval; PV: Kidney shape; sulci long; extending end to end; exine: reticulate; Equitorial diameter: 27.23µm; Polar axis: 32.17µm; length of sulci: 34.06µm; exine thickness: 2.18µm.

6.9.2.q. Arenga porphyrocarpa (Bl. *ex* Mart.) H. E. Moore

Monosulcate grains; isopolar; asymmetric; EV: Elliptic; sulci long; extending from pole to pole; narrow; exine: psilate; Equitorial diameter: 30.78µm; length of sulci: 31.76µm; exine thickness: 0.97µm.

6.9.2.r. Caryota obtusa Griff.

Monosulcate grains; isopolar; bilaterally symmetrical; EV: prolate to spheroidal; PV: Elliptic; sulci long; exine: reticulate; Equitorial diameter: 13.58µm; Polar axis: 26.55µm; length of sulci: 11.50 µm.

6.9.2.s. Chamaedorea elegans Mart.

Monosulcate grains; apolar; asymmetric; EV: Elliptic; PV: Triangular; sulci long, narrow, extending end to end; exine: psilate; Equitorial diameter: 27.35µm; Polar axis: 30.17µm; length of sulci: 30.09µm.

6.9.2.t.Calamus guruba Buch.-Ham. *ex* Mart.

Disulcate grains; heteropolar; bilaterally symmetric; EV: Sub-prolate; sulci long, broad, extending end to end; exine; psilate; Equitorial diameter: 26.54µm; length of sulci: 15.31µm; exine thickness: 2.93µm.

6.9.2.u. Calamus arborescens Griff.

Pollen disulcate; heteropolar; asymmetric, ellipsoidal in equatorial view; exine psilate, aperture narrow; Equitorial diameter: 24.44µm; length of sulci: 20.76µm.

6.9.2.v. Adonidia merrilli (Becc.) Becc.

Monosulcate grains; bilaterally symmetrical; isopolar; ellipsoidal in Equitorial view; exine psilate; aperture long, broad, extending end to end; Equitorial diameter: 25.05µm; length of sulci: 29.50µm; exine thickness: 1.46µm.

6.9.2.w. Borassus flabellifer L.

Monosulcate; isopolar; bilaterally symmetrical, elliptical in equatorial view, sub-circular in polar view; exine verrucate; Equitorial diameter: 24.63µm; length of sulci: 25.85µm; exine thickness: 1.45µm.

6.10. Fruit Ripening

After the pollination, ovaries get fertilized and finally modified into fruits. Usually, the pollination occurs during March to April but 19 palms were recorded of which 9 species shows flowering and fruiting period during April to July and rest of the 11 species from August to November. There are 6 species like *Caryota urens*, *Caryota mitis* and *Caryota obtusa*, *Wallichia densiflora*, *Wallichia disticha*, *Wallichia triandra* and *Wallichia caryotoides* those exhibit their fruiting phase once in a lifetime.

6.11. Palm Seed Germination

In field observation, it has been recorded that in West Bengal most of the palm seeds germinate and the minute embryo in the seed grows, the single cotyledon (seedling leaf) never expands and functions like a green assimilating blade, but remains partially or wholly enclosed within the seed itself and function as a hustorium to absorb nutrients of the endosperm. This special function of the cotyledon continues till the seedling is capable of uptaking nutrients from the soil by its own root system.

6.12. Dormancy in Palm Seeds

Unlike dicotyledonous seeds where dormancy is a natural process, in palm there is no true period of dormancy. The embryo which is embedded in the endosperm close to the seed coat dries up quickly and becomes incapable of germination if favorable condition does not prevail. Hence the period of dormancy of palm seeds is the length of time required to complete drying of the embryo after maturation of seed. The exact period of 'dormancy' is difficult to record because several internal and external factors are responsible for it. Among the internal factors, the thick endocarps cover delays drying process of the embryo. It has been found that the palms of the subtropical areas where there are marked seasonal changes, the embryo remains viable for a longer period, whereas in the humid tropics due to absence of seasonal change, the embryo looses viability quickly.

6.13. Types of Palm Seed Germination

According to the amount of extension of the cotyledonary structures following types of germination can be broadly recognized.

6.13.1. Remote Ligular

In this type of germination the cotyledonary petiole and the sheath with the ligule extend carrying the embryo out of the seed. The young seedling develops through the ligule. The remote ligular germination (Fig. 68) is common in most Coryphoid genera of palms. In *Borassus, Hyphaene* and *Lodoicea* the cotyledonary sheath may grow upto several meters into the ground before the development of shoot and roots. In *Borassus flabellifer* a succulent primary leaf is formed under the ground and is eaten as vegetable. Among 50 indigenous seedlings, 37 species has been recorded with remote ligular germination (Table. 21) e.g. *Caryota urens, C. obtusa, Cocos nucifera, Arenga micrantha, Wallichia carytoides etc.* On the other hand among 47 introduced palms, 25 species shows adjacent ligular germination e.g. *Dypsis lutescens, Ptychosperma macarthurii, Vitchia merrillii, Bractris major, Elaesis guieensis* etc.

Table 21: Seedling with Remote germination and treatment

Name	Humidity	Required water	Required sunlight	Suitable temperature	Germination date
Caryota maxima	50%	Water lover	Part shade to full sun	0º C~45ºC	6 - 12 months
Caryota mitis	50%	Water lover	Full shade or full sun	10ºC~45ºC	6 - 12 months
Caryota urens	50%	Water lover	Part shade to full sun	0ºC~40ºC	90-120 Days
Licuala grandis	80%	Water lover	Full shade or full sun	15ºC~45ºC	45 - 60 days
Livistona jenkinsiana	70%	Regular watering	Full shade or full sun	0ºC~40ºC	4 - 6 weeks
Livistona speciosa	60-70%	Regular watering	Gradual sun	0ºC~40ºC	4 - 6 weeks
Phoenix rupicola.	40%	Water periodically	Full sun	0ºC~40ºC	2 - 4 weeks
Phoenix acaulis	40%	Water sparingly	Full sun	0ºC~45ºC	2 - 4 weeks
Phoenix robelenii	40%	Water periodically	Part shade to full sun	10ºC~45ºC	2 - 6 weeks
Phoenix sylvestris	50%	Unfussy as to degree of watering	Full sun	0ºC~50ºC	2 - 4 weeks

6.13.2. Adjacent Ligular

In most palm genera of the subfamilies, Arecoideae and Calamoideae, the cotyledonary sheath does not grow longer but remain close to the seed and the young seedling leaves develop through the adjacent ligule. Among 50 indigenous palms seedlings 15 were recorded with adjacent ligular germination namely *Licuala peltata, Livistona jenkinsiana, Trachycarpus martianus, T. fortunei etc.* (Table 22). On the other hand among 47 introduced palms 22 were adjacent ligular, they are *Dypsis lutescens, Ptychosperma macarthurii, Vitchia merrillii, Bractris major, Elaesis guieensis* etc.

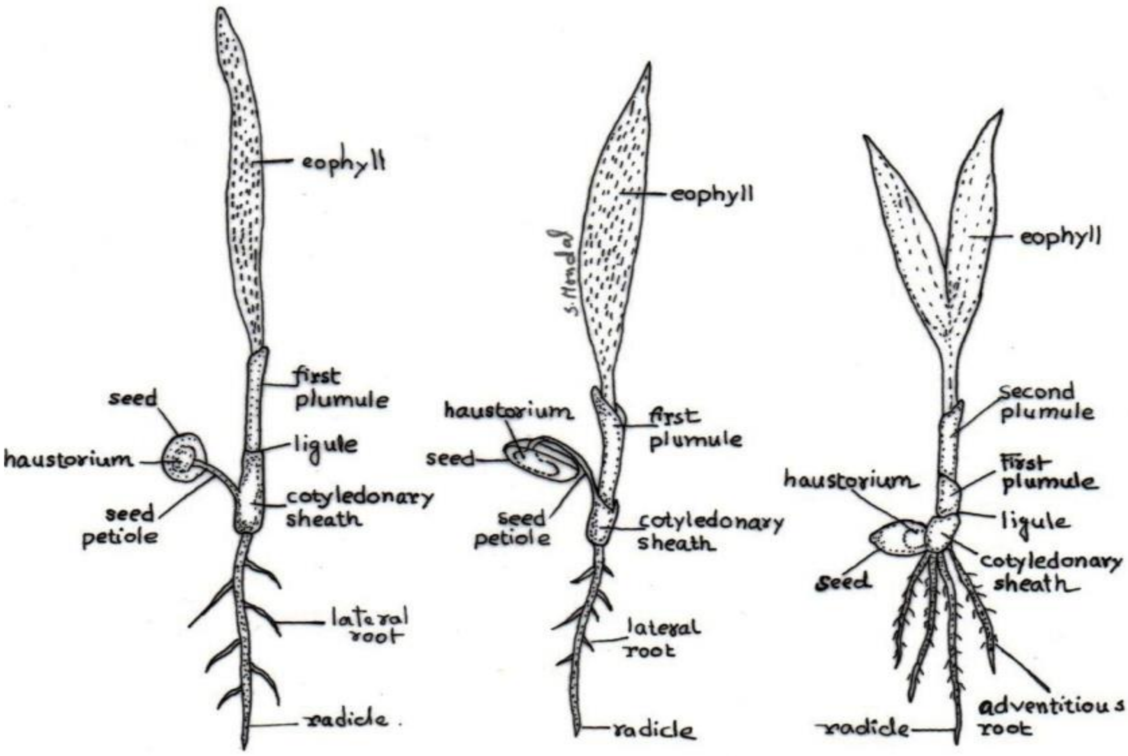

Fig. 68: Different types of Palms seedling

Table 22: Seedling with Adjacent germination

Name	**Humidity**	**Water Requirement**	**Requirement of Sunlight**	**Suitable Temperature**	**Date of Germination**
Archontophoenix alexandrae	60%	Regular water can withstand flooding well	Partial shade to full sunlight	10ºC~40ºC	4 - 12 weeks
Areca catechu	60%	Plenty of water	Semi shaded sites to full sunlight	15ºC~40ºC	45 - 60 days
Areca triandra	70%	Water lover	Partial shade to full sun	30ºC~35ºC	2 - 4 months
Arenga pinnata	60%	Adequate water	Partial shade to full sun	20ºC~40ºC	2 - 6 weeks
Bentinckia nicobarica	60%	Water lover	Partial shade to full sun	10ºC~40ºC	2 - 3 months

Carpentaria acuminata	50%	Water lover	Partial shade to full sun	8ºC~10ºC	2 - 3 months
Chamaedorea catractarum	70%	Water lover	Full shade to part sun	15ºC~40ºC	2 - 4 months
Cyphophoenix fulcita	80%	Water lover	Full shade to part sun		3 - 5 months
Dypsis decaryi	30%	Water sparingly	Full sun	5ºC~50ºC	2 - 3 months
Dypsis fibrosa	40%	Water sparingly	Full sun	10ºC~50ºC	2 - 4 months
Dypsis leocomalla	40%	Water sparingly	Full sun to partial shade	10ºC~50ºC	2 - 4 months
Dypsis lutescence	50%	Water lover	Part shade to full sun	10ºC~50ºC	2 - 4 months
Adonidia merrillii	80-90%	Requires moist but well drained soil	Full sun to partial shade	22ºC~32ºC	
Ptychosperma macarthurii	50%	Lives in or near water	Part shade or full sun	10ºC~45ºC	2 - 3 months
Roystonea regia	50%	Regular watering	Full sun	10ºC~40ºC	3 - 4 months
Wodyetia bifurcata	40%	Regular watering but can tolerate drought conditions	Full sun	15ºC~45ºC	1 - 3 months

Table 23: Phenology, Life forms, Habit groups and modes of Pollination for palms of West Bengal (Flowering Calendar) [Abbreviation used: LTSP = Large Tall- Stemmed Palm, LLMSSP = Large Leaved Medium Short Stemmed Palm, MSP = Medium Size Palm, M/SPSS = Medium/Small Palms with Short Stem, SP = Small Palm, LAP = Large Acaulescent Palm, SAP = Small Acaulescent Palm, cp/CP = Climbing Palm, CFP = Cluster Forming Palm, UP = Underground Palm]

Taxa	**Life forms**	**Habit groups**	**Germination**	**Flowering**	**Fruiting**
Areca triandra Roxb.	LLMSSP	CFP	AL	Feb – Jun	Sept – Nov
Areca catechu L.	LLMSSP	CFP	AL	Throughout the year	
Areca nagensis Griff.	LLMSSP	CFP	AL	Mar – Jun	Sept
Arenga nana Griff.	LLMSSP	CFP	AL	Mar	Apr
Borassus flabellifer L.	LTSP	CFP	RL	Mar – Apr	July – Sept

Calamus acanthospathus Griff.	cp	CP	AL	Mar – Apr	Aug – Nov
Calamus erectus Roxb.	cp	CP	AL	July – Aug	Nov – Dec
Calamus flagellum Griff.	cp	CP	AL	June	Sep – Oct
Calamus floribundus Griff.	cp	CP	AL	Apr – May	June
Calamus gracilis Roxb.	cp	CP	AL	Apr – May	Nov
Calamus guruba Buch-Ham	cp	CP	AL	Nov – Dec	Apr – May
Calamus hookerianus Becc.	cp	CP	AL	July – Aug	Apr – May
Calamus inermis Anders.	cp	CP	AL	Unknown	
Calamus khasianus Becc.	cp	CP	AL	Nov – Dec	Apr – May
Calamus kingianus Becc.	cp	CP	AL	Nov – Dec	Feb – March
Calamus latifolious Roxb.	cp	CP	AL	July	Feb
Calamus leptospadix Griff.	cp	CP	AL	May – June	Mar – Oct
Calamus longisetus Griff.	cp	CP	AL	Nov – Dec	Apr – May
Calamus nambariensis Becc.	cp	CP	AL	July	Feb
Calamus speudoerectus Mondal, Basu & Chowdhury	cp	CP	Al	Dec – Feb	Feb – May
Calamus tenuis Roxb.	cp	CP	AL	Sept – Oct	Apr – May
Calamus viminalis Willd.	cp	CP	AL	Nov – Dec	Apr – May
Caryota mitis Lour.	LTSP	CFP	RL	Palm flower once in its lifetime	
Caryota obtusa Griff.	LTSP	CFP	RL	Palm flower once in its lifetime	
Caryota urens L.	LTSP	CFP	RL	Palm flower once in its lifetime	
Cocos nucifera L.	LTSP	CFP	AL	Throughout the year	
Corypha macropoda Kurz	LTSP	CFP	AL	once in its lifetime	
Corypha taliera Roxb.	LTSP	CFP	AL	once in its lifetime	
Corypha umbraculifera L.	LTSP	CFP	AL	once in its lifetime	
Corypha utan Lamk.	LTSP	CFP	AL	once in its lifetime	
Daemonorops jenkinsiana Mart.	cp	CP	RL	July	Apr
Daemonorops teraiensis Mondal & Chowdhury	cp	CP	RL	Mar – May	Apr – June
Licuala peltata Roxb.	M/S	UP	RL	Sept – Nov	Apr – May

	PSS				
Livistona jenkinsiana Griff	M/S PSS	CFP	RL	Feb – March	Sept – Dec
Nypa fruticans Wurmb.	LAP	UP	AL	Sept – Nov	May – Jun
Phoenix acaulis Buch-Ham. *ex* Roxb.	SAP	UP	RT	Jan – May	June
Phoenixloureirii Kunth	SAP	UP	RT	Jan	Aug
Phoenix paludosa Roxb.	M/S-PSS	UP	RT	June – Jan	Feb
Phoenix rupicola Anders.	LTSP	CFP	RT	Apr/March	Sept
Phoenix sylvestris (L.) Roxb.	M/S PSS	CFP	RT	Dec – Jan	Apr – June
Pinanga gracilis (Roxb.) Bl.	M/S PSS	UP	AL	June – Sept	Jan
Pinanga griffitiihii Mart.	M/S SSP	UP	AL	Mar	May
Plectocomia assamica Griff.	cp	CP	AL	Mar	May
Plectocomia bractealis Becc.	Cp	CP	AL	Unknown	
Plectocomia himalayana Griff.	Cp	CP	AL	Mar – May	Not known
Plectocomia khasiyana Griff.	cp	CP	AL	Unknown	
Trachycarpus martianus (Wall. *ex* Mart.) Wendl.	LTSP	CFP	RT	Mar – Apr	Aug – Sept
Trachycarpus fortune (Hook.) Wendl.	LTSP	CFP	RT	Mar – May	Not Known
Trachycarpus latisectus Spanner, Noltie & Gibbons	LTSP	CFP	RT	Mar – Apr	Aug – Sept.
Wallichia caryotoides Roxb.	SAP	UP	AL	Palm flower once in its lifetime	
Wallichia oblongifolia (Griff.) Mart.	SAP	UP	AL	Palm flower once in its lifetime	
Wallichia disticha Anders.	MSP	CFP	AL	Palm flower once in its lifetime	

6.14. Propagation of palms

Palms are generally propagated by seeds, but they are also propagated by vegetative means such as by rhizomes, suckers etc. Seeds are the only means of propagation in all palms that have single stem with one terminal bud. Like many other monocot plants, palms cannot be grafted or budded or propagated by using some portion of the stem as cutting.

6.14.1. Propagation by Seed

Propagation by seed is the easiest, cheap and predictable method for all palms except those where seeds are not obtainable. The date palm (*Phoenix dactylifera*, *P. sylvestris*) although produces quantity of seeds and propagated by suckers for retaining parental characters of superior genotypes which otherwise deteriorate if propagated by seeds.

Seeds can be sown in seed beds or in pots in a soil mixture approximately 6 – 18 cm deep. Only the fully ripe and freshly harvested seeds should be taken for germination.

Palm seeds that germinate in adjacent ligular type can be sown without difficulty in any type of seed bed or seed pan depending on the number and size of the seeds to be sown. Seeds should not be sown too deep into the soil, the best result is obtained if seeds are sown about 1 cm below the surface. If the seeds are fresh no soaking with water is necessary, seeds should be cleaned, removing the fibre and the pulp. Seeds that throw longer sheaths should not be sown in beds or in deep pots because once germinated seedling cannot be taken for transplantation. Excepting *Latania*, all other Borassoid palms should be sown in a shallow pot keeping the seeds half buried. The giant *Lodoicea maldivica* (Giant Double Coconut) seeds cannot be sown in a standard sized seed pan. Moreover as the seed throws out several meter long sheath before producing first leaf and root, it is impossible to dig out the seedling from the nursery bed, without causing fatal injury to the young plant. Hence *Lodoicea* seed should always be sown directly at the spot where this giant palm is to be grown. For achieving success ground preparation is necessary so that the sheath can grow easily into the soil then turns up with its shoot.

The giant *Lodoicea maldivica* palm at the centre of the Large Palm House of the AJC Bose Indian Botanic Garden, Howrah was grown in this manner where the seed sown in 1894. For raising *Nypa fruticans* seedlings in the nursery, the best result can be obtained if the mature fruit are sown in mud with their stigmatic side half buried. For steady growth of the seedlings there should be water above the mud bed. It is not necessary that the water should be saline. There are some gardens in India (Theosophical Society's Garden in Adyar, Madras and raj Bhavan Garden in Kolkata) where *Nypa* palms were raised and grown successfully in sweet water surroundings.

6.14.2. Vegetative Propagation

Some genera and species of palm have suckering or clumping habit. These palms over a period of time develop several stems (shoot) which are joined at the base below the ground or at the ground level. In some species of *Calamus, Bactris, Raphis,* the underground stems produce several shoots away from the main stem and from a huge colony.

Palm clump to be separated or splitted for taking out suckers needs careful examination for ascertaining whether the parent plant has sufficient number of suckers and healthy enough to sustain the stress of injury of splitting or severing of suckers. The suckers that have developed roots should normally be selected for separating from the parent plant. In stoloniferous palms, a portion of the underground stem along with the shoot may be separated. In some clustering palms adventitious roots develop from the nodes above the soil. By putting moist leaf mould around these roots and covering the ball of leaf mould with polythene film enhance development of more roots. The shoot along with the roots can be taken and planted as a new plant. By these methods it is possible to separate stems of *Hydriastele microspadix, Ptychosperma macarthurii Rhopaloblaste singaporensis, Raphis excelsa, R. humilis, Areca triandra, Licuala spinosa, Dypsis lutescens*, and several cluster forming slender palms (Fig. 69,70,71,72).

6.14.3. Bulbil Shoots

In exceptional cases, in some palms, the entire inflorescence or individual rachilla or the male and female flowers transform into vegetative shoots, popularly called as bulbil shoots. Instances of such bulbil shoot production were recorded in following palms *e.g. Arenga pinnata, A. engleri, Areca catechu, Borassus flabellifer, Dypsis lutescens, Cocos nucifera, Coccothrinax argentea, Elaeis guineensis, Phoenix sylvestris, P. rupicola*.

Fig. 69: A. *Licuala grandis* Wendl. **B.** Mature fruits of *L. grandis* **C.** Seeds **D.** Seedlings with seed bed **E.** Different size of seedlings **F.** Measurement of seedlings

Fig. 70: A. Seeds of *Phoenix dactylifera* L. **B.** Measurement of seeds **C.** Sprouting stage of Seed **D.** Seedlings in the seed bed **E & F.** Measurement of the seedling

Fig. 71: Various stages of the seeds germination process of *Phoenix sylvestris* Roxb.

Fig. 72: A & E. Seeds with seedlings of *Veitchia merrillii* Becc. **B.** Ripe fruits of *Ptychosperma macarthurii* (Wendl) Nichols. **C.** Seedlings of *Phoenix acaulis* Buch–Ham *ex* Roxb. **D.** Terminal inflorescence in *Dypsis lutescens* Wendl. (Abnormal condition) **F.** Seedlings of *Dypsis lutescens* Wendl.

Fig. 73: Pollens photograph under compound microscope and scanning electron microscope (SEM) **A-A1.** *Areca catechu* L. **B-B1.** *Areca triandra* Roxb. **C-C1.** *Phoenix dactylifera* L. **D-D1.** *Phoenix sylvestris* Roxb. **E-E1.** *Calamus erectus* Roxb. **F-F1.** *Cocos nucifera* Linn. **G.** *Borassus flabellifer* L. **H.** *Daemonorops jenkinsiana* (Griff.) Mart. **I.** *Calamus acanthospathus* Griff.

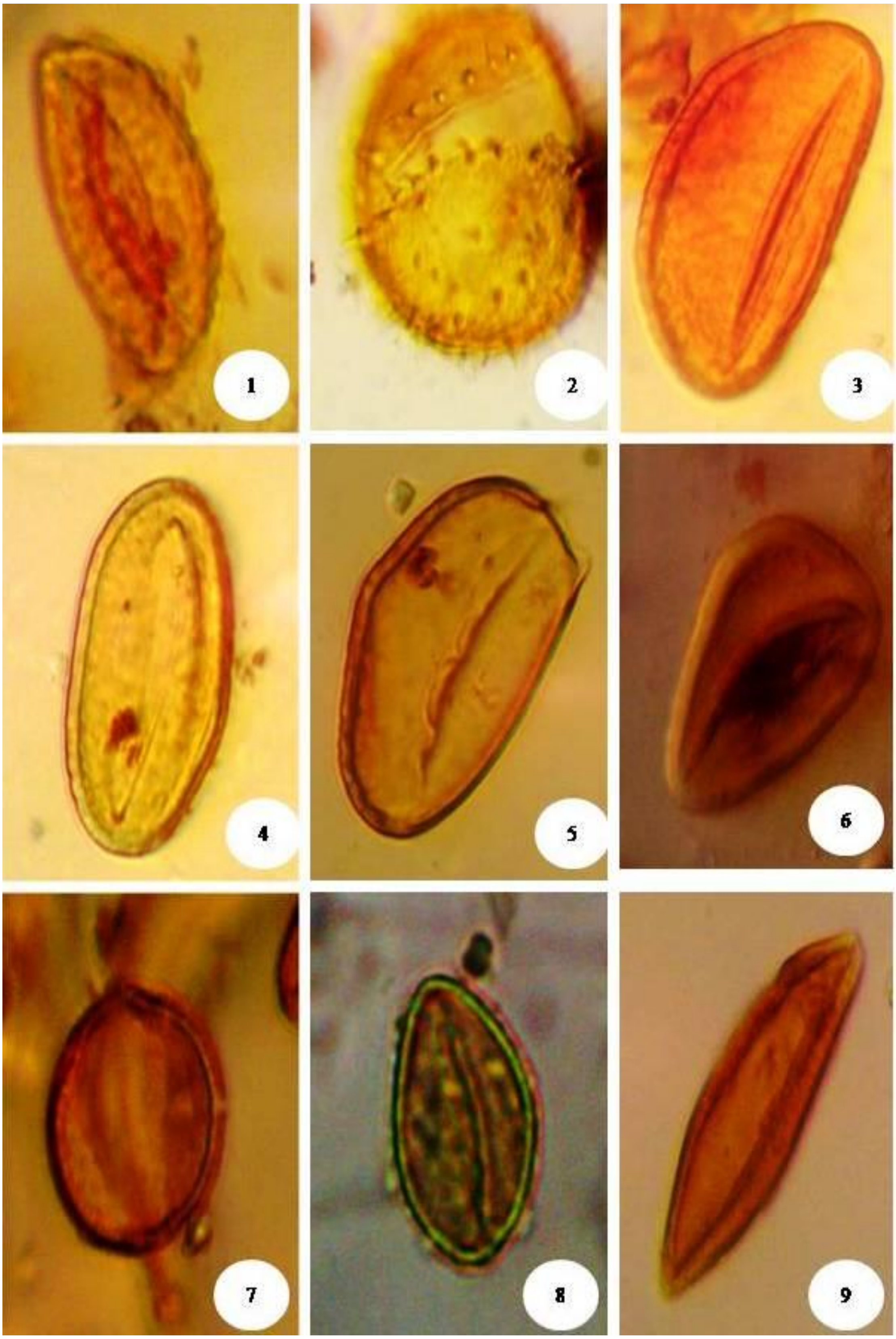

Fig. 74: Photographs of palm pollens under LM: **1.** *Wallichia densiflora* Mart. **2.** *Nypa fruticans* Wurmb. **3.** *Roystonea regia* (Kunth) Cook **4.** *Latania loddigessi* Mart. **5.** *Livistona australis* R.Br. **6.** *Phoenix roebelenii* Brien. **7.** *Caryota urens* L. **8.** *Daemonorops jenkinsiana* (Griff.) Mart. **9.** *Areca triandra* Roxb.