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Reproductive Phenology of True Mangrove Species in Pichavaram Mangrove Forests, Tamilnadu, India - A Comparative account

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Abstract

The target of this study was to analyse various phonological characteristics and reproductive biology of mangroves in Pichavaram for developing a data bank which could be of help to forest managers in planning for regeneration of species in the forest. We collected data on number of days taken by species to flower and to produce mature propagules/seeds. We also recorded all phenophases of each species and maturity characteristic of mangrove seeds in Pichavaram forest blocks. Storage life of seeds materials for various mangrove species was also tested with the help of mist chamber design. *Excoecaria agallocha* and *Acanthus ilicifolius* take only 2-3 months to produce mature hypocotyls whereas *Rhizophora mucronata, Bruguiera cylindrica* and *Xylocarpus mekongensis* complete these phases between 4 and 6 months. 30 % of seeds of Rhizophora apiculata and *Ceriops decandra* germinated after a storage period of up to 45 days showing higher viability than other species. However, fresh seeds of a majority of mangrove species exhibited more than 65-94 % germination. Proper identification of period of collection, maturity characteristics and germination timings will aid in better regeneration of mangroves in Pichavaram.

Keywords: Germination, Mangrove, Phenology, Pichavaram, Seeds.

1 Introduction

Mangrove forests are among the world's most productive ecosystems and sustain a variety of marine and estuarine communities [1,2]. However, mangroves are also one of the world's most threatened tropical and subtropical ecosystems and are being degraded in most countries mainly because of anthropogenic activities and unsustainable exploitation[3]. Mangroves are the only tall tree forests situated between the land and sea. [4,5] and they are tightly bound to the coastal environments in which they occur. Once established, mangroves offer recreational potential, a sustainable supply of seafood for aquatic animals and useful products for community subsistence [7]. As a primary producer, mangroves also serve as food for herbivores and detritivores. Litter-fall, consisting primarily of mangrove leaves, becomes available following leaf senescence and death. However, mangroves are also one of the world's most threatened tropical and subtropical ecosystems and are being degraded in most countries mainly because of anthropogenic activities and unsustainable exploitation [8].

Tropical plant communities with their high level of species diversity display phonological events staggered in time and space, which are, governed both by biotic and abiotic factors[9]. The plants may either stagger their phonological activity to avoid competition for pollination and disperser agents or may opt for clumping of phenological activity to attract the pollinators and dispersers or to swamp the predators by producing the vulnerable organs in concentrated burst [10]. Understanding of such behaviour of the communities is useful in evolving proper management strategy. Information on phenology is useful in predicting the interactions of plants and animals to the changing environment [11]. Description of various phonological events of plants is helpful in understanding of ecosystem functioning [12]. Only a few studies have been carried out on phonological events of mangrove species in different regions of the world [13, 14]. Some earlier studies on the Orissa mangroves by [15,16] gives only limited information on flowering and fruiting periods of different species. [17] found reproductive events in mangroves were relatively synchronous among trees at particular latitude and this was constant among years. However, the reproductive status of individual trees highly varied between years. Individual trees and clusters did switch synchronously from reproductive to a non reproductive state across years.

Despite the importance of mangrove ecosystems, very few studies have considered the phenology of different mangrove species [18-26]. Most phenological studies have been confined to monitoring flowering and fruiting by direct observation, and very few studies have combined direct observations with litter-fall measurements to assess the phenology of these species [27]. Phenological events in mangroves are influenced by local or regional environmental conditions, particularly day length, air temperature, rainfall and water status [28,29]. This study was carried out to investigate the Reproductive phenological events, seed viability and seed germination of mangrove tree species in Pichavaram mangrove forest.

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2 Material and methods

2.1 Study Area

Pichavaram is situated in the southeast coast of India in the Tamil Nadu State. It is located at about 225 km south of Chennai and 5 km north east of Chidambaram, Cuddalore district, Tamil Nadu, between latitude 11°20' to 11°30' north and longitudes 79°45' to 79°55' east. It is an estuarine mangrove situated at the confluence of Uppanar, a tributary of the Coleroon River. Fishing villages, croplands, and Aquaculture ponds surround the area. This mangrove wetland has 51 islets and the total area of the Vellar-Pichavaram-Coleroon estuarine complex is 2335.5 ha of which only 241 ha. is occupied by dense mangrove vegetation. Nearly 593 ha, of this wetland is occupied by helophytic vegetation like *Suaeda* 262.5 ha. by barren mud flats and 1238.50 ha., by barren high saline soil. Of this, the mangrove wetland occupies only 1200 ha. comprising the entire mangrove vegetation located in the middle portion of the Vellar-Pichavaram-Coleroon wetland which has been declared on 15th December 1987 as a reserved forest by the Department of Forest, Government of Tamil Nadu.

The Pichavaram mangrove has 51 islets of varying size with an area of 1200 ha, of which 40% is occupied by urban waterways (for fishing), 50% by mangrove forests and the rest by mud and sand flats. Pichavaram mangrove forest is located between the Vellar and Coleroon estuaries. Seventeen hamlets belonging to four revenue villages - Killai, Pichavaram, Thandavarayasozhaganpettai (T.S. Pettai) and Thillaividangan - utilize the resources of the Pichavaram mangrove wetlands. Among the 17 hamlets, nine depend mainly on fishing, eight others mainly on farming. There are about 4,400 households in these hamlets, and their total population is about 16,600. The sprawling mangrove is crisscrossed by numerous channels and creeks linking other water bodies in this region. The tides are semi-diurnal with a range of 0.5±1.0 m. The geology of the area is dominated by Quaternary sediments. Pichavaram mangrove wetland consists of three Reserve Forests (RF), namely Killai RF, Pichavaram RF and Pichavaram Extension RF. According to recent survey the total number of 12 true mangrove plant species is present in this mangrove wetland. The climate of the region is semi-arid dominated by a northeast monsoon (October - January). Areas surrounding the mangrove are under extensive agricultural use.

2.1 Data collection

A total of 30 quadrats each 10 m x 10 m in size were sampled randomly covering an area of 3000 m^2 at each site. Thus, a total of 60 quadrats covering an area of 6,000 m^2 were studied across two sites. On the basis of data obtained from quadrat samples on the structural parameters, only dominant species, exhibiting higher Importance Value Index (IVI), were selected for phonological study. Data on various phenophases on selected mangrove species were collected through observation of individual trees at an interval of 15 days on these sites during the two years of study. A tree species was considered to be passing through peak of a particular phenophase if three out of five subsamples (branches) from the tree were found in that particular phenophase.

2.3. Collection of Seeds

The freshly fallen seeds were collected from the ground, due care was taken to collect only mature/healthy seeds showing no physical deformity and discarding immature seeds or seeds eaten by crabs, etc. Seed germination was studied in situ under field conditions by using specially designed moist chamber (2.5 m x 3 m) with a covering of blue polythene sheet and an entry door covered with a flap. The door was kept closed except while making observation. A total of 100 seeds of each species were placed in a mist chamber in the field except *Xylocarpus granatum* for which 50 seeds were placed in the field. Water was sprayed on seeds using a pump operated sprayer inside the chamber every day in late afternoon to maintain moisture. Seed germination was observed every day up to 105 days under field conditions.

3 Results and Discussion

In the present study abundant flowering and fruiting months for selected mangrove species in Pichavaram mangrove forest are given in Table 1. *Aegiceras corniculatum, Ceriops decandra, Lumnitzera racemosa,* and *Sonneratia apetala* tend to form pure zones in many areas. Flowering duration of the various mangrove species are given in Table 2. Most of the species are produced the flowers in the months between May to September. The *Xylocarpus* species flowers continuously for a prolonged period and an individual plant was observed in different stages of flowering and fruiting, e.g. flower bud initiation, flowering, fruit initiation, intermediate and mature fruits etc., at one time. While in *L. racemosa*, and *Acanthus ilicifolius* flowering takes place in unison across stands for a very short period. Species that flower during winter are *A. ilicifolius* and *C. decandra*. The mangrove species of Pichavaram viz. *S. apetala*, *A. illicifolius* and *C. decandra* initiate their flowering activities in winter (Dec-Jan) and complete the fruiting stage by March-April. All other species exhibited initiation of flowering in summer (April-May) and completed their fruiting phase in Rainy season (July-September) except for *E. agallocha* and *R. mucronata*. *E. agallocha* took only two months period (June-July) and *R. mucronata* took more than five months (February-July) to complete these two phenophases. Details of Bud initiation to flowering periods given in Table 2. Duration of fruiting ranges from 1 – 6 months. *R. mucronata* takes longer time for producing mature hypocotyls followed by *X. mekongensis* and *A. officinalis*. Total period taken from bud initiation to flower is higher for *R. mucronata* and lowest for *E. agallocha*. These species exhibited the same pattern for total period from flower initiation to formation of mature propagule. *B. gymnorrhiza* takes 35 days for producing full flowers from bud initiation. *R. mucronata* and *X. mekongensis* took maximum time to complete the flower to mature propagule phenophase. Lesser time was taken by *E. agallocha* and *A. ilicifolius* to complete this phase. There are only few studies on mangrove phonological aspects in Goa and Andamans Island in India. Species such as *E. agallocha, A. corniculatum, X. Mekongensis, B. gymnorrhiza* and *A. ilicifolius* take similar time to complete the phases of floral bud to mature hypocotyls. Details on storage life of seeds/hypocotyles of different mangrove species are given in Table 3. The seed collection periods may easily be identified for good quality of seed/ hypocotyl on the basis of mature seed characteristics which will aid in achieving higher rates of seed germination and survival. The mature hypocotyl of *Rhizophora* species can be identified by prominent maturity zone near collar and distinct root initiation. Mature fruits of *Xylocarpus*

species exhibit woody dry look and show cracks near ridges. Mature fruits of *Bruguiera* and *Sonneratia* species are reddish yellow/gray in colour. Higher seed viability was observed in case of *Rhizophora apiculata* and *C. decandra* as approximately 30 % of total seeds germinated after 45 days of storage. However, *A. officinalis*, *Excoecaria agallocha* lost seed viability within 15 days of storage period. The seeds of *Bruguiera gymnorrhiza*, *Rhizophora apiculata*, *Xylocarpus mekongensis*, *Ceriops decandra*, *Aegiceras corniculatum*, and *Lumnitzera racemosa* exhibited 65 - 94 % germination with no storage period. This indicates that successful regeneration of above mangrove species could be achieved by sowing the fresh matured seeds/hypocotyls.

Table 1: Period and duration of flowering of mangrove species in Pichavaram Mangrove forest

S.No	Taxa	Family	Commencement of Flowering	Duration of seed production (months)
1.	*Acanthus ilicifolius*	Acanthaceae	March	1
2.	*Aegiceras corniculatum*	Myrsinaceae	August	3
3.	*Avicennia officinalis*	Avicenniaceae	September	2
4.	*Avicennia marina*	Avicenniaceae	September	3
5.	*Bruguiera cylindrica*	Rhizophoraceae	March	3
6.	*Ceriops decandra*	Rhizophoraceae	April	3
7.	*Excoecaria agallocha*	Euphorbiaceae	July	2
8.	*Lumnitzera racemosa*	Combretaceae	July	1
9.	*Rhizophora apiculata*	Rhizophoraceae	September	5
10.	*Rhizophora mucronata*	Rhizophoraceae	October	3
11.	*Xylocarpus mekongensis*	Meliaceae	September	6
12.	*Sonneratia apetala*	Sonneratiaceae	March	2

Table 2: Seasonal variations in flowering duration of mangrove species of Pichavaram mangrove area

S.No	Taxa	Days from bud initiation to flower	Days from flower to mature fruit/ hypocotyls	Total no. of days for flowering & fruiting	Period of flowering & fruiting
1.	*Acanthus ilicifolius*	14	34	49	May – July
2.	*Aegiceras corniculatum*	20	50	71	May – Sep
3.	*Avicennia officinalis*	27	73	100	Aug – Oct
4.	*Avicennia marina*	25	60	85	Aug – Oct
5.	*Bruguiera cylindrica*	30	65	100	June – Oct
6.	*Ceriops decandra*	34	69	102	Aug - Oct
7.	*Excoecaria agallocha*	13	26	39	Aug - Dec
8.	*Lumnitzera racemosa*	25	45	60	Aug –Nov
9.	*Rhizophora apiculata*	50	85	120	Aug – Dec
10.	*Rhizophora mucronata*	54	93	147	Sep – Jan
11.	*Xylocarpus mekongensis*	25	59	84	June - Aug
12.	*Sonneratia apetala*	30	84	113	July - Sep

Table 3: Effect of storage period on germination of seed materials of true mangrove in Pichavaram mangrove forest

S.No	Taxa	Storage period of seed (in days)						
		15	30	45	60	75	90	105
1	*Acanthus ilicifolius*	14/30	11/30	9/30	4/30	-	-	-
2	*Aegiceras corniculatum*	22/40	20/40	19/40	17/40	-	-	-
3	*Avicennia officinalis*	16/35	-	-	-	-	-	-
4	*Avicennia marina*	10/30	4/35	-	-	-	-	-
5	*Bruguiera cylindrica*	26/45	21/45	20/45	18/45	17/45	-	-
6	*Ceriops decandra*	26/50	23/50	21/50	19/50	16/50	11/50	8/50
7	*Excoecaria agallocha*	16/30	-	-	-	-	-	-
8	*Lumnitzera racemosa*	18/40	11/40	6/40	-	-	-	-
9	*Rhizophora apiculata*	23/40	21/40	18/40	13/40	9/40	-	-
10	*Rhizophora mucronata*	26/30	23/30	21/30	18/30	17/30	-	-
11	*Sonneratia apetala*	26/35	21/35	-	-	-	-	-
12	*Xylocarpus mekongensis*	26/50	19/50	17/50	-	-	-	-

In the case of mangroves, spatial and temporal variations in reproductive phenology have been reported by a number of scientists. Thus site specific information is necessary in terms of reproductive phenology [30] There is some information available on phenology of mangrove species. The flowering in mangrove species occurs throughout the year with majority of flowering during the rainy season. According to the report, *Rhizophora mucronata* has the flowering period spanning over winter and summer months. *Bruguiera gymnorrhiza* produces flowers in the summer and rainy periods. In Costa Rica, *Rhizophora harrisonii* produces mature propagules mainly during June and July. [31] has reported the flowering season for *R. mucronata* during July to September in the mangroves of Andaman and Nicobar island while [32] have reported it to be August to January for the mangroves of western coast of India, [33] has reported it to be October to December for the Indian mangroves and [34] reported January to February for the mangrove of Gujarat. Therefore, a significant variation in the flowering season of *R. mucronata* can be seen even in the mangrove forests of India.Similarly, in Malaysia, fruiting in *Rhizophora* occurs during June to December Most species in Myanmar flower and bear fruits several months earlier in the drier and stressed sites than in moist sites. Flowering and fruiting occur during May to Mid-July on the drier sites and during July and mid-August in the lower intertidal zone in *A. Corniculatum.* In tropical moist forests, ripening of the fruits takes place in a single peak before monsoon suggesting that survival of seeds and seedlings is critically dependent on moisture availability. However, no such event is seen in mangroves which indicate that rainfall is not the only source of moisture for all the species. Since most of the propagules and seeds of mangroves directly fall into the river systems or marshy ground below, the moisture need may be met from there. [35] observed that mangroves do not rely absolutely on rainfall for survival because they can extract fresh water from the sea through salt excreting glands. However, the amount of rainfall influences mangroves in two ways: (1) rainfall determines the rate of weathering and the amount of silt brought to the mangrove swamps and (2) high rainfall reduces the incidence of hyper salinity [36]. The findings of the present work may be useful in restoration initiatives requiring collection of healthy planting materials. Further, seed predation is an important determinant of the structure and composition of mangrove forests as propagules are food for crabs and insects [37].

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