



AUTECOLOGY AND CONSERVATION MANAGEMENT OF A RARE PALM SPECIES: THE CASE STUDY OF LIPSTICK PALM *Cyrtostachys renda* Blume IN KERUMUTAN WILDLIFE SANCTUARY, RIAU

**By
Didik Widyatmoko**



**POSTGRADUATE PROGRAMME
BOGOR AGRICULTURAL UNIVERSITY
2001**

© Hak cipta milik IPB (Institut Pertanian Bogor)

Bogor Agricultural University

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber:
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan artikel atau tinjauan suatu masalah.
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB.
2. Dilarang mengurnikan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

ABSTRACT

Didik Widyatmoko. Autecology and Conservation Management of a Rare Palm Species: The Case Study of Lipstick Palm *Cyrtostachys renda* Blume in Kerumutan Wildlife Sanctuary, Riau, under the Supervision of Prof. Dr. Ir. H. Guhardja, M.Sc., Dr. Johanis Palar Moge, Dr. Eko Baroto Walujo, and Dede Setiadi, M.S.

The aims of the research are to construct an integrated approach combining biological, physical, and socio-economic components for developing a comprehensive conservation strategy for sustainable management of plant resource, with special reference to the rare palm *Cyrtostachys renda*, and to elucidate interaction patterns between the palm and its environmental quality parameters. The research was conducted at Kerumutan Wildlife Sanctuary, Riau, including 16 different sites, covering a wide range of vegetation association, forest and habitat types, altitudes, population abundances, and spanning four aspects of the reserve.

Based on the overall similarity of specimens using an Unweighted Pairs Group Method of Averaging (UPGMA) and the ordination analysis, *Cyrtostachys renda* and *C. lakka* were determined as one species. The population status was growing, viable, consisting of dominant young plants with lower numbers of older age classes. The palm abundances varied with habitat types and forest association patterns, and were determined by a combination of a number of interrelated factors, including drainage quality, edaphic factors, nutrient contents, habitat characteristics, peat depth, and forest and interspecific associations.

Cyrtostachys renda requires specific ecological and habitat conditions. Well-drained area becomes the palm favourable habitat which is needed by the species to survive, and is therefore crucial to conserve. The palm is determined to be an indicator species of the Southeast Asian lowland peat swamp forest. In order to conserve this species effectively, its suitable habitat must be properly managed. The suitable habitat characteristics are well-drained sites with a high sand content, a thin peat layer, and a low C/N value; less acidic soil and water; and soil and water of low major nutrient contents but with relatively high organic substances.



Hak cipta ini dilindungi Undang-Undang. Hak cipta ini milik IPB (Institut Pertanian Bogor)

Hak Cipta Dilindungi Undang-Undang
1. Dilarang mengutip, sebagian atau seluruhnya karya tulis ini tanpa mengemukakan sumbernya.
a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan artikel, dan penyusunan karya tulis lainnya yang dipublikasikan.
b. Pengutipan tidak mengizinkan kepentingan yang wajar IPB.
2. Dilarang mengemukakan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

Bogor Agricultural University



The largest populations occurred at sites where the forest associations dominated by Anacardiaceae members (mainly *Gluta renghas* and *G. wallichii*), Perocarpaceae species (mainly *Shorea parvifolia* and *S. rugosa*), and Burseraceae (particularly *Pandanus terrestris*). The population status of *Costachys renda* within this sanctuary was growing, consisting of dominant young plants with lower numbers of the older stage classes, though the population and structures varied spatially. Demographic attributes, reproductive behaviour, and individual variations of the three stages (sucker, juvenile, and adult) varied considerably. Ages of all stemmed individuals were estimated, resulting a unilinear relationship between age and stem height. However, there were a number of differences in reproductive characteristics between cultivated and wild representatives. A number of modifications (variations) occurred under cultivation. Population abundances varied considerably among sites and were determined a combination of interrelated habitat characteristics and environmental quality parameters including drainage quality (habitat types), edaphic factors, nutrient contents, peat depth, and interspecific and forest associations. The percentage of the sand was most influential, particularly to palm densities, sizes, frequency, and basal area. Individual palm growth was plant size- and habitat type-dependent. Lipstick palm has more valuable use values than just as a horticultural purpose and its complex interconnectedness within the natural ecosystem was indicated, suggesting its importance in the natural environment and conservation. This palm species can be a potential flag species to promote the conservation of the highly degraded Southeast Asian peat swamp ecosystem. In order to sustainably manage the attractive palm, the key interrelated components influencing the survival should be acknowledged, including eco-biological, physical, and socio-economic aspects. A proper protection, in combination with wise uses, would be a desirable strategy for sustainable management and conservation of the distinctive species.

1. Ditanggung jawab oleh Departemen Ilmu Kelternan, Institut Pertanian Bogor
 - a. Pengutipannya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB.
2. Dilarang mengunikan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

RINGKASAN

Didik Widyatmoko. Antekologi dan Manajemen Konservasi Palem Pinangka: Studi Kasus Pinang Merah *Cyrtostachys renda* Blume di Suaka Margasatwa Kerumutan, Riau, dilakukan di bawah bimbingan Prof. Dr. Ir. Dedi Guhardja, M.Sc., Dr. Johanis Palar Mogeja, Dr. Eko Baroto Walujo, dan Dr. Ir. Dede Setiadi, M.S.

Tujuan penelitian ini adalah untuk mengkonstruksi pendekatan terpadu dalam pengelolaan sumberdaya tumbuhan dengan cara mengintegrasikan aspek ekologi, fisik, dan sosio-ekonomi dalam rangka menyusun strategi konservasi yang efektif dalam pengelolaan dan pemanfaatan sumberdaya alam secara berkelanjutan. Penelitian difokuskan pada analisis pola-pola interaksi antara Pinang Merah (*Cyrtostachys renda*) dengan parameter-parameter kualitas lingkungan, uji fenetik (sebagai basis penentuan keragaman jenis), penilaian status populasi (struktur, kelimpahan, dan ukuran populasi) dan demografi (*lifetable*, mortalitas umur, kesintasan (*survivorship*), perilaku reproduksi baik tumbuhan liar maupun budidaya, serta pertumbuhan dan perkecambahan), penentuan ekologis (termasuk tipe habitat, tipe dan asosiasi vegetasi, dan pola asosiasi antar spesies), pengaruh kualitas tanah dan air terhadap status dan kepadatan populasi, serta pengkajian pemanfaatan dan nilai kegunaan pinang merah terancam kepunahan, *Cyrtostachys renda* Blume, di Suaka Margasatwa Kerumutan, Riau. Penelitian telah dilakukan dari Juli 1996 sampai dengan Juni 2000, meliputi 16 lokasi penelitian yang mencakup berbagai asosiasi vegetasi (hutan) dan tipe habitat, ketinggian, kepadatan populasi, serta meliputi empat sisi kawasan suaka margasatwa. Studi perkecambahan dan morfologi semai dilakukan di Bagian Pembibitan Kebun Raya Bogor.

Berdasarkan pada kesamaan karakter morfologis secara keseluruhan, dengan menggunakan metode Unweighted Pairs Group Method of Averaging (UPGMA) dan ordinaasi Multidimensional Scaling (MDS), *Cyrtostachys renda* dan *C. lakka* termasuk dalam satu spesies (sinonim). Status populasi pinang merah di kawasan konservasi ini masih normal, tumbuh secara alami, dengan jumlah individu muda lebih dominan dan menurun sesuai dengan kelas umur serta membentuk sebuah



1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mengutip sumbernya.
- a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
- b. Pengutipan tidak merugikan kepentingan yang wajar IPB.
2. Dilarang mengunahkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

struktur piramida. Secara keseluruhan, struktur populasi didominasi oleh kelompok (kelas) tunas vegetatif (*sucker*), sedang kelas-kelas yang lebih tua (muda dan dewasa, memiliki stem) didominasi oleh individu-individu dengan tinggi batang antara 0.0 dan 4.0 m (47.5%), diameter batang antara 4.0 dan 10.0 cm (82.0%), dan arah *leaf scar* antara 0 dan 60 (69.2%). Di sebagian besar lokasi yang diteliti, arah tumbuhan dewasa jauh lebih sedikit dibandingkan dengan jumlah tunas vegetatifnya.

Populasi bervariasi menurut tipe habitat dan asosiasi hutan, terutama ditentukan oleh kombinasi dari sejumlah faktor yang saling berkaitan antara kualitas habitat (kelembapan air), faktor edafik, karakteristik habitat, kedalaman lapisan humus, serta pola asosiasi vegetasi dan asosiasi antar spesies. Walaupun tumbuh di daerah rawa, pinang ini mempunyai preferensi ekologis tertentu dan menyukai lokasi berdrainase baik (tanah dengan tekstur lebih kasar atau persentase kandungan pasir lebih tinggi), menghindari daerah-daerah yang selalu tergenang dengan lapisan humus tebal, dan memilih tanah yang tidak terlalu masam dengan kandungan mikro nutrisi tetapi dengan bahan organik yang lebih tinggi. Preferensi ekologis berdasarkan tekstur tanah terlihat sangat nyata, dimana populasi-populasi besar sampai di lokasi-lokasi dengan persentase pasir tinggi dan berdrainase baik. Persentase pasir berpengaruh nyata terhadap kepadatan stem dan rumpun, ukuran rumpun, frekuensi, basal area, serta penutupan tajuk. Daerah dengan drainase baik menjadi habitat kritis (*critical habitat*) pinang ini. Untuk itu, habitat yang sesuai untuk pinang ini (daerah rawa tetapi berdrainase baik) perlu dikonservasi agar sebagian besar populasinya di suaka tersebut bisa sintas dan berevolusi. Dua populasi penting (besar) yang perlu diproteksi lebih ketat terletak di dekat perbatasan Dusun Galaga dan Sungai Kempas.

Populasi terbesar terdapat di lokasi-lokasi dengan asosiasi hutan yang didominasi oleh anggota-anggota Anacardiaceae (*Gluta renghas* dan *G. wallichii*), Dipterocarpaceae (*Shorea parvifolia* dan *S. rugosa*), dan Pandanaceae (*Pandanus terrestris*). Palem ini cenderung berasosiasi dengan spesies-spesies tertentu. *Gluta renghas*, *Meliodoxa conferta*, *Shorea parvifolia*, *Korthalsia flagellaris*, dan *Pandanus terrestris* mempunyai derajat asosiasi paling besar, yang mengindikasikan adanya kesamaan preferensi ekologis dan tempat tumbuh dengan pinang merah.



Atribut-atribut demografi, reproduksi, dan variasi individu dari ke tiga kelas tumbuhan nampak bervariasi. Estimasi umur dari setiap individu yang memiliki batang (muda dan dewasa) dihitung dan menghasilkan satu formula kurvilinier $Y = \ln(X) - 21.93$, dimana Y adalah tinggi batang dan X umur, dengan nilai $R^2 = 0.98$ dan $p < 0.001$. Tumbuhan liar pinang merah mulai berbunga pada umur antara 15 dan 30 tahun, atau setelah memiliki tinggi batang > 2 m, atau setelah memiliki jumlah leaf scar antara 15 dan 25, dan diperkirakan bisa hidup lebih dari 80 tahun. Individu-individu dengan tinggi batang $< 1,5$ m (memiliki kurang dari 10 leaf scar) berumur kurang dari 17 atau 18 tahun) tidak pernah dijumpai berbunga. Tumbuhan yang ditanam (*cultivated*) cenderung berbunga lebih awal dibandingkan dengan tumbuhan liar. Rataan jumlah buah individu tumbuhan liar lebih sedikit dibandingkan dengan rata-rata jumlah buah individu tanaman budidaya. Perbedaan jumlah buah terutama disebabkan oleh perbedaan panjang rachilla dari ke dua sumber tumbuhan tersebut (tumbuhan liar memiliki rata-rata rachilla lebih pendek), tetapi perbedaan jumlah rachilla tiap tandan dari ke dua tipe ini cukup nyata. Bobot buah tumbuhan liar lebih ringan daripada buah tanaman budidaya, dan ini disebabkan oleh perbedaan berat biji atau endospermanya.

Persentase perkecambahan biji dari tumbuhan liar jauh lebih rendah dibandingkan dengan tanaman budidaya, dan ini mengindikasikan bahwa tumbuhan liar menghasilkan biji dengan kualitas kurang baik. Hasil ini didukung oleh fakta bahwa di alam *Cyrtostachys renda* cenderung beregenerasi melalui tunas vegetatif (*sucker*) daripada melalui bijinya. Sementara kepadatan tunas vegetatif mencapai 4,82 per hektar, persentase tumbuhan dewasa yang dijumpai berbunga atau berbuah hanya 5.14%. Tunas vegetatif tumbuh lebih cepat daripada semai, namun laju pertumbuhannya (*growth rate*) pinang ini secara umum sangat lambat. Pembentukan tunas vegetatif nampak lebih efektif untuk mengembangkan populasi di habitat-habitat yang selalu tergenang (*waterlogged*), walaupun mortalitas pada kelas ini cukup tinggi. Laju produksi daun berbeda menurut kelas atau tahapan umur (*plant size - dependent*) dan tumbuhan dewasa merupakan kelas yang paling produktif dalam membentuk daun. Walaupun secara umum tidak dijumpai hama yang signifikan, daun tumbuhan muda rawan terhadap serangan belalang *Valanga*

2. Dilarang mengemukakan dan memperbanyak atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

1. Dilarang menyalin sebagian atau seluruh karya tulis ini dengan cara apapun untuk kepentingan komersial, penelitian, pendidikan, atau untuk kepentingan lain yang bertentangan dengan peraturan yang berlaku.

1. Dilarang menyalin sebagian atau seluruh karya tulis ini dengan cara apapun untuk kepentingan komersial, penelitian, pendidikan, atau untuk kepentingan lain yang bertentangan dengan peraturan yang berlaku.



nigricornis sumatrensis. Kerusakan habitat merupakan ancaman paling serius terhadap kelestarian pinang ini di alam.

Nilai rata-rata pengetahuan masyarakat Kerumutan terhadap manfaat Pinang Merah adalah 1,2 dan mengindikasikan adanya nilai kegunaan lain selain sebagai tanaman hias. Masyarakat di sekitar lokasi-lokasi dimana dijumpai populasi besar pinang memiliki nilai pengetahuan lebih tinggi. Semakin jauh suatu lokasi dari habitat alami pinang ini, jumlah manfaat yang dapat dikenal masyarakat cenderung menurun. Berdasarkan analisis preferensi spesies, batang Pinang Merah merupakan bahan yang paling dipilih masyarakat lokal untuk membangun lantai rumah, dengan nilai ranking rata-rata hanya di bawah bahan dengan prioritas tinggi yaitu meranti bakau (*Shorea rugosa*). Pemilihan batang pinang ini didasarkan pada beberapa pertimbangan, seperti batang mudah ditangani, lurus, rapi, dan licin, walaupun keawetannya di bawah *Shorea parvifolia* (meranti semut).

Untuk dapat mengelola sumberdaya tumbuhan secara berkelanjutan diperlukan pemahaman terhadap aspek-aspek eko-biologi, fisik, dan sosio-ekonomi. Keterkaitan dari berbagai aspek ini yang sering tidak diperhatikan oleh para pihak yang terlibat dalam pengelolaan sumberdaya alam. Akibatnya, kerusakan sumberdaya alam secara serius merupakan fenomena umum di Indonesia dan negara-negara berkembang lainnya. Dengan memahami fungsi dan peranan ekologisnya, serta menghargai nilai kegunaan dan nilai keberadaan dari tiap spesies termasuk spesies yang tidak spektakuler seperti Pinang Merah), pengelolaan sumberdaya alam akan lebih bijaksana.

total population, while the older stages (including juveniles and adults) only comprised 11.0%. Within juvenile and adult stages, there was a dominance of individuals with stem heights between 0.0 and 4.0 m (47.5%), stem diameters between 4.0 and 10.0 cm (82.0%), and leaf scar numbers between 0 and 60 (69.2%). At most sites, the numbers of adult individuals were much lower than those of suckers.

Cyrtostachys renda has ecological preferences and habitat requirements. It is crucial to conserve its most suitable habitat (well drained area), which is occupied by the palm to survive and develop evolutionary lines. Population densities (densities and sizes) varied with habitat types and forest association forms, and were determined by a combination of a number of interrelated factors, including drainage quality, edaphic factors, nutrient contents, peat depth, habitat characteristics, and forest and interspecific association. Although this species is confined to peat swamp ecosystem, it prefers sites with well drained soils (a coarse texture), avoiding permanently waterlogged areas, less acidic soils, and soils of lower mineral contents but with higher organic forms and thinner peat layers. The well-drained area becomes the palm critical habitat which is needed by this species to survive. Growth, survivorship, frequency, stem diameter and stem height become the most interrelated species parameters with environmental quality parameters.

The largest populations occurred in sites with a higher fine sand content and dominance of Anacardiaceae members (mainly *Gluta renghas* and *G. wallichii*), Dipterocarpaceae species (mainly *Shorea parvifolia* and *S. rugosa*), and Pandanaceae (particularly *Pandanus terrestris*). The percentage of fine sand seems to determine densities and sizes of the palm populations, and is most influential to stem density. The interspecific association tests show that this palm tends to associate with specific species. Based on the measures of the degree of association, *Gluta renghas*, *Eleiodoxa conferta*, *Shorea parvifolia*, *Korthalsia flagellaris*, and *Pandanus terrestris* were the most associated species with *Cyrtostachys renda*, indicating similar ecological preferences and habitat requirements amongst these species.

Demographic attributes, reproductive behaviour, and individual variations of the three stage classes (sucker, juvenile, and adult) varied considerably. Ages of all



mmed individuals were estimated, resulting a curvilinear relationship between age and stem height ($Y = 7.77 \ln(X) - 21.93$, where $Y =$ height and $X =$ age, with $r^2 = 0.81$ and $p < 0.001$). Wild plants of *Cyrtostachys renda* reach reproductive maturity and start to produce seeds at between 25 and 30 years of age, or when they have a stem height in excess of 2.0 m, or when they have between 15 and 25 leaf scars, and they can survive more than 80 years. Individuals less than 1.5 m in height with less than 10 leaf scars, with an approximate age of 17 – 18 years never produced reproductive structures over the study period. However, cultivated plants appear to flower and reproduce earlier than wild representatives, and a number of phenological variations (variations) occurred under cultivation. Cultivated plants appear to flower more frequently and produce seeds more abundantly. On average, seed of cultivated individuals were also heavier. The presence of more fruits in cultivated plants was particularly due to their longer rachillae, rather than their rachilla numbers. Seeds of cultivated plants gave 74.0% germination, while wild seeds only gave 11.0% germination, indicating a lower quality of the seeds produced. This is supported by the fact that *Cyrtostachys renda* tends to regenerate through the development of suckers, rather than through seedling establishment. Although higher mortality was experienced by suckers, sucker development is more strategic to cope with waterlogged conditions, as this cohort has a more rapid growth than seedling. While the density of sucker reached 84.82 / ha on average, the percentage of known flowering or fruiting plants was only 5.14% of the total population. Individual growth (determined by the number of new leaves produced per year) was plant size dependent, with adult stage became the most productive class. There were no serious pests or diseases observed during the study, but the grasshopper *Valanga nigricornis* appears to be a potential threat for young leaves. Conversely, habitat loss and forest degradation become the most serious threat to the palm sustainability.

The average value of community knowledge of the uses of *Cyrtostachys renda* (Linn.) in Kerumutan and the adjacent areas is 1.2, indicating its different use values. Number of different plant uses appears to decrease as locations are farther from the palm natural habitat. The palm stem was frequently used to construct bagan's floor and there are at least five tree species which are most preferred by the local communities for developing the bagan's floor. The highest rank was assigned





Shorea rugosa (meranti bakau) with the average rank 1.45 and *Cyrtostachys renda* (with the average rank 2.00). *Shorea rugosa* became the most preferred species might be due to its durability, strength, and resistance to termite and moth attack, while *C. renda* was preferred because it is easily managed (the stem is light and smooth), though it is not as durable as the less preferred species *Shorea parvifolia* (meranti semut).

In order to manage plant and other natural resources sustainably, we need to understand many interrelated aspects, including eco-biological, physical, and socio-economic aspects. To develop an effective conservation strategy, land managers and other stakeholders should be aware of the interconnectedness among the natural components. Tangible and direct use oriented approach, together with negligence, has led to the destruction and degradation of our natural resources, becoming a common, complicated, and unsolvable problem. Thus, to understand the ecological functions and roles, and to appreciate both the use and existence values of any kind species, including an apparently non-spectacular species such as *Cyrtostachys renda*, is essential if we are to achieve wise and sustainable natural resource management.

4. Ditakung sebagai bagian atau seluruh karya tulis ini dapat dipertanggungjawabkan dan dipublikasikan sebagai berikut:

- a. Pengutipan hanya untuk keperluan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
- b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengunahkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



**BIOTECHNOLOGY AND CONSERVATION MANAGEMENT
OF A RARE PALM SPECIES: THE CASE STUDY OF
LIPSTICK PALM *Cyrtostachys renda* Blume
IN KERUMUTAN WILDLIFE SANCTUARY, RIAU**

© Hak cipta milik IPB (Institut Pertanian Bogor)

**By
Didik Widyatmoko**

**A dissertation submitted to the Programme of Postgraduate,
Bogor Agricultural University, in partial fulfillment of the requirements
for the degree of Doctor of Philosophy**

Bogor Agricultural University

**POSTGRADUATE PROGRAMME
BOGOR AGRICULTURAL UNIVERSITY
2001**

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

- a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
- b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



Title of Dissertation : Autecology and Conservation Management of a Rare Palm Species: The Case Study of Lipstick Palm *Cyrtostachys renda* Blume in Kerumutan Wildlife Sanctuary, Riau

Name of Candidate : Didik Widyatmoko

Number of Candidate: 985069 / PSL

Programme of Study : Natural Resource and Environmental Management

Approval

1. Advisory Committee

Prof. Dr. Ir. Edi Guhardja, M.Sc.
Chairman

Dr. Johannis Palar Moge
Member

Dr. Eko Baroto Walujo
Member

Dr. Ir. Dede Setiadi, M.S.
Member

2. Chairman of Study Programme

Prof. Dr. Ir. M. Sri Saeni, M.S.

3. Director of Postgraduate Programme

Prof. Dr. Ir. Sinfida Manuwoto, M.Sc.

Date of Passing: 23 August 2001

Hak Cipta dilindungi Undang-Undang
1. Di larang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber:
a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
b. Pengutipan tidak merugikan kepentingan yang wajar IPB.
2. Di larang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

© Hak cipta milik IPB (Institut Pertanian Bogor)

Bogor Agricultural University

CURRICULUM VITAE

Didik Widyatmoko. Born in Sragen, Central Java, on 28 August 1962, a son of Soewito, BA and Sri Rubiyati. He was graduated from SD Negeri I Lahbang, Sragen in 1974 (Primary School), SMP Negeri I Sragen in 1977 (Junior High School), SMA Negeri I Sragen in 1981 (Senior High School), University of Gadjah Mada, Faculty of Biology, Yogyakarta in 1986 (S1 / Undergraduate), and University of Canterbury, School of Forestry, New Zealand in 1994 (S2 / Master Degree).

Since 1988 the candidate has been working in the Indonesian Botanic Gardens, Indonesian Institute of Sciences (LIPI), as a research staff. In 1990 he was eligible to become a participant of the BIOTROP - Kasetsart University Regional Training Course on Aquatic Weed Management, Thailand. In 1991 – 1992 he was in charge of the Collection Department of Cibodas Botanic Gardens (Kepala Seksi Koleksi). In 1992 he pursued a master degree in the University of Canterbury, School of Forestry, New Zealand, and graduated in 1994. In 1994 he was then promoted to the Research Manager of the Indonesian Botanic Gardens, up to 1998. In 1996 he was involved in the Training Course in Palm Taxonomy, Royal Botanic Gardens, Kew, England. In 1997, he was promoted to the Head of Registration / Data Base Department (Kepala Seksi Registrasi), Bogor Botanic Gardens, until he started his doctoral study in Bogor Agricultural University, Study Programme of Natural Resource and Environmental Management in 1998. In 1999 he was granted a Melbourne University Academic Visit Grant as part and support of his doctoral study. He has published a number of international scientific publications in the fields of plant ecology, conservation biology and management.

The candidate married Dra. Siti Roosita Ariati, M.Sc. in 1995 and has a daughter of five years old, named Safira Prabawidya Pusparani, and a son of three months old Irfan Alfieri Widyatmoko.



Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip, salin, atau menjiplak sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan artikel atau tinjauan suatu masalah.

2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



TABLE OF CONTENTS

	Page
ABSTRACT	i
DAFTAR ISI	iii
SUMMARY	vii
CURRICULUM VITAE	xiii
TABLE OF CONTENTS	xiv
LIST OF TABLES	xix
LIST OF FIGURES	xxi
LIST OF APPENDICES	xxiv
ACKNOWLEDGMENTS	xxvi
INTRODUCTION	1
1. Research Background	1
1. Aims	16
1. Hypotheses	17
1. Expected Results	17
LITERATURE STUDY	18
2.1 Overview of <i>Cyrtostachys</i> with special reference to <i>Cyrtostachys renda</i>	18
2.1.1 Systematic Account	20
2.1.2 Common Names	25
2.1.3 Habitat and Ecology	25
2.1.4 Geographic Distribution	26
2.1.5 Variation Within Species	28
2.1.5.1 <i>Geographic variation</i>	28
2.1.5.2 <i>Variation under cultivation</i>	28
2.1.5.2.1 <i>Definition of cultivation</i> <i>and domestication</i>	28
2.1.5.2.2 <i>Testimony of palm domestication</i>	31

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengurniakan dan memperbanyak atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



	2.1.5.2.3 <i>Modifications of C. renda</i> (variations under cultivation)	33
	2.1.6 Growth and Life Span	33
	2.1.6.1 <i>Seedling establishment</i>	33
	2.1.6.2 <i>Establishment phase</i>	34
	2.1.7 Mechanics and Allometry	35
	2.1.8 Interspecific Association	37
	2.1.9 Age estimation	39
	2.1.10 Fossil Record	40
	2.1.11 Anatomy	40
	2.1.12 Category of Conservation Status	40
	2.1.13 Uses	41
	2.1.14 Definitions and Explanations	42
2.	Concepts and Categories of Rarity	44
	2.2.1 Concepts of Rarity	44
	2.2.1.1 <i>Rarity as a temporal phenomenon</i>	45
	2.2.1.2 <i>Rarity as a spatial phenomenon</i>	46
	2.2.1.3 <i>Rarity as a taxonomic phenomenon</i>	48
	2.2.2 Categories/Forms of Rarity (Rarity Classification Systems)	50
	2.2.3 Causes of Rarity and Threatening Processes	52
III.	APPROACH AND METHODOLOGY	56
3.1	Approach	56
3.2	Methodology	57
	3.2.1 Study Sites	57
	3.2.2 Phenetic Analysis	61
	3.2.3 Population Structure and Status	61
	3.2.4 Demography, Age Estimation, and Germination	62
	3.2.5 Definition and Counting of Clumps and Individuals of <i>Cyrtostachys renda</i>	69

Hak Cipta Dilindungi Undang-Undang

© Hak cipta milik IPB (Institut Pertanian Bogor)

2.

3.

Bogor Agricultural University

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



3.2.6	Interspecific Association	70
3.2.6.1	<i>Test of association</i>	72
3.2.6.2	<i>Measures of the degree of association</i>	74
3.2.7	Water Quality Analyses	74
3.2.8	Soil Analyses	
3.2.9	Interactions Between Species and Physical Environment Quality	
3.2.10	Deciding Priority Sites To Be Conserved	76
3.2.11	Estimation of Use value and Species Preference	80
3.2.12	Geographic Distribution	83
3.2.13	Time Schedule	84

V. RESULTS AND DISCUSSIONS

4.1	Description and Characteristics of the Study Area	85
4.1.1	Physical Components	85
4.1.1.1	Administrative Management and Boundaries	85
4.1.1.2	Acessions	87
4.1.1.3	Physiography and Classification of Kerumutan Peatswamp Forest	87
4.1.1.4	Zonation	90
4.1.1.4.1	<i>Core Zone</i>	90
4.1.1.4.2	<i>Restricted Use Zone</i>	90
4.1.1.4.3	<i>Buffer Zone</i>	91
4.1.1.5	Hidrology and Water Quality	92
4.1.1.6	Soil Quality	99
4.1.2	Biological Components	101
4.1.2.1	Forest and Vegetation Types	101
4.1.2.2	Fauna	105
4.1.3	Socio-Economic Components	106
4.1.3.1	Livelihoods	107

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



	4.1.3.1.1 <i>Swidden agriculture</i>	107
	4.1.3.1.2 <i>Rubber and oil palm plantations</i>	107
	4.1.3.1.3 <i>Fishing</i>	107
	4.1.3.1.4 <i>Labor</i>	108
	4.1.3.2 Habitation and Population	108
	4.1.4 Ecological Consequences of Low Nutrients with High Secondary Compounds	110
4	Variations Within <i>Cyrtostachys renda</i>	114
	4.2.1 Phenetic Analysis (Geographic Variations)	114
4	Autecology of <i>Cyrtostachys renda</i>	117
	4.3.1 Population Structure, Abundance, and Demography	117
	4.3.1.1 Population Structure and Abundance	117
	4.3.1.1.1 Allometry	117
	4.3.1.1.2 Demography	123
	4.3.1.2.1 Reproduction and Reproductive Behaviour	124
	4.3.1.2.2 Plant Growth	125
	4.3.1.2.3 Survivorship	126
	4.3.2 Interactions with the Biological Components	129
	4.3.2.1 Interspecific Association	129
	4.3.2.2 Forest Association Preferences	131
	4.3.2.3 Pests	137
	4.3.3 Interactions with the Physical Components	140
	4.3.3.1 Interactions with Habitat Type (Specificity)	140
	4.3.3.2 Interactions with Soil Quality	144
	4.3.3.3 Interactions with Water Quality	159
	4.3.3.4 Interactions with Peat Depth	159
	4.3.3.5 Interactions with the Combined Environmental Quality Parameters	162

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan berita atau tinjauan suatu masalah.
b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



4.3.4	Seed Germination, Seedling Establishment, and Vegetative Development	165
4.3.4.1	Seed Germination and Seedling Establishment	165
4.3.4.2	Further Seedling Establishment	167
4.3.4.3	Development Stages of Sucker (vegetative shoot)	168
4.3.4.4	Growth of Sucker and Seedling	169
4.3.5	Conservation Management and Strategy	174
4.4.1	Habitat Integrity and Protection	174
4.4.2	Sustainable Use	175
4.4.2.1	Estimate of Use Value	177
4.4.2.2	Species Preference	179
4.4.3	Threats and Human Disturbances	183
4.4.3.1	Habitat Destruction and Plantation Development	183
4.4.3.2	River Access	183
4.4.3.3	Road Building	184
4.4.3.4	Lack of Conservation Awareness	184
4.4.3.5	Fishing	185
4.4.3.6	Wildlife Hunting	185
4.4.3.7	Logging and Log Stealing	185
4.4.3.8	Habitation within the Reserve	187
4.4.4	<i>Ex Situ</i> Management and Strategy	188
4.4.4.1	Cultivation	188
4.4.4.2	Modifications Under Cultivation	190
4.4.4.3	Maintenance	193
V.	CONCLUSIONS AND RECOMMENDATIONS	195
	REFERENCES	201
	APPENDICES	210

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.

b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

LIST OF TABLES

Number	Text	Page
1.1	Conservation (protected) areas in Riau in 1999.	16
2.1	Interspecific interactions and ecological processes that may result in positive and negative association among species.	38
3.1	The 2 x 2 contingency table for species association	72
4.1	Results of water quality measurements from three forest (habitat) types of Kerumutan Wildlife Sanctuary, Riau.	95
4.2	Summary of ecological attributes and benefits derived from pristine peatswamps.	98
4.3	Results of chemical and physical analyses of soils of the study area.	100
4.4	Population densities and numbers of households of 15 villages covering Kerumutan Wildlife Sanctuary, Riau.	109
4.5	Occupation along Kerumutan River, from upstream to downstream.	110
4.6	Above ground characteristics of two main types of Kerumutan peatswamp forest in 0.2 ha transects at two distinctive localities (based on the tree data analyses, trees measured were those had a diameter > 10 cm).	112
4.7	Abundance (frequency, density, and basal area) of three stage classes of <i>Cyrtostachys renda</i> at various locations within Kerumutan Wildlife Sanctuary.	120
4.8	Abundance parameters of <i>Cyrtostachys renda</i> measured in the study areas.	121
4.9	Measurement attributes for <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary, Riau.	124
4.10	Results of the association tests between <i>Cyrtostachys renda</i> and the eleven co-occurrence species.	129

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.

b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.





4.11	Densities and sizes of <i>Cyrtostachys renda</i> at various locations in association with forest association and habitat type within Kerumutan Wildlife Sanctuary.	133
4.12	Forest (vegetation) associations at 16 sites within Kerumutan Wildlife Sanctuary in which populations of <i>Cyrtostachys renda</i> were searched.	132
4.13	Scoring values between species parameters (population structure, demography, and abundance) and habitat types within Kerumutan Wildlife Sanctuary, Riau.	142
4.14	Stem diameter average (cm) of <i>Cyrtostachys renda</i> at various localities within Kerumutan Wildlife Sanctuary.	146
4.15	Values of correlation coefficient R^2 between species parameters measured (population structure, demography, and abundance) and environmental quality parameters (water quality, soil quality, and peat depth).	163
4.16	Average values of community knowledge of the uses of <i>Cyrtostachys renda</i> in various locations within and outside Kerumutan Wildlife Sanctuary.	179
4.17	Basic data matrix for species preference to construct bagan's floor.	181
4.18	Comparison of reproductive and vegetative measurement attributes between wild and cultivated plants of <i>Cyrtostachys renda</i> .	192

© Hak cipta milik IPB (Institut Pertanian Bogor)

Bogor Agricultural University

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

- Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
- Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

LIST OF FIGURES

Number	Text	Page
1.1	Research background.	2
1.2	An integrated approach to species-based conservation strategy (the case study of <i>Cyrtostachys renda</i>).	13
2.1	Known (solid) and inferred (dotted) geographic distribution of <i>Cyrtostachys renda</i> .	27
2.2	A continuum from wild state to major crop.	30
2.3	Pipe model of tree construction.	36
2.4	New Structure for the IUCN Red List Categories.	52
3.1	Study sites of <i>Cyrtostachys renda</i> within Kerumutan Wildlife Sanctuary, Riau.	59
3.2	Sampling methodology of the study area (habitat and forest classification).	60
3.3	Determination of the taxonomic status of <i>Cyrtostachys renda</i> and <i>C. lakka</i> .	65
3.4.1	Attributes measured to perform population structure and status of <i>Cyrtostachys renda</i> in Kerumutan Wildlife Sanctuary.	66
3.4.2	The systematic parallel line method used in the study area.	67
3.5	Methodology of demographic study of <i>Cyrtostachys renda</i> in Kerumutan Wildlife Sanctuary, Riau.	68
3.6	Diagram (procedure) of interspecific association test.	71
3.7	Water quality analysis of three habitat types of Kerumutan Wildlife Sanctuary.	75
3.8	Soil quality analysis of three habitat types of Kerumutan Wildlife Sanctuary.	77



3.9	Methodology for measuring species and environmental quality interactions.	78
1.10	Methodology for deciding sites of high priority for conservation.	79
1.11	Methodology of use value estimate of <i>Cyrtostachys renda</i> in Kerumutan and the adjacent area.	80
1.12	Methodology for measuring species preference among 20 respondents in Kerumutan and the adjacent area.	82
1.13	Methodology for mapping the geographic distribution of <i>Cyrtostachys renda</i> .	83
4.1	Locations of the study area (16 sites) within Kerumutan Wildlife Sanctuary, Riau, showing the different habitats and forest types.	86
4.2	The Unweighted Pairs Group Method of Averaging (UPGMA) Classification of <i>Cyrtostachys renda</i> and <i>C. lakka</i>	115
4.3	A two dimensional ordination of <i>Cyrtostachys renda</i> and <i>C. lakka</i> .	116
4.4	Stem height-class frequency distribution of <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary (n = 506).	119
4.5	Stem height-class frequency distribution (%) of <i>Cyrtostachys renda</i> at various sites within Kerumutan Wildlife Sanctuary (n = 506).	119
4.6	Stem diameter-class frequency distribution of <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary (n = 506).	119
4.7	Stem diameter-class frequency distribution (%) of <i>Cyrtostachys renda</i> at various sites within Kerumutan Wildlife Sanctuary (n = 506).	119
4.8	Population structure of <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary by number of leaf scars (n = 506).	119
4.9	Population structure of <i>Cyrtostachys renda</i> by stage class at Kerumutan Wildlife Sanctuary.	119

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber:

- Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan berita atau tinjauan suatu masalah.
- Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



4.10	Population survivorship curve for <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary.	128
4.11	Spatial distribution of <i>Cyrtostachys renda</i> and the other (associated) plants in a plot of 40 m x 40 m at Galoga border, Kerumutan Wildlife Sanctuary.	132
4.12	Geographic distribution of <i>Cyrtostachys renda</i> in association with the distribution (extent) of the Southeast Asian lowland peatswamps.	134
4.13	A specimen of the grasshopper species <i>Valanga nigricornis sumatrensis</i> found to attack the young leaves of <i>Cyrtostachys renda</i> .	138
4.14	Dendrogram based on the similarity matrix of population structure, demographic, and abundance parameters showing clustering of 16 different sites in respect of three habitat types of Kerumutan Wildlife Sanctuary.	143
4.15	Ordination based on the similarity matrix of population structure, demographic, and abundance parameters showing clustering of 16 different sites in respect of three habitat types of Kerumutan Wildlife Sanctuary.	143
4.16	Relationship between stem density of <i>Cyrtostachys renda</i> and soil texture.	150
4.17	Relationship between stem densities of <i>Cyrtostachys renda</i> and levels of three major soil minerals.	151
4.18	Relationship between soil texture (% fine sand) and stem density of <i>Cyrtostachys renda</i> within Kerumutan Wildlife Sanctuary.	152
4.19	Relationship between % clay and clump density of <i>Cyrtostachys renda</i> within Kerumutan Wildlife Sanctuary.	153
4.20	Relationship between soil moisture and clump size of <i>Cyrtostachys renda</i> .	154
4.21	Relationship between clump size of <i>Cyrtostachys renda</i> and level of Ca^{++} within Kerumutan Wildlife Sanctuary.	155

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang menguraikan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



4.22	Relationship between clump size of <i>Cyrtostachys renda</i> and level of Mg ⁺⁺ within Kerumutan Wildlife Sanctuary.	156
4.23	Relationship between clump size of <i>Cyrtostachys renda</i> and level of K ⁺ within Kerumutan Wildlife Sanctuary.	157
4.24	Relationship between C/N ratio and clump size of <i>Cyrtostachys renda</i> within Kerumutan Wildlife Sanctuary.	158
4.25	Relationship between clump density of <i>Cyrtostachys renda</i> and peat depth at Kerumutan Wildlife Sanctuary	161
4.26	Dendrogram showing clustering of 14 different species parameters (including population structure, demographic, and abundance parameters) based on the similarity matrix of physical parameters measured (water quality, soil quality, and peat depth).	164
4.27	Ordination showing clustering of 14 different species parameters (including population structure, demographic, and abundance parameters) based on the similarity matrix of physical parameters measured (water quality, soil quality, and peat depth).	164
4.28	Seed germination and seedling establishment of <i>Cyrtostachys renda</i> .	170
4.29	Further seedling establishment (autotrophic stage) of <i>Cyrtostachys renda</i> .	171
4.30	Development stages of sucker (vegetative shoot) of <i>Cyrtostachys renda</i> .	172
4.31	Growth of sucker and seedling of <i>Cyrtostachys renda</i> .	173
4.32	Dendrogram based on the similarity matrix and showing clustering of 20 respondents in respect of five tree species used for bagan's floor according to the responses of the interviewees in Kerumutan and the adjacent areas.	182

Hak Cipta Dilindungi Undang-Undang

© Hak cipta milik IPB (Institut Pertanian Bogor)

Bogor Agricultural University

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

LIST OF APPENDICES

Number	Text	Page
1a	Parallel line method (transect) was used to assess population structure and status.	210
1b	Counting the number of individuals plants within a large clump.	210
1c	Measuring stem diameter at breast height and counting individual plants.	211
1d	Measuring the leaf size (length) of a sucker.	211
1e	Individual plants were marked to measure demographic paramcters.	212
1f	Germination trials to perform seed germination and seedling establishment.	212
1g	<i>Cyrtostachys renda</i> occurred with <i>Calophyllum soulattri</i> and <i>Gluta wallichii</i> , occupying the subcanopy of Kerumutan forest.	213
1h	Adult stems of <i>Cyrtostachys renda</i> were often cut to construct bagan's floor and logging rails.	213
1i	Disturbance of <i>Cyrtostachys renda</i> at Galoga border, Kerumutan Wildlife Sanctuary.	214
1j	The bright-red sealing wax palm <i>Cyrtostachys renda</i> occurred at Kempas Creek, Kerumutan Wildlife Sanctuary.	214
1k	Morphological character (attribute) measurements for <i>Cyrtostachys renda</i> and <i>C. lakka</i> .	215
1l	Checklist of herbarium specimens of <i>Cyrtostachys renda</i> Blume (Synonym: <i>Cyrtostachys lakka</i> Becc.).	216
2	Density of <i>Cyrtostachys renda</i> at different habitat types within Kerumutan Wildlife Sanctuary.	218

© Hak cipta milik IPB (Institut Pertanian Bogor)

Bogor Agricultural University

Hak Cipta Dilindungi Undang-Undang

1. Dilarang menyalin sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
 b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



3	Relationship between height of stems and number of leaf scars within <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary.	219
4	Relationship between stem height and stem diameter of <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary.	219
5	Logarithmic relationship between stem diameter and canopy circle area of <i>Cyrtostachys renda</i> .	219
6	Relationship between stem height and canopy circle area of <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary.	219
7	Comparison amongst measurement attributes within <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary.	220
8	Relationship between age and stem height of <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary.	221
9	Relationship between stem height and stem-height increment of <i>Cyrtostachys renda</i> at Kerumutan Wildlife Sanctuary.	222
10	Relationship between height of sucker and number of leaves within <i>Cyrtostachys renda</i> .	223
11	Relationship between height of juvenile and number of leaves within <i>Cyrtostachys renda</i> .	224
12	Relationship between height of adult and number of leaves within <i>Cyrtostachys renda</i> .	225
13	Interspecific association data summary for each pair of species.	226
14	Basic data of species parameters measured of each location within Kerumutan Wildlife Sanctuary, Riau.	227
15	Scoring values of the basic data of species parameters measured (population structure, demography, and abundance).	228
16	Uses of <i>Cyrtostachys renda</i> in Kerumutan and the adjacent areas, Riau.	229

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber.

- a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah.
- b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



17	Standardized data matrix using standard deviation.	231
18	Similarity matrix based on simple matching coefficients.	231
19	Basic data of overall population (adults and juveniles).	232

Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber:
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan brosur atau tinjauan suatu masalah.
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB.
2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

ACKNOWLEDGMENTS

This dissertation is written based on the research results and is submitted to the Programme of Postgraduate, Bogor Agricultural University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. The research title is Autecology and Conservation Management of a Rare Palm Species: The Case Study of Lipstick Palm *Cyrtostachys renda* Blume in Wildlife Sanctuary, Riau, and was conducted under the supervision of Prof. Dr. Ir. Edi Guhardja, M.Sc. as the Chairman of the Advisory Committee and Dr. Johanis Palar Moge, Dr. Eko Baroto Walujo, and Dr. Ir. Dede Setiadi, M.S. as the Members of the Advisory Committee. The candidate would like to thank the Advisory Committee and the Postgraduate Programme of Bogor Agricultural University (particularly Prof. Dr. Ir. Sjafrida Manuwoto, M.Sc., Prof. Dr. Ir. Daniel R. Monintja, and Prof. Dr. Ir. Kooswardhono Mudikdjo) for the opportunity, knowledge, skill, assistance, and encouragement. The candidate would also like to acknowledge Prof. Dr. Ir. Daniel Murdiyarsa and Dr. Rochadi Abdulhadi as the external examiners, the Director General and the Secretary of the Directorate – General of Nature Protection and Conservation, the Indonesian Ministry of Forestry, for permission to enter and study Kerumutan Wildlife Sanctuary, Riau. In Riau the number of people who have helped the author is very great. Firstly, the candidate appreciated Mr. Susilo Legowo (formerly Kepala Sub Balai Konservasi Sumber Daya Alam Riau), Mr. Djati Witjaksono Hadi (formerly Kepala Unit Konservasi Sumber Daya Alam Riau), Mr. Ali Nafsir Siregar (formerly Kasubsie Konservasi Sumber Daya Alam Rengat), and Mr. Mual Daulay (Kasubbag Tata Usaha, SBKSDA Riau) for their administrative assistance and permission. Mr. Marjohan, Mr. Zulkifli, Mr. Sulamat, and Mr. Bahudin Siregar (forest rangers of Kerumutan Wildlife Sanctuary) joined the candidate in the field, not only helping to collect data, herbarium materials and samples, but also providing



Hak Cipta Dilindungi Undang-Undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mengutip sumbernya.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan berita atau tinjauan suatu masalah.

2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.



2. Dilarang mengemukakan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB.

a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan berita atau tinjauan suatu masalah.

b. Pengutipan tidak merugikan kepentingan yang wajar IPB.

guidance and companionship. Secondly, Mr. Dombo and Mr. Ramli from Palaloga Enclave, Mr. Hatta and Mr. Sani from Kerumutan Village, and Mr. Maman from Kampung Pulau Village also accompanied the researcher in the field acting as guides and companions, providing information on the accessibility of selected sites and where Linau populations might be found, providing information on plant uses and finding respondents, sometimes climbing trees to collect materials, and helping to cross streams and creeks.

The next appreciation must go to Dr. John Dransfield, Prof. Pauline Y. Hedges, and Dr. Mark Burgman who supervised and helped the author during scientific visits. The author also thanks Yayasan Sosial Chevron dan Texaco Indonesia particularly the former President (Mr. Baihaki H. Hakim) and Vice President (Mr. Untung Suryanto), who supported and partially funded the research works, and Mrs. Rika Juniarsih for her administrative assistance during the surveys. Special thanks must also go to Mr. David Sudradjat and Mr. Bambang Gumilar from Rumbai Ecological Club for their company during the third Kerumutan flora expedition.

Great appreciation must also go to Dr. Suhirman, Dr. Dedy Darnaedi, and the members of Kerumutan Project Team for their professionalism and cooperation, including Mr. Wihermanto, Mr. Sutarno, Mr. Joko R. Witono, Mr. Manang Suryana, Mr. Subekti Purwantoro, Mr. Saripudin, Mr. Tatang Daradjat, Mrs. Jajat S. Sardiwinata, Mr. Maman Suratman, Mr. Holif Imamuddin, Mrs. Entim Fatimah, Mr. Ruspandi, Mr. Dumiyati S. Saputra, Mr. Endat Hidajat, Mr. Cecep Suryana, and Mr. Ading Supandi. The candidate also thank Mr. Nana Kosasih, Mr. Endjum, and Mr. Djadjat Sudradjat for their assistance during the germination trials. A large number of people assisted this study and the candidate thanks them all individually and apologise if anyone is omitted.

Finally, I would like to thank my beloved family, Siti Roosita Ariati and Safira Pratiwidy Pusparani, and my parents, Soewito and Sri Rubiyati, whose encouragement and blessing enabled this dissertation to be completed.