UNIVERSITI PUTRA MALAYSIA

REPRODUCTIVE BIOLOGY OF *CALAMUS MANAN* MIQUEL

DAVID ALLOYSIUS

REPRODUCTIVE BIOLOGY OF *CALAMUS MANAN* Miquel

By

DAVID ALLOYSIUS

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Forestry, Universiti Putra Malaysia

May 1999

Dedicated to my wife Regina Binduin Luit
and
daughters: Dionetta, Beatrice, Debbie and Brenda

ACKNOWLEDGEMENTS

I would like to thank the Chairman of my Supervisory Committee, Associate Professor Dr. Kamis Awang for his guidance, constructive comments and professional inputs throughout the completing of this research. My appreciation also goes to Associate Professors Dr. Nor Aini Ab. Shukor and Dr. Ahmad Said Sajap, the members of the Supervisory Committee for their valuable contributions especially in commenting and proofreading the manuscripts.

Mr. Chan Hing Hon, Mr. John Tay and Mr. Cyril Pinso of Rakyat Berjaya Sdn. Bhd. were the persons who suggested the idea for pursuing my post-graduate study. I would never forget your support and encouragement. I thank my fellow colleagues at Luasong Forestry Centre especially Mr. James Rubinsin Kotulai, Mr. Charles Garcia, Mr. Agustine Dangantil, Mr. Gideon Peter Jaitol and Uncle Pulenthiren Arumugum for their advice and morale support.

The following provided assistance in laboratory work: Dr. Doreen Goh and the staff of the Plant Biotechnology Unit (PBL), Tawau, the staff of Pests and Diseases Monitoring Unit (P&D), Luasong Forestry Centre and Ms. Chia Fui Ree, Mr. Chen Thau En, Mr. Arthur Chung and Mr. Saikeh Lantoh of Forest Research Centre, Sepilok. The staff of the Plant Improvement and Seed Production Unit (PISP) leaded by Mr. Juniansah Selamat help in most of the field work.

My parents and family have given their endless support in the course of completing this work. My wife, Regina Binduin Luit has offered her sympathy and tolerance during my struggle to finish the writing on time.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

REPRODUCTIVE BIOLOGY OF *CALAMUS MANAN* Miquel

By

DAVID ALLOYSIUS

May 1999

Chairman: Associate Professor Kamis Awang, Ph.D.

Faculty: Forestry

Adopting a plant improvement programme that combines silviculture and genetic improvement could increase yields of *Calamus manan* plantations. The silviculture of *C. manan* is well studied but not on the aspects of genetic improvement. Information on reproductive biology, which is one of the basis for all genetic improvement programmes, is still lacking for *C. manan*. The objective of this study was therefore to investigate the reproductive biology of *C. manan*.

The study was done in a rattan plantation located at Luasong, Tawau, Sabah. The floral morphology of *C. manan* was common for species in genus *Calamus*. Observations showed that *C. manan* flowered annually but with different intensities. The inflorescence emergence normally occurred in October – December and fruits matured 16–17 months after. No clear relationship was detected between inflorescence emergence and meteorological parameters. Anthesis in male plants (41 days) was found to be longer than in female plants (25 days). There were about 60,000 and 9,000 pollen grains in pre-anthesis and fallen flowers, respectively. *C. manan* pollens could maintained half of its initial

viability for four, eight and twelve weeks if desiccated and stored at 25°C, 4°C and -18°C, respectively. Anthesis occurred at night, suggesting the important role of nocturnal insects especially moths in pollination. Bees were proposed as pollinators during the daytime. A controlled pollination experiment was conducted to determine the best pollination bag and the differences between fresh and stored pollens in effecting fertilization. The sex ratio in a planted population was found to be male-biased but had a tendency to move towards unity as the age of the stand increased. The fruit production capacity of *C. manan* increased as the plants grew older.

The implications of the reproductive characteristics on plantation establishment of *C. manan* are discussed.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

BIOLOGI MEMBIAK *CALAMUS MANAN* Miquel

Oleh

DAVID ALLOYSIUS

Mei 1999

Pengerusi: **Profesor Madya Kamis Awang, Ph.D.**

Fakulti: **Perhutanan**

Penggunaan amalan pembaikbiakan tumbuhan yang merupakan gabungan silvikultur dan pembaikbiakan genetik akan dapat meningkatkan hasil ladang *Calamus manan*. Kajian silvikultur *C. manan* telah banyak dilakukan tetapi tidak dalam bidang pembaikbiakan genetik. Maklumat pembiakan biologi *C. manan* masih sedikit sedangkan ia merupakan asas kepada semua program pembaikbiakan genetik. Tujuan kajian ini adalah untuk menentukan biologi membiak *C. manan*.

Kajian ini dibuat di ladang rotan yang terletak di Luasong, Tawau, Sabah. Morfologi bunga *C. manan* adalah sama seperti seperti spesies-spesies lain dalam genus *Calamus*. Pemerhatian mendapati *C. manan* berbunga setiap tahun tetapi dengan keamatan yang berbeza. Jambak bunga biasanya dikeluarkan pada bulan Oktober – Disember dan buah akan matang dalam tempoh 16-17 bulan selepas pendebungaan. Pengeluaran jambak bunga dengan semua parameter cuaca didapati tidak berhubungkait. Antesis pada pokok jantan (41 hari) adalah lebih lama berbanding pada pokok betina (25 hari). Bunga sebelum antesis dan bunga

yang telah gugur masing-masing menghasilkan 60,000 dan 9,000 bijian debunga. Separuh daripada keupayaan bercambah bijian debunga *C. manan* dapat dikekalkan selama empat minggu jika dikeringkan dan disimpan pada suhu 25°C, lapan minggu pada suhu 4°C dan 12 minggu pada suhu -18°C. Peranan serangga-serangga malaman terutama kupu-kupu dianggap penting dalam proses pendebungaan berikutan antesis berlaku pada sebelah malam hari. Spesies lebah dicadangkan sebagai agen pendebungaan pada siang hari. Satu kajian pendebungaan terkawal dibuat untuk menilai jenis beg pendebungaan yang terbaik dan perbezaan di antara debunga segar dengan debunga yang telah disimpan dalam menjayakan persenyawaan. Nisbah jantina di kalangan populasi yang ditanam lebih kepada jantan tetapi menuju keseimbangan dengan peningkatan umur dirian. Keupayaan pengeluaran buah *C. manan* meningkat dengan peningkatan umur.

Perbincangan dibuat akan kesan ciri-ciri membiak terhadap penubuhan ladang *C. manan*.

CHAPTER I

GENERAL INTRODUCTION

Calamus manan Miquel (Palmae: Calamoideae) is a solitary rattan found naturally in Dipterocarp forests of the southern Thailand, West Malaysia, Sumatra and probably in Kalimantan's Borneo (Dransfield, 1979). *C. manan* produces fine quality cane of diameter ranging from 25 mm to 80 mm, and are used mainly for the construction of furniture frames (Wan Razali *et al.*, 1992).

In Peninsular Malaysia, *C. manan* is one of the most important species belonging to the large-diameter group with diameter sizes of more than 18 mm. It is also one of the highly-sought species by the rattan extractors (Mohd. Zaki and Aminuddin, 1997). As a result of exploitation for decades, the availability of this species from the wild is very limited and confined to protected areas like National Park and forest reserves (Aminuddin, 1994; Wan Razali *et al.*, 1992). Uncontrolled harvesting also contributes to the scarcity of the species in the wild, as *C. manan* is a single-stemmed species, harvesting of stem means killing the plant. Therefore, its regeneration depends merely on fruits produced by mature plants.

To ensure a perpetual supply of *C. manan* cane to the furniture industry of Malaysia, plantation programmes involving this species were started since 1969. As end of 1995, the total area planted with *C. manan* was about 10,000 ha of which 6,000 ha are planted under rubber stands (Mohd. Zaki and Aminuddin, 1997). *C. manan* and the small-diameter *C. caesius* are in fact the most dominant plantation species which accounted for almost all of the 31,000 ha planted with rattans in Malaysia (Mohd. Zaki and Aminuddin, 1997). These two indigenous species have already been categorized as major forest product under the National Forestry Act of 1984 (Nur Supardi and Lim, 1994).

The choice of *C. manan* as one of the major rattan plantation species in Malaysia has promoted research activities for the species since early 1980s. One of the earliest organizations involved in the research of rattans particularly on *C. manan* is the Forest Research Institute of Malaysia (FRIM). Most of the previous research in the fields of silviculture, pests and diseases, economic and processing are well documented in the manual "A Guide to the Cultivation of Rattan" by FRIM (Wan Razali *et al.* 1992). On the other hand, a few organizations in Malaysia such as Innoprise Corporation Sdn. Bhd. (ICSB) have started an improvement programme for supporting their plantation programmes (Garcia *et al.*, 1994). ICSB has about 11,500 ha of rattan plantation, established under a logged-over forest near Luasong, about 100 km northwest of Tawau, Sabah.

Plant improvement, which is a combination of silviculture and genetic improvement (Zobel and Talbert, 1984), is a tool for upgrading yield of plantation species, perpetually. In Malaysia, research on silviculture of *C. manan* have been carried out since its early introduction as a plantation species, but the research on genetic improvement is still at its infancy stage. To succeed in genetic improvement programme, a detailed knowledge of reproductive biology of the targeted species must be obtained (Sedgley and Griffin, 1989). The knowledge of reproductive biology in this context includes understanding the flower morphology, reproductive phenology and pollination of the species.

Thus, the objective of this study was to investigate the reproductive biology of *C. manan* for supporting the on-going genetic improvement programme of this species at ICSB's rattan plantation in Luasong, Tawau, Sabah.

CHAPTER II

LITERATURE REVIEW

Rattan

Rattans are climbing members of the palm family, Palmae or Arecaceae. Rattans comprise about 600 different species, distributed in thirteen genera (Dransfield, 1992b). Three of the 13 genera (*Laccosperma, Eremosphatha* and *Oncocalamus*) are found only in the equatorial rain forests of Africa. The other genera (*Calamus, Daemonorops, Ceratolobus, Korthalsia, Plectocomia, Plectocomiopsis, Myrialepis, Calospatha, Pogonatium* and *Retispatha*) are distributed from the Indian subcontinent and southern China, through the Malesian region to Fiji, Vanuatu and tropical and subtropical parts of eastern Australia. *Calamus* is the largest genus with about 370 species altogether (Dransfield, 1992b).

Distribution of Rattans in Malaysia

The taxonomic works for Malaysian rattans are refined and published in three manuals for Peninsular Malaysia, Sabah and Sarawak (Dransfield, 1979, 1984, 1992a, 1992b).

One hundred and ninety-four or about one-third of all rattan species are found in Malaysia (Dransfield and Manokaran, 1994). *Calamus* is the most represented genus with 113 species followed by *Daemonorops* (47 species), *Korthalsia* (19 species), *Plectocomiopsis* (5 species), *Plectocomia* (4 species), *Ceratolobus* (4 species) and one species each of *Myrialepis, Calospatha* and *Retispatha*. *Calospatha* and *Retispatha* are endemic to Malaysia (Dransfield, 1992b).

***Calamus manan* Miquel**

Dransfield (1979) described the taxonomy and distribution of *C. manan*. The aspects of physiology of *C. manan* have been reported by Aminuddin (1987, 1992). Raja Barizan Raja Sulaiman (1992) reviewed some aspects of flowering and fruiting patterns of *C. manan* and other commercial species. The silviculture, processing and marketing of *C. manan* have been compiled in a manual by Wan Razali Wan Mohd. *et al.* (1992), that describes the aspects of uses, plant establishment, fertilization, pests and diseases, tissue culture, harvesting and economic of cultivation of *C. manan* as a plantation species.

Reproductive Biology of Tropical Trees

Sexual System

Sexual system is the spatial and temporal distribution of male and female function within and between individual trees. There are three main groups of sexual system in the tropic, namely dioecious, monoecious and hermaphrodite (Bawa, 1980). In dioecious species, plants generally bear either male or female flowers throughout their life span. The monoecious species are characterized by the presence of both male and female flowers on the same plant and hermaphroditic by the presence of bisexual or perfect flowers.

Many tree species in tropical forests are dioecious (Ashton, 1969; Bawa, 1974, 1980; Bawa and Oplar, 1975). Conifers on the other hand, are generally monoecious (bearing male and female strobili at different locations in the crown). Appanah (1990) reported that most of the understory tree species of the lowland dipterocarp forest are dioecious, whereas emergent and canopy species mostly have hermaphrodite flowers. Some well-known examples of dioecious species are *Xerospermum* and *Nephelium* (Sapindaceae). In tropical eucalypts, flowers are morphologically bisexual or hermaphrodite. Individual eucalypt flowers are protandrous (shedding pollen before the stigmas are receptive) but this in not an effective barrier to self pollination between different flowers on the same tree (geitonogamy) (Griffin, 1988).

Bawa (1980) has postulated the correlation between entomophilly (pollination by insects) and dioecy. He found that the correlation is stronger in the wet evergreen forest than in the dry deciduous forest where there are fewer bird- and bat-pollinated species. In Simaroubaeae of Costa Rica, there are four genera with dioecious species and one genus with hermaphrodite species, all dioecious species are entomophilus while the hermaphrodite taxon is hummingbird-pollinated. A similar association between pollination and sexual system is noted within the Guttiferae.

Mating (Breeding) System

Mating system is the extent to which progeny resulting from a reproductive episode deviates from outcrossing (Dafni, 1992).

Tree species in tropical rain forest typically occur at low densities (Ashton, 1982; O'Malley and Bawa, 1987). Because of low density of reproductive individuals, the mating system could range from a high degree of inbreeding due to selfing (Fedorov, 1966) to wide outcrossing (Ashton, 1969). Controlled pollination experiments performed by Bawa (1974) in a semi-deciduous forest in Costa Rica showed that 54% and 22% of the tree species studied were self-incompatible and dioecious respectively, suggesting that outbreeding systems predominate. Murawski and Hamrick (1991) examined the mating system of nine tropical tree species occurring on Barro Colorado Island, Republic of Panama, through allozyme analysis. They found that most species were highly outcrossed, indicated by outcrossing rates ranging from 0.35 to 1.08, using mixed mating model. However, two species that occurred at low densities had low outcrossing rates (less than 0.70).

Chan (1981) identified three kinds of breeding system among the studied dipterocarp species: outbreeding species, inbreeding species and apomictic species. *Shorea* species within the sections Muticae (e.g. *Shorea acuminata* and *Shorea leprosula*) and Pachycarpae (e.g. *Shorea splendida*) are outcrossing species. *Dipterocarpus oblongifolius,* which is a self-compatible species, is more towards inbreeding due to the possibility of self-pollination. Some dipterocarps like *Shorea agami, S. resinosa, S. macroptera* and *Hopea subalata* are apomictic species (Kaur, 1977). Apomixis is a replacement of sexual by asexual reproduction, and is actually the evolutionary result of a tendency to reduce genetic recombination (Frankel and Galun, 1977).

Self-incompatibility, a mechanism to ensure outcrossing has been reported in tropical trees like teak (Verbenaceae) by Bryndum and Hedegart (1969) and Hedegart (1973), tropical eucalypts (Myrtaceae) by Eldridge (1970, 1976), Hodgson (1974) and Pryor (1976) and dipterocarps (Chan, 1981; Ha *et al.*, 1988).

Floral Morphology and Biology

Appanah and Chan (1981) described the flower morphology of six closely related *Shorea* of section Muticae. "Petals are oblong and creamy white to pale yellow in colour. The petals are revolute and incurved when open. Each flower has 15 stamens arranged in three verticils of unequal length; each stamen bears 4-celled subglobose white anthers and terminates in short awn-like connectival appendages. These appendages become prominently reflexed during anther dehiscence. The filaments are broader at the base and taper to the anthers. The ovary is ovoid in shape, with a distinct stylopodium. The style is long, filiform and terminates in a minute trifid stigma. The flowers are borne on dense, semi-pendant and paniculate axillary or terminal inflorescence". "The flower of all the species are small (roughly 1-1.5 cm in length), cream-coloured, and bell-shaped at anthesis. Individual flowers on an inflorescence open at dusk and emit a penetrating, sickeningly sweet smell, with corollas dropping to the forest floor the next day. Over a million blossoms may be presented on a single night by an individual in peak bloom (Ashton *et al.,* 1988).

In some Sri Lankan dipterocarps, the average blooming period of each inflorescence, individual tree and population of the studied species was short, ranging between two and five days, five and 15 days and 10 and 18 days respectively (Dayanandan *et al*., 1990). Whereas Appanah and Chan (1981) observed that the duration of blooming of *Shorea* section Muticae ranged between 15 days in *S. macroptera* and 25 days in *S. leprosula.*