Chapter 2
LITERATURE STUDY
SYNOPSIS OF Cyrtostachys renda

2.1 Overview of Cyrtostachys with Special Reference to Cyrtostachys renda

The first publication of the genus Cyrtostachys is entitled “Cyrtostachys Blume” that was published in the Bulletin des Sciences Physiques et Naturelles en Neerlande 1: 66 in 1838 by the author Carl Ludwig von Blume. The type of the genus is Cyrtostachys renda Blume 1838. Blume (1796 – 1862) is an important Dutch botanist and becomes the most significant early contributor to the development of Indonesian palm botany. Most of his works were conducted in Java, Sumatra, and other islands of then the Dutch East Indies (Indonesia), describing many palms in these islands (Uhl and Dransfield, 1987) and almost all of which are still accepted as clearly defined species (Dransfield, 1994). At the generic and species level, Blume’s contribution to palm botany is very significant, although he published no acceptable names of higher categories (taxa).

Odoardo Beccari, an Italian botanist, the greatest palm taxonomist of the later half of the 19th and the early 20th century (Uhl and Dransfield, 1987) is the author of Cyrtostachys lakka Becc. and C. lakka var. singaporensis Becc. Cyrtostachys lakka and C. lakka var. singaporensis were at very first published in Annales Du Jardin Botanique De Buitenzorg II: 141 in 1885 (see Treub, 1885). Cyrtostachys lakka was therefore published later than C. renda. Later, C. renda was given for specimens from Sumatra, Bangka and Belitung, while C. lakka labelled for those from Borneo and Malay Peninsula (e.g. Treub, 1885; Bailey, 1913; Millard, 1915; Backer and Brink, 1968). Bailey (1913) characterised C. renda Blume var. duvivierianum Pynaert. from Sumatra with bright coloured leafstalks. Beccari had a lot of field experience in the Malesian region, particularly in Borneo where C. lakka occurs. He focused his study on the palms of Asia, and to a lesser extent on those of Africa and Madagascar (Uhl
and Dransfield, 1987). *Cyrtostachys renda* and *C. lakka* are two resembling species, therefore their variations and ecology need to be investigated.

The name *Cyrtostachys* was adopted from the Greek "Cyrtos" which means curved or bent and "stachys" which means a spike. Therefore, *Cyrtostachys* means an allusion to the curved spikes of flowers (Bailey, 1913; Millard, 1915). On the other hand, the name "renda" was most probably adopted from the Sumatran (Indrapura) word "rendah" (in Treub, 1885) which means low appearance (habitus), while *lakka* means sealing wax (e.g. in Bailey, 1913; Millard, 1915). The common name "sealing wax palm" comes from the colour of the red wax that was, in the past, used to seal letters and official documents (Tucker, 1992), referring to the crownshafts of *C. renda* which truly have a shiny bright red surface texture.

*Cyrtostachys* is a small-medium palm genus comprising 12 species: *C. renda* Blume (*C. lakka* Becc. is a synonym, see the results of phenetic analysis), *C. kisu* Becc., *C. ceramic* Wendl., *C. loriae* Becc., *C. peekeliana* Becc., *C. brassii* Burret, *C. compsoclada* Burret, *C. elegans* Burret, *C. microcarpa* Burret, *C. phanoprolepis* Burret, *C. ledermanniana* Becc., and *C. glauca* H. E. Moore (Widyatmoko and Dransfield, unpublished paper). Members of the genus are distributed from Southern Thailand to the Solomon Islands and most of the species occur in New Guinea and Melanesia (Papuasian species). *Cyrtostachys renda* is the only species found to the west of Wallace's Line (South Thailand, Malay Peninsula, Sumatra, and Borneo), one species (*C. peekeliana*) on New Ireland, the Bismarck Archipelago, and one species (*C. kisu*) on Bougenville Island, Baga Island, and Fauro Island (the Solomon Islands). The distribution range of *C. renda* is therefore curiously distinct from the other members of the genus. *Cyrtostachys renda* is widely cultivated while the others are insufficiently known.

Nearly all members of the genus *Cyrtostachys* are distinct, even when they are still juveniles. The details of their flowering structures are also significantly different from the other palm groups, therefore Uhl and Dransfield
(1987) classify this group into a different subtribe, namely Cyrtostachydinae. *Cyrtostachys* is thought to be an isolated genus with no clear relatives (Dransfield and Uhl, 1986; Uhl and Dransfield, 1987).

Most species of the genus *Cyrtostachys* occur mainly in lowland rain forests as undergrowth or canopy palms. However, their altitude ranges vary from 0 m (e.g. *C. renda*) up to about 900 m above sea level (e.g. *C. compsoclada*, Burret, 1936). *Cyrtostachys renda* in particular is confined to peat swamp forest in the lowlands, usually near the coast, but can also be found in lowland heath forest, e.g. in Natuna Island (*Mogea* 2990) and Balembangan Island, Sabah (SAN 86702). The other members of *Cyrtostachys* are mostly single-stemmed and lack red colour, some of those are even very large palms such as *C. peekeliana* and *C. kisu*, while *C. renda* is a distinct multi-stemmed representative with a bright red colour.

Palms as characteristic components of many tropical ecosystems (Moore, 1979) are attractive subjects for ecological research and many aspects such as ecological requirements, habitat preferences, population structure, demography, reproductive biology, and use have not been investigated in detail (Brown, 1976; Uhl and Dransfield, 1987; Tomlinson, 1990; Henderson, 1995). Palms frequently dominate tropical vegetation, even in certain marginal habitats, such as freshwater swamp and mangrove, and serve as important indicators of soil and vegetation types and drainage patterns (Moore, 1979; Uhl and Dransfield, 1987). They may also be very precise markers of certain forest types (Moore, 1979), such as the taxonomically distinctive palm *Cyrtostachys renda* in the tropical lowland peat swamp forests of Southeast Asia.

### 2.1.1 Systematic Account

There has been debate and confusion in the classification (naming, characteristics) between *Cyrtostachys renda* and *C. lakka* (e.g. Treub, 1885; Bailey, 1913; Backer and Brink, 1968). Typus: *Cyrtostachys* Blume (Dransfield and Uhl, 1986; Uhl and Dransfield, 1987). Phenetic analysis is conducted in this study (*see Chapter 4*) to provide a better taxonomic status.


Clustered or very rarely single stemmed, up to 30 stems when clustered, rather low to moderate: 3-10 m tall, but commonly only 3 to 8 m, monoecious palm. Stem erect, bare, straight, slender, green to grayish brown, unarmed usually tufted with greyish white lichens, hard, 4-12 cm in diameter, distinctly ringed with leaf scars forming internodes, the young stem internodes normally marked with fine striations of lighter green, when old the stems lose their vigor, where clustering often with basal vegetative shoots (suckers), the clump close, often have stolons (from the stem base) running along the ground, which can extend up to 1.5 m long, particularly in wet soils. Crown small with arched leaves, the crown gradually diminishes in size with ages, smooth, bright red crownshaft, the red crownshaft becomes more conspicuous as the plant ages.
Leaves pinnate, persisting at stem-apex, neatly abscising, 1.3 – 2.9 m long, arching, dark green above and polar or somewhat glaucous beneath, selfcleaning; *leafsheath* tubular, forming a well defined crownshaft, ± 60 cm, bright red like the petiole and rachis, glabrous or scaly, brilliant scarlet, completely enclosing the stem; *petiole* short, 15-30 cm, smooth, slender, unarmed, bright red, adaxially channelled or flattened, abaxially smooth rounded or convex, glabrous; *rachis* like the petiole but adaxially channelled at the base and angled in the middle and the tip, abaxially rounded or flattened c. 1.4 m long, bearing a number of leaflets tapered to the apex; *leaflets* 15 – 90 cm long (± 50 cm on the average), linear, evenly spaced along the midrib with both ranks form a V-shape, lanceolate, erect, acute, acuminate at tips, single fold, stiff, ascending, partly with bifid apex, adaxially green glabrous, abaxially glaucous often with ramenta along the mid vein, leaflets 50 - 70 (25 - 35 in the either side of the rachis); *veinlets* linear, conspicuous or obscure. *Inflorescence* infrafoliar (below the crownshaft), highly branched up to 3 orders, spreading, protandrous or pendulous, green when young and dark brown when ripe, the whole inflorescence enclosed in bud by tubular bract (prophyll) with the upper one pointed and becoming deciduous when flowers open (Blombery and Rodd 1982); *peduncle* very short or short ringed with bract scars, ± oval or triangular in cross section, ringed with bract scars; *prophyll* ± lanceolate, enclosing the inflorescence, tubular, raised above the winged base of the peduncle, caducous, splitting; *peduncular bract* borne just above the prophyll, caducous; subsequent bracts inconspicuous, small, triangular, incomplete; *rachis* longer than peduncle; *first order branches* spreading, robust, with a short bare portion at the base, then branching to produce rachillae or secondary branches; *second-order branches* less spreading, also with a short base portion, then branching to produce rachillae; *rachillae* elongate, cylindrical, curved, roughened, expanding long before anthesis, c. 50 cm long, c. 5 mm wide and c. 55 in number; rachilla bracts short, ± triangular, spirally arranged, not very crowded, each bract with a shallow pit bearing a triad of flowers (a female between 2 males), triads borne
throughout the length of the rachillae. Flowers greenish when young and dark or black when old; staminate flowers with 3 overlapping sepals and 3 petals touching in bud; sepals very small toothed margins; petals valvate at tips, about twice as long as sepals, united with the sepals at the base: stamens 9-15 with the filaments joined at the base, the small sterile pistil is 2 to 3 branched; pollen elliptic or circular (Uhl & Dransfield 1987); pistillate flowers with 3 sepals and petals with edges touching in bud, the sterile stamens united into small 6-toothed ring, sepals imbricate, with very small toothed margins; petals imbricate, proximally rounded, the tips valvate; gynoecium unilocular, ellipsoidal; ovary with 3 stigmas. Fruits ellipsoid or ovoid, narrow at tip (nearly egg-shaped) with the old style attached, green when young and dark brown to black when ripe (often with a red base), 8 - 9 x 5 - 6 mm in size; stigma remains apical; epicarp smooth; mesocarp thin, oily, with abundant longitudinal fibers; endocarp thin, closely adhering to the seed. Seed globose or ellipsoid, black, 4 - 6 mm in diameter, apically attached, the hilum orbicular, endosperm equable; embryo basal; germinate within 2 to 3 months requiring heat. Germination epigeal, adjacent tongue-shaped (ligular); seedling leaf bifid with narrow lobes, n=16 (Sarkar, 1970 in Uhl and Dransfield, 1987).

Specimens Examined – PENINSULAR THAILAND. Ta Samet, N. Sritamarat, Kerr 14332 (K, BM); Phru Kok Daan, Tak Bai, Narathiwat, Niyomdham 852 (K); Tho Daeng c. 30 km SE of Narathiwat, Barford & Uechirakten 41772 (K). SUMATRA. Bengkalis, S. Selat Pandjang, Bengkalis, Beguin 457 (BO, L); P. Padang, Sumatra’s Oostkust, de Haan 20 (BO); Troemon, Aceh, Asdat 171 (BO); Rasau, Way Kambas Reserve, Dransfield 1252 (BO); Natuna Island, West Bunguran, Sungai Segeran, Mogeia 2990 (BO); Bangka, Djeboes, Teysmann no coll. number (BO); Bintan, Riau, Teysmann no coll. number (BO); Sumatra, no coll. number (K, Type Specimen). BORNEO. Linga, Province of Batang Lupar, Sarawak, Beccari 3438 (K, Type Specimen); Kapit, Upper Rejang River, Sarawak, Clements 21377 (BO); Rian Road, Miri District, Sarawak, Salleh 1214 (K, L); RP. 36 Mengalong, Southside, Sipitang, Sandakan, Sabah, Lassim Ahmad 73141 (BO); Pulau Balembangan, NE Inner Side of Telok Long, Kudat, Sandakan, Sabah, BCS-EFA-LM et al. SAN 86702 (K, L); Maruntongan, North Borneo, Brunei, Keith 2491 (K); Belait, Km. 20 Labi Road, Labi, Brunei, JD 7279 (K); Bukit Bakong, Raring, Brunei, JHB 275 (K).
According to Blume, *Cyrtostachys renda* was found in Sumatra, stem gregarious, c. 10 meter in height, erect, slender; **frond** 1.7 – 2.0 m long, pinnate; **petiole** c. 15 cm; **leaflet** lanceolate, commonly 70 cm long, 4.5 – 5.0 cm wide, acuminate at tips; **fruit** ovoid, narrow at tip, 9 mm long, 6 mm wide; **seed** globose, 5 – 5.5 mm in diameter. Meanwhile, Beccari argued that *C. lakka* was a different species, found in Borneo (in Treub, 1885), stem straight, slender; **frond** approximately 1.25 m, pinnate; **petiole** short, c. 7 cm; **leaflet** lanceolate, commonly 50 cm long, 3 cm wide, acuminate; **fruit** ovoid, very narrow at tip, 10 cm long, 5 mm wide; **seed** ovate, 5 x 4 mm in size.

My own opinion is that these two species belonging to the same species (synonym). A phenetic analysis using an Unweighted Pairs Group Method of Averaging and the Ordination Analysis show that all specimens from those two islands are clustered and forming one group. However, some geographic variations do occur within this species, i.e. between Bornean and Sumatran specimens. Based on their appearances, Bornean specimens tend to have obovoid fruits, brighter leafsheaths (bright red), longer crownshafts, with smaller trees (stems), while those of Sumatra tend to have ovoid fruits, paler crownshafts (yellowish or brownish red), shorter crownshafts, with larger stems. However, such appearances are not significant or consistent after they are tested quantitatively using the UPGMA and Ordination Analyses (see Chapter 5).

Thus, I conclude that *Cyrtostachys renda* (based on the Sumatran specimens) and *C. lakka* (based on the Bornean specimens) are the same species.

**Classification of Cyrtostachys renda**

Kingdom: Plantae  
Division: Spermatophyta  
Subdivision: Spermatophytina  
Class: Angiospermopsida  
Subclass: Monocotyledonidae  
Order: Arecales (Principes)  
Family: Arecaceae  
Subfamily: Arecoideae  
Tribe: Arecceae  
Subtribe: Cyrtostachydinae Dransfield and Uhl 1986  
Genus: *Cyrtostachys* Blume 1838  
Species: *Cyrtostachys renda* Blume 1838
2.1.2 Common Names

There are many common names of *Cyrtostachys renda*. They are Pinang Merah (Indonesian, but the common name Palem Merah is also often mentioned), Linau (Riau, in common with *Oncosperma*), Pinang Rimbou or Pinang Rendah or Pinang Rende (Indrapura), Pinang Lempiauw or Lepiaw (Bangka), Pinang Raja, Pinang Antan, Keredok (Malay); Ka Daeng (Thai); Sealing Wax Palm, Lipstick Palm (English); and Gruben Rendapalme or Rotstammige Rendapalme (German). In Indonesian terminology, Pinang Merah seems to be a more specific (appropriate) name for *Cyrtostachys renda*, as pinang refers to the taxon genus (including *Areca, Pinanga, and Cyrtostachys*) while palem refers to the higher taxon, family (Areaceae).

2.1.3 Habitat and Ecology

*Cyrtostachys renda* is an equatorial palm species confined to lowland peat swamp forests, usually near the tidal coast areas and along river banks (Meijer, 1963; Uhl and Dransfield, 1987) and behind the mouths of large streams (Burch, 1966), at altitudes from 0 up to about 500 m above sea level (Uhl and Dransfield, 1987). The ecological preferences of palms for certain habitat, microclimate, soil fertility, and water relation features still remain poorly understood (Tomlinson, 1979). However, there are geographic tendencies that can be studied for some species (Moraes, 1996). The distribution patterns for certain palm species show some adaptations that are related to edaphic conditions, such as drainage and formation (Moraes, 1996). The limits of many palm species distribution are remain poorly known and therefore further studies are needed to provide a complete view of the ecology of the group.

In some habitats of the lipstick palm, the accumulations of peaty organic materials often overlays decomposed granite fines, such as yellow clay, or even on humic sands derived from eroded sand stones (Tucker, 1992). Sometimes the species forms a prominent component of the forest vegetation, e.g. in the downstream of Kerumutan River (Galoga border), Riau, Sumatra. However, in
heavily shaded sites of Kerumutan Wildlife Sanctuary it forms very poorly formed clumps with only very few stems. Conversely, this plant tends to establish dense clumps of many stems in drainage lines, creek and stream banks of the reserve where the sun light penetrates. It seems that *C. renda* has an ability to colonise disturbed habitats or unstable conditions (in some extent) to become established in ecologically limited spaces, e.g. at a disturbed site of Galoga border.

2.1.4 Geographic Distribution

*Cyrtostachys renda* is the only *Cyrtostachys* representative occurs in the west of Wallace's Line, including Southern Thailand, Peninsular Malaysia, Sumatra, and Borneo, occurring mainly in coastal areas (Treub, 1885; Ridley, 1926; Whitmore, 1982; Backer and Brink, 1968; Uhl and Dransfield, 1987; Fig. 2.1). This palm becomes one of the characteristic components of the southeast Asian lowland peat swamp forest. There may be populations of this species occurring in the eastern coastal area of Borneo (Kalimantan Timur), because this area contains a substantial peat swamp formation, but no specimens have been collected from this part up to day. The eastern coastal area of Borneo appears to be the eastern geographic distribution limit of this species. The possible occurrence of this palm in the Islands of Siberut, Mentawai, and Pagai is still questionable. The other *Cyrtostachys* members are all from New Guinea and the Solomons (Uhl and Dransfield, 1987). *Cyrtostachys renda* is now widely cultivated.
Fig. 2.1 Known (solid line) and inferred (dotted) geographic distribution of *Cyrtostachys renda*. A minimum convex polygon is used.
2.1.5 Variation Within Species

Natural variation seems to fall into three categories: individual variation, geographic variation, and polymorphism, while the most conspicuous variation occurs in artificial conditions, namely variation under domestication (Patterson, 1978). Although individuals are unique in several recognisable ways and polymorphism (the co-existence of two or more well-marked variants/varieties in the same region, therefore the intermediates do not occur) shows conspicuous differences, such variations are not determined by the local conditions of life which become the important aspects of this study. Individual variation in particular seems to be random and without any function (Patterson, 1978), therefore more attention is given to geographic variation in this study.

2.1.5.1 Geographic variation

In general, geographic variation within a species involves more obvious differences than the details (characteristics) that distinguish individuals from the same place. Individuals of a species from one region may be difficult to differentiate, but those from widely separated regions can often be distinguished readily. In this study, the specimens of *Cyrtostachys renda* from Sumatra and Borneo are analysed to determine possible similarities (thus dissimilarities) in order to provide a fixed taxonomic status. Geographic variation involves adaptations to climate, edaphic conditions, and other environmental conditions. The differences between *C. renda* and *C. lakka* may most probably be caused by their geographic characteristics.

2.1.5.2 Variation under cultivation

2.1.5.2.1 Definition of cultivation and domestication

Although a number of authors have given the definitions of domestication and cultivation, clearer definitions and understanding are still needed, particularly for palm study. Palm is a plant group that has been used by human and brought into his household for a long period, e.g. coconut (*Cocos nucifera* L.), areca (*Areca catechu* L.), date (*Phoenix dactylifera* L.), and oil
Palm (Elaeis guineensis Jacq.). As part of my research with the sealing wax palm (Cyrtostachys renda Blume), the question of cultivation and domestication in this lipstick palm is reviewed.

Based upon accumulated knowledge of plant genetic and geographic variation, anthropological, archeological, and ethnobotanical studies of human-plant interactions, the explanation of cultivated and domesticated plants will always change in time (Clement, 1992). The best definition of domestication is provided by Harlan (1975):

"To domesticate means to bring into the human household. In the case of domesticated plants, it means that they have been altered genetically from their wild state and have come to be dependent upon man for survival. Thus, domestication implies a change in ecological adaptation, and this is usually associated with morphological differentiation. There are inevitably many intermediate states".

"To cultivate means to conduct those activities involved in caring for a plant, such as tilling the soil, preparing a seedbed, weeding, pruning, protecting, watering, and manuring. Cultivation is concerned with human activities, while domestication deals with the genetic response of the plants being cultivated. Therefore, it is possible to cultivate wild plants and cultivated plants are not necessarily domesticated".

The key point of the domestication’s definitions is “completely dependent upon man for survival”, because this is the point of no return in the domestication process. For example, in annual plants, it means that the plants may not be able to survive without human preparation of a favorable agro-ecosystem and elimination of competition, while in perennials this means that the plants will not reproduce themselves successfully, thus their genotypes fail to survive into the next generation (Clement, 1992). Varieties and landraces (morphologically distinct races developed by humans in different geographical areas) of the same species may differ in the degree of modification due to selection, e.g. completely domesticated and semi-domesticated landraces, while wild types have little or no modification at all. Thus, if a species has at least one fully domesticated landrace (kultivar) and its survival is dependent upon human intervention, it may be considered to be domesticated. However, a variety of
Landraces (> one landrace) can be considered as a better proof of the plant importance to humans. More than 99% of all domesticated plants were developed by pre-modern farmers (Harlan, 1975). The oil palm is often cited as one of the few modern domesticates.

There are varying degrees of cultivation and domestication, from relatively primitive to highly sophisticated (advanced), and cultivated plants are necessarily domesticated. Any plant that has been cultivated for a long period (many generations) would inevitably be modified by natural selection in cultivation and by the farmer’s conscious or subconscious selection. In this stage, the plant starts to become domesticated. It is difficult to determine which palms are most domesticated, because there are different criteria for each species. However, there are two major criteria generally agreed: 1) the inability to survive without human intervention, and 2) the existence of at least one landrace within the species (Clement, 1992). Figure 2.2 shows a continuum from wild species to major crops. This process refers not only to human interaction with plants to obtain their economic products, but also to the plant genetic responses to the interaction, i.e. progressive changes in gene frequencies, leading finally to full domestication.

<table>
<thead>
<tr>
<th>Wild Species</th>
<th>Used Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild, economic importance unknown, not necessarily found in wilderness areas</td>
<td>Uses and benefits known (i.e. indigenous knowledge)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivated Species</th>
<th>Managed Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human activities occurred: plant caring, soil tilling, seedbed preparation, weeding, pruning, protecting, watering, manuring.</td>
<td>Protection, study, human interference and interaction initiated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Domesticated Species</th>
<th>Major Crops (Plantation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brought into man’s household, altered genetically from wild state, dependent upon man for survival, at least have one landrace dependent upon human intervention</td>
<td>Large scales of plantation</td>
</tr>
</tbody>
</table>

Figure 2.2 A continuum from wild state to major crop.
Management is a less sophisticated form of cultivation. In this stage, the plant may be protected from human-caused environmental modification (e.g. land clearing and disturbance), liberated from competition from other species, or seeds and seedlings may be planted, although without seedbed preparation per se. Plant management implies human-plant interaction and includes mass selection and thus genetic modification of the species managed. Many Neotropical palms appear to have been managed in this way and morphological modifications are frequently observed (Balee, 1988 in Clement, 1992).

Usage is the closest step to the wild state and Clement (1992) includes this stage in the step of wild and used as the initial stage in the domestication process. My own opinion is that used stage should be regarded as a separated stage, because there must be a period that wild plants (which later become cultivated or domesticated) were not used until their importance were known by man. Many of the wild plants remain unused, thus undomesticated or cultivated, while others are used, although not necessarily cultivated or domesticated.

1.5.2.2 Testimony of palm domestication

How can the domestication of a palm be proven? It is a common phenomenon that only very few representatives or even none of most domesticated plants are still existed in their native habitats, which enables them to continue reproduction and establishment. Even such samples remain unstudied or reported, e.g. Areca catechu (pinang) and Cocos nucifera (kelapa). The ecology of the native representatives, their native habitats, and natural history of these species are unknown. Pinang has been cultivated for about 3,000 years, thus the history of its interaction with humans is probably twice this. The centre origin of this species may be in the East Indies, from Indonesia northward to the Philippines (Rao, 1982 in Clement, 1992). Widyatmoko (1996) found that few significant populations of A. catechu occurred in the native forest of Bogani Nani Wartabone National Park, North Sulawesi (Tumokang River, Mount Bande). Further investigations are required to proof whether these
populations are native representatives. In fact, the populations occurred in a native undisturbed habitat, where there were no any other cultivated plants. The characters of pinang appears to have been modified by selection. Advanced representatives have larger nut size, better nut quality, higher fruit / bunch ratio, probably more bunches per tree than the primitive ones (Bavappa and Nair's, 1982 in Clement, 1992). The center of origin of coconut is also most likely in the East Indies, but it is impossible to define exactly. Purseglove (1985) in Clement (1992) noted the reestablishment of coconuts on Krakatau as proof of its natural dispersal ability after floating in ocean currents. Gruezo and Harries (1984) and Buckley and Harries (1984) in Clement (1992) reported that primitive representatives of coconut were found in wild, self-sown situations in the Philippines and Australia, where the modern types were not found. This indicates that the advanced types require human intervention for continued survival. Harries (1978) in Clement (1992) identified the long, angular, and thick husked coconut as most primitive, while the round and thin husked coconut is most advanced (modern).

During the domestication process, a variety of morphological characters and ratios between diverse components of the reproductive and vegetative biomass or within the reproductive organ are modified. Some of the modifications may include reduction or elimination of spines; increased ease of propagation; increase in seed production, higher percentage and more rapid germination; reduced natural dispersal ability (e.g. fruit do not abscise readily from the rachilla or are easily damaged by falling from the tree); increased proportion of usable product (part) in the harvestable product (e.g. higher fruit to bunch ratio and higher mesocarp to fruit ratio); and increased proportion of harvestable product in the year's biological growth (increased Harvest Index). It is certain that not all of the modifications will be found in each modified species. Chapter 4, the possible modifications within Cyrtostachys renda is analysed and wherever possible an attempt made to quantify its degree of modification due to cultivation.
2.1.5.2.3 Modifications of Cyrtostachys renda \textit{(variations under cultivation)}

Lipstick palm may have been cultivated for about 200 years, particularly in Java and Sumatra, since before Blume firstly described this species in 1838. The history of its interaction with humans may have been started a long time before it was firstly described. It is a very recent introduction comparing to \textit{Areca catechu}, which has been cultivated for about 3,000 years (Rao, 1982), or the date palm \textit{Phoenix dactylifera} that may have been domesticated in India to the Atlantic Ocean for about 10,000 years (Chevalier, 1952 in Clement, 1992).

2.1.6 Growth and Life Span

2.1.6.1 Seedling establishment

The phase of seedling establishment in palms can be defined into two ways (Tomlinson, 1990). The first, it begins with the enlargement of the embryo some time after the fruit is mature (germination), until the exhaustion of the endosperm reserves. This point is difficult to establish as morphological changes may not be observed. The second, the expansion or emergence of the first bladed seedling leaf (eophyll) is regarded as the end of seedling development, although the endosperm itself may be not exhausted yet. Brown (1976) suggested that seedling establishment is initiated by the emergence of a seedling and continues until the seedling reaches the autotrophic state. The autotrophic stage is essentially established when the seedling leaves expand and unfold. Robertson (1983) in Tomlinson (1990) divided germination in \textit{Jubaeopsis} into five stages, beginning with the emergence of the ligule (seedling) from the seed and ending with the appearance of the first eophyll (first bladed leaf). A knowledge of seedling establishment and biology is important in commercial practices, because almost all palms in horticulture and agriculture are economically grown from seed. Although vegetative division is possible for some palm species, the demand for high quantities of plants will be difficult to supply through this way. Environmental conditions that determine germination need to be studied for successful efforts. For example, high soil temperature is
germinate the seed of oil palm (*Elaeis guineensis*, Rees in 1990), while oxygen concentration may influence the seed of *Jubaeopsis caffra* (Robertson and Small, 1977 in Tomlinson, 1990). However, recent studies on palms (e.g. Chazdon, 1992; Enright and Watson, 1992; Ratsirarson et al., 1996) have been concerned with the seedling phase in demographic aspects. In such studies, quantitative and survival studies in mixed populations become important.

### 6.2 Establishment phase

The establishment of post-seedling phase is very important in the ontogeny of palm, because it is the foundation for the mature primary axis. Although establishment growth occurs to some extent in all vascular plants, it is only pronounced in monocotyledons, even in those which have secondary thickening (Tomlinson, 1990). Establishment phase is vital for woody monocotyledons because of their inability to generate secondary vascular and mechanical tissues from a vascular cambium. Without secondary growth, a radicle of palm would be inadequate to support the water required for an enlarging aerial shoot system, even if the radicle could increase its absorptive area by branching. Conversely, the root insertion would become a bottle-neck to transport requirements. In contrast, via secondary thickening, the radicle of dicotyledons becomes the massive tap root of the plant, thus the bottle-neck is eliminated by secondary tissues. In palms, the drawback of a radicle of fixed diameter is overcome by the production of adventitious roots over an increasing stem surface. For example, the radicle of *Archontophoenix* is short-lived and substituted very early by adventitious roots. The increase in stem surface is achieved as a result of the gradual increase in diameter of the axis. Establishment growth involves an increase in diameter of each successive internode. Thus, the establishment growth is a gradual process and results in an obconical axis (Tomlinson, 1990).
For *Cyrtostachys renda*, information on the time taken from seed to develop a visible or defined stem (establishment phase) is unknown. Even, the establishment phase of almost all of wild palms is less understood. The two palm species with a known establishment phase are *Neodypsis decaryi* (12 years on average based on the palm plantation data, Ratsirarson *et al.*, 1996) and *Rhopalostylis sapida* (40 – 50 years, Enright, 1985). In this study, 15 years is determined to be the minimum time required for a new scdling of *C. renda* to produce a visible stem.

In the adult individuals of *Cyrtostachys renda*, the leaves are shed about once every 4 months by comparison (on average), consequently one internode takes about 4 months to develop if growth is maintained at this rate (one leaf can only produce one leaf scar). This means that on a crown with 6 leaves, the oldest leaf is probably about 2 years old, if growth is maintained at this rate. Based on this study (age estimation), the individual plants can live for approximately 80 years. The growth rate is naturally slow and lower temperatures and light exposures will lower the growth rate. Humidity combined with cloud cover which is almost a daily factor in tropical environment tends to reduce moisture stress in the plant.

2.1.7 Mechanics and Allometry

In contrast with dicotyledons, the trunk and crown of palms do not maintain a constant proportion. The crown is built to its mature size during the establishment phase and is connected to the root system by an appropriate number of short pipe units, because a tall trunk is not yet developed. Growth in height then involves the extension of a fixed number of pipes, because there is no replacement of pipes. As individual leaves fall, only the leaf of the short and immediate connection to the permanent pipe becomes disused. The unit pipe effectively functions throughout the life span of the tree, both in conduction and support. In palms, fibrovascular bundles are discrete units (Tomlinson, 1990).
Fig. 2.3 Pipe model of tree construction, adapted from Shinozaki et al. (1964) in Tomlinson (1990). (A) Unit pipe. (B) Increasing aggregation of units. (C) Older units lost from aggregation producing a hydraulically disused pipe but still functioning mechanically. (D) Older plant, with accumulation of hydraulically disused pipes. (E) Unit pipe. (F) Aggregation of pipes in young palm. (G) Further addition of pipe units. (H) Mature crown, with fixed number of pipes. (I) Older tree, crown and pipes are fixed in number, but older crown units are lost, the axial portion of the pipe still functions hydraulically, only the distal attachment is lost.

Because the vascular system is formed during establishment growth (initial stem development), it must anticipate all future transport and strength needs. Thus the palm is overbuilt mechanically and hydraulically, and increase in stem rigidity occurs with age. Some diameter increase may also occur with age. However, the situation in nature must be more complex than this point, because in the absence of a vascular cambium, height-diameter relationship in
some species does approach that for dicotyledonous trees, e.g. *Roystonea*, *Archontophoenix*, *Euterpe*, and *Oncosperma* (Tomlinson, 1990). A short, young palm is mechanically very robust, and as the palm grows taller it moves into the area where it has the correct proportions of a dicotyledonous tree. Eventually, it could reach the limit of its mechanical strength at the buckling line (the trunk would collapse under its own weight). The question is how close might a palm species come to this limit? In *Socratea exorrhiza*, two unexpected results appear. First, there is a closer approximation to the calculated diameter-height slope for dicotyledonous trees over a wide range of heights. Second, some tall individuals have dimensions which bring them beyond the buckling limit. This confirms the two possibilities: palms can grow in diameter with age and that their mechanical proportions change with age (Tomlinson, 1990).

### 2.1.8 Interspecific Association

Species interactions are very important in the ecology of a species. The detection of species association can have important ecological implications in resource management (Ludwig and Reynolds, 1988). However, the detection of an association pattern does not provide a causal understanding of why such a mechanism might exist. Rather, pattern detection can be used to generate hypotheses of possible underlying causal factors, which further studies can be designed to address.

There are two standpoints for treating the interspecific association: first deals with the overlapping of distribution of two species regardless of the area on which neither of the two species is present (e.g. Dice Index, Whittaker Index, and Bray Index) and the second treats the whole area examined considering the single or joint occurrence by chance of the two species (e.g. Cole’s association coefficient and De Vries’s quantile correlation coefficient) (Morisita, 1959). Up to present, many indices based on the quadrat sampling have been devised for determining the degree of interspecific association. Schluter (1984) shows some
ecological processes that may result in a positive or negative association between two species (Table 2.1).

Table 2.1 Interspecific interactions and ecological processes that may result in positive and negative association among species.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Negative</th>
<th>Ecological Process</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutualism</td>
<td>Resources compete and are used exclusively by species.</td>
<td>Species enhance each other’s survival probabilities.</td>
<td></td>
</tr>
<tr>
<td>Competition</td>
<td>Interference between species produces occasional exclusion.</td>
<td>Species fluctuate in unison in response to limited resources.</td>
<td></td>
</tr>
<tr>
<td>Predation</td>
<td>High predator densities produce a local depression of prey.</td>
<td>Predators fluctuate in positive response to variations in prey.</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>Species have different resource requirements.</td>
<td>Species have a common response to a supply of unlimited resources.</td>
<td></td>
</tr>
</tbody>
</table>


There are a number of biotic and abiotic factors influencing the interactions, distribution, and abundance of species within any given community (Ludwig and Reynolds, 1988). Generally, an association between two species occurs because: (1) both species select or avoid the same habitat or habitat factors, (2) they have the same general abiotic and biotic environmental requirements, or (3) one or both of the species have an affinity for the other, either attraction or repulsion. Thus, the association may be positive, negative, or absent (Hubalek, 1982 in Ludwig and Reynolds, 1988).

Palm species often demonstrate a regional pattern of association, although their individuals usually do not show a strict pattern of association among themselves (Moraes, 1996). Kahn and Mejia (1990) show an example of the Amazonian taxa *Euterpe precatoria*, *Socratea exorrhiza*, *Oenocarpus bataua*, and *Mauritia flexuosa* which tend to occur together and their distribution is similar to that observed in Peru, while Moraes (1996) finds *Iriartea deltoidea* and *Euterpe precatoria* to occur together in humid premontane forests in well-drained soils of the Andes piedmont.
2.1.9 Age Estimation

Palms provide ideal subjects for plant age estimations and demographic studies. Tomlinson (1979) noted that palm ages or stages can be determined by the presence of leaf (frond) scars, while leaf production rates are easily determined. Palms are relatively easy to recognise and count, thus quantitative demographic studies can accurately be conducted. For example, Van Valen (1975) used the data of Bannister (1970) to construct a life-table for Euterpe oleracea (a Puerto Rican subcanopy species) and Esler (1969) studied the leaf fall and flowering of nikau (Rhopalostylis sapida), the only palm native to New Zealand. Bullock (1980) studied the demography of Podococcus barteri, an undergrowth palm of West African rainforests, while Enright (1985) analysed the age, reproduction and biomass allocation in Rhopalostylis sapida. Further, Pinero (1988) conducted demographic studies in Astrocarum mexicanum and their use in understanding community dynamics, while Lieberman et al. (1988) investigated the age size relationships and growth behaviour of Welfia georgii.

ately, Chazdon (1992) elucidated the patterns of growth and reproduction of Geonoma congesta, a clustered understory palm, and Ratsirarson et al. (1996) conducted the demographic studies, leaf removal, and fruit harvesting assessments in Neodypsis decaryi, a threatened Madagascar palm species.

Problems associated with the determination of palm ages are present. Although the number of leaf scars present on the stem can be accurately determined, accurate frond numbers annually shed are probably not at the same rate. In addition, the time taken for juveniles to develop a visible stem (above ground) is uncertain and different among palm species, as well as different between wild and cultivated individuals. The estimate of the time required by palms to pass through the juvenile (establishment) phase can be based on individual palms of known age growing in gardens or cultivation (Enright, 1985; Ratsirarson et al., 1996). However, data on leaf production, growth, and flowering of individuals growing in the artificial conditions are not likely to be a true reflection of those occur in the wild (natural conditions). Clearly, findings
on leaf production rate, population structure, and reproduction (both generatively and vegetatively) of many species (particularly clustering palms) occurring in pristine environments are waited.

2.1.10 Fossil Record

Pollen referable to *Cyrtostachys* has been recorded from Upper Miocene deposits in Borneo (Muller, 1972 in Uhl and Dransfield, 1987). Other fossil records are unknown.

2.1.1 Anatomy

Tomlinson (1961) in Uhl and Dransfield (1987) showed that the leaves of *Cyrtostachys* could be distinguished from those of other arecoid palms by the sinuous epidermal cell walls and fibrous hypodermis.

2.1.12 Category of Conservation Status

According to the WCMC Status Report of 29 March 1996, *Cyrtostachys renda* was not considered threatened globally, but obviously becoming rare and threatened in nearly all known local populations. The loss of the natural habitats continues. The 1996 WCMC Local Status Report for *C. renda* is Vulnerable (Brunei), Rare (Kalimantan), Vulnerable (Sabah), Not Threatened (Sarawak), Endangered / Vulnerable (Peninsular Malaysia), Endangered (Singapore), Rare (Sumatra), and Endangered (Thailand). In many parts of Sumatra and Kalimantan, the populations are severely disturbed. For example, only one single individual juvenile plant was found in Marang Forest, outside Palangka Raya, Central Kalimantan in the 1997 survey. Due to drainage development, the palm has become very rare in Singapore Island, while IUCN (1995) considered this species as Vulnerable globally. A further and detail investigation is required to propose a more certain conservation status of this species (e.g. using RAMAS RED LIST Species Classifications Under Uncertainty, 1999).
The threatened palms *Cyrtostachys renda* and *C. lakka* have been protected under the Regulation of the Government of Indonesia No. 7 (1999), namely *Peraturan Pemerintah Republik Indonesia Nomor 7 Tahun 1999 Tentang Pengawetan Jenis Tumbuhan dan Satwa*.

### Uses

Young and adult plants are extracted from their habitats and have become commercially important ornamental plants (Bailey, 1913; Burkill, 1966; 1982; Uhl and Dransfield, 1987; Stewart, 1994). The stem is locally used for supporting *Nypa* leaf thatch (Uhl and Dransfield, 1987), constructing floors of local pondok (bagan), and constructing logging rails. Skeat and Blagden in Burkill (1966) stated that the hard outer wood of the stem is used for making darts in Pahang and Malaysia. The young stem apex is often eaten by local people providing a good source for vegetable. This potential use has not been widely known. The larger *Cyrtostachys* members from New Guinea potentially supply timber. Some Sumatranese consider the lipstick palm to be a plant with supernatural connections, believing that it can repel ghosts, while some Malay believe that this palm may either repel or attract ghosts, depending on the area. Skeat and Bagden in Burkill (1966) mentioned that the leaves of this palm together with those of *Neottopteris nidus* (?) and the other leaves are required to chase earth-demons away from a new clearing.

In the past, most ethnobotanical studies have recorded vernacular names and uses of plant species with little emphasis on quantitative studies (Hoft *et al.*, 1999). In recent years, there have been attempts to improve the traditional data collection and analyses through incorporating suitable quantitative methods of research, and such methods have now been used becoming a new approach in this field. Quantitative approaches are particularly constructed to describe the variables quantitatively and analyse the observed patterns in the study and different approaches are made to collect and analyse quantitative and qualitative data, depending on the objectives of the researcher and the nature of study.
Statistical and multivariate analyses are usually applied to the interpretation of various types of ethnobotanical data, including knowledge and uses of plants by different ethnic, social or gender groups (e.g. indigenous knowledge about the uses of wild plant resources is rapidly disappearing from traditional communities), preference information on different plant species (which species are most preferred), quantitative impact on human uses on growth and regeneration patterns (e.g. many wild plants are seriously threatened by species-selective overexploitation and habitat loss), size and stage class distribution of woody plant species (e.g. imbalance in size or stage class distribution is often experienced by threatened plants due to the extensive harvests of adult individuals), and quantitative plant morphological characteristics of useful plants (Hoft et al., 1999). A reliable procedure of plant use value estimation has been introduced by Phillips and Gentry (1993a, 1993b), while Hoft et al. (1999) proposed the application of multivariate and statistical analyses. Quantification often helps to generate quality information, which in turn contributes substantially to resource conservation and development. In the context of conservation and sustainability use of wild plant resources, quantitative ethnobotany can contribute to the scientific base for management decisions (Hoft et al., 1999).

2.1.14 Definitions and Explanations

The definitions and explanations below are presented to explain terminologies related to the population, status, life-form, density, and size of *Cyrtostachys renda*.

a. **Population** is the total number of individuals of the taxon. For functional reasons, primarily owing to differences between life-forms, population numbers are expressed as numbers of mature individuals only (IUCN, 1994).

b. **Subpopulations** are geographically or otherwise distinct groups in the population between which there is little exchange (typically one successful migrant individual or gamete per year or less) (IUCN, 1994).
Number of mature individuals is the number of individuals known, estimated, or inferred to be capable of reproduction. When estimating this quantity, the following points should be regarded:

- Where the population is characterised by natural fluctuations the minimum number should be used.
- Because this measure is intended to count individuals capable of reproduction, thus it should exclude individuals that are environmentally, behaviourally or otherwise reproductively suppressed in the wild.
- In the case of populations with biased adult or breeding sex ratios it is appropriate to use lower estimates for the number of mature individuals.
- Reproducing units within a clone (clump) should be counted as individuals, except where such units are unable to survive alone.

Location is a geographically or ecologically distinct area in which a single event (e.g. pollution, stochastic or catastrophic event) will soon affect all individuals of the taxon present. A location usually, but not always, contains all or part of a subpopulation of the taxon, and is typically a small proportion of the taxon's total distribution (IUCN, 1994).

e. Clump density represents the number of clumps per sampled area (clumps / hectare).

f. Tree or stem density represents the number of stemmed individuals per sampled area (trees / hectare, or stems / ha). Thus, the stemmed individuals include juveniles and adults. Juvenile and adult densities are also separately presented in this study. More detail classification and determination of adults, juveniles, and suckers is presented in Chapter 3 Approach and Methodology.

g. Clump size represents the number of stemmed individuals per clump (stems / clump).
1. Types of habitat is the types of distinct habitat referring the characteristics and conditions of the ground surface of the study area, particularly classifying the water drainage qualities among the habitat types. Three types of habitat were determined in this study: permanently waterlogged forest, seasonally flooded forest, and well-drained forest.

Forest association represents vegetation associations occurred in the study area, based on the floristic and structural differences in association types, representing both familial and specific associations (dominances).

2.2 Concepts and Categories of Rarity

2.2.1 Concepts of Rarity

Rarity is a complex concept involving a number of different meanings and appears to be based on public awareness of and concern for much publicised extinct or near-extinct species (Batianoff and Burgess, 1993; Usher, 1986). Rarity is a very colloquial and often political use (Batianoff and Burgess, 1993), a concept that is dependent on temporal perspective, spatial scale, and taxonomic constraint (Given and Norton, 1993; Gaston, 1994). Rarity is a combination of dynamic factors relating to actual and potential species distribution which is involving the biology of the species and the ecology of the area (Reveal, 1981; Cropper, 1993). Rarity concept therefore needs corrections from scientific communities over time, depending on the knowledge of species studied and the rarity definition used (Batianoff and Burgess, 1993). However, scientists seem to have difficulties with this concept and its application (Usher, 1986). In conservation, rarity has primarily been a species concept, although clearly it also applies to populations (Given and Norton, 1993).

At local scales, plant lists (both published and unpublished) do not provide definitions of rarity under which they operate. As a consequence,
The term “plant rarity” loses its scientific meaning, and the arguments for conservation and management of biodiversity are being weakened and confused. This makes it difficult for conservation managers to justify the decisions they make in setting aside and managing lands and ecosystems which may have been of great value for human needs (Batianoff and Burgess, 1993). Assessment of rarity must therefore take into account a number of essential aspects, including an operative definition of area, number of populations, number of individuals (population size), biology of the species, and ecology of the area studied. Thus, availability of reliable data and basic documentation (including geographical and taxonomic information) is important, but it is not sufficient. The biology of the species and the ecology of the area should therefore be investigated.

2.2.1 Rarity as a Temporal Phenomenon

Plant species are usually changing in abundance through time, many of which going through periods of transient rarity. According to Given and Norton (1993), there are four extreme trends in species abundance: (1) those that have always been common and probably will continue to be so for the foreseeable future (this should be put in the time scale perspective), (2) species that appear to have always been rare, e.g. species confined to specific habitats, (3) species that become more common, e.g. favoured by human activities, and (4) species that become less abundant, e.g. disturbed by human activities. It is therefore important to consider time in evaluating rarity. Species that are rare today may not be rare in ten years time, some may have become less abundant, while some other species have always been rare or common. In addition, some plant populations can show pronounced changes in numbers through time which do not necessarily reflect the abundance of the species. Rather, they reflect natural dynamic processes within the populations, e.g. some orchid populations.

Batianof and Burgess (1993) stated that population changes in size and density over time are natural events in the evolution of species, but species extinctions
due to human activity or unwitting intervention are regarded as unnatural occurrences.

The species abundant changes through time can be described mathematically as $N_{t+1} = N_t + fN_t$ where $N_{t+1}$ = the population size at time t+1, $N_t$ = the population size at time t, and $fN_t$ = the rate of change x population size at time t. Based on this formula, there is no relationship between population size and rate of change in size, but small populations are clearly more vulnerable to disturbances (or stochastic events) than the large ones.

### 2.2.1.2 Rarity as a Spatial Phenomenon

Rarity is very much dependent on a species’ distribution within a particular area (Cropper, 1993; Given and Norton, 1993; Batianoff and Burgess, 1993), or upon the operative definition of the area (Reveal, 1981). Some species are naturally rare because their main habitats are very limited, e.g. plants occurring on very acid peat swamp forests, limestone rocks, or kerangas forests. This definition is based on both geographic and demographic criteria (Argus and Pryer, 1990; Cropper, 1993), so rarity, in this case, does not imply endangerment or impending extinction. Some species that are rare regionally or nationally or globally may be very abundant locally (including endemic species) where they are reproductive and competing very well in those localities, while some nationally common species may be locally very scarce. For example, *Pinanga javana* is considered an endangered species nationally (and globally), being confined to the mountain forests of western Java, but locally it consists of significant populations. Then, the same locality the rattan *Calamus spectabilis* is also considered very threatened in west Java, or even probably extinct (WCMC, 1997), but it is more common in Sumatra. Conversely, *Areca catechu* is nationally common but locally can be very rare. Because these criteria vary considerably, the application of rarity concept is subjective (Cropper, 1993), even though the information on plant distribution and population size is objective (Argus and Pryer, 1990).
Some species can be rare because they have limited distributional ranges, e.g. due to specialised habitat requirements, or because they are simply localised species. This concept is expanded by Drury (1974) into three types of geographic distribution: a) species associated with stressed or extreme sites, b) widespread distribution but locally infrequent species, and c) species that occur in large numbers but only in a few localities. These situations have been referred to as pseudo-rarity or diffusive rarity, and is clearly different from species that are genuinely rare throughout their range (suffusive rarity).

Rabinowitz (1981) proposed five types of plant rarity based on a species distribution within the habitat size(s) available (1-5) and Cropper (1993) added one group (6): (1) species with *small populations* scattered over a large geographical range and found in several habitats, (2) species with large populations scattered over a large geographical range but found in *specific habitats*, (3) species that are constantly *sparse in specific habitats* but scattered over a large geographical range, (4) species that have a *restricted geographical range* but are locally abundant in specific habitats, (5) species that have a *restricted geographical range* and are *sparse in specific habitats*, and (6) species that, although common in some areas, *fit into one of the above categories in other regions*.

Usher (1986) gives an example of the application of the so called quantitative distribution system in the British Isles. The Isles is divided into geographical unit areas of 10 km grid squares. A plant is regarded rare if it occurs in fifteen or fewer of these squares. However, the method can effectively be used as a measure of rarity only in places where the vegetation is well known. In practice, the information of plant rarity within a given area heavily depends on published lists or papers compiled by botanical experts, and the representation of taxa by a few herbarium specimens and/or a restricted known range is used as an indicator of the rarity. In most cases the criteria of plant rarity listings are based on prima facie evidence (Argus and Pryer, 1990).
Burgman (1988) states that at a local scale plant rarity is common in Western Australia and Batianoff et al. (1985) in Batianoff and Burgess (1993) show that 62% of the Queensland's Mountain Coolum flora occurrence was classified as infrequent and/or rare, while abundant and/or frequent flora only covered 38%. In their study, flora occurrence was determined by the estimation of “Abundant” (having >25% cover), “Frequent” (6-25%), “Infrequent” (1-5%), and “Rare” (<1%). In more detail, the Mountain area had only about 4% of the plant species ranked as abundant, 34% as frequent, while 8% of those rated as rare and 54% as infrequent. This shows that the number of rare species is twice the number of abundant species that dominate the area. It is important to realise, however, that local infrequency or rarity of plant species is a natural and common phenomenon (Batianoff and Burgess, 1993).

2.1.3 Rarity as a Taxonomic Phenomenon

Rarity is not only dependent on time and space, but is also dependant on taxonomic criteria used, which is a product of our taxonomic understanding (Given and Norton, 1993). Many apparently rare species are regarded as rare because they are considered as distinct or different entities from those of more widespread species. On the other hand, some rare taxa may have not been recognised because they have been regarded or grouped into more common taxa. For example, well-known families such as the Arecaceae family have many species, subspecies, and varieties. This reflects knowledge of the taxa, their economic usefulness, and the opinions of the taxonomists involved. Since official rare plant lists contain only taxa that are named at species level, the elevation of a lower ranked taxon to species level can create a new rare species.

Apart from those three concepts of rarity, rarity can also be the product of our limited knowledge in plant distributions and reflects the lack of botanical exploration of many areas. Many rare species are considered rare because their distributions are not well known. For Indonesian situation, which is consisting of many islands with their own geographic characteristics, rarity is a very
complex phenomenon. However, as our knowledge improves, and some apparently rare species can be found, then the rarity of certain species may be revised.

Rarity can also be the result of mis-identification due to the failure in recognising uncommon species. In the field, it is very possible that some people incorrectly identified a species, which then later the species is correctly identified as a more common species. Thus rare or less common taxa can be mis-identified. A good local example relates to the endangered palm *Pinanga javana*. This species on first identification has a tendency to assign to the more common palm species *Pinanga coronata*. Then, the endangered rattan *Ceratolobus pseudoconcolor* can be mis-recognised as *C. glaucescens*, if we do not examine it more carefully, e.g. looking at the difference of the abaxial leaf colour.

The question of the lowest numbers of individuals required before a species is considered rare is also debatable. In Australia a species with fewer than 1000 plants within conservation reserves is regarded as rare and threatened (Batianoff and Burgess, 1993). According to Leigh and Briggs (1992) a species classified as Rare (R) if the number of individuals known to occur in the wild fewer than 5000 for trees, or 10,000 for herbs. From qualitative point of view, a plant is defined as rare when “although not presently threatened with extinction, it is in such small numbers throughout its range that it may become endangered if its present environment worsens.” Meanwhile, a plant is defined as endangered when “its prospects of survival and reproduction are in immediate jeopardy from one or more causes” (The 1977 Native Plant Protection Act of the California Legislature in Holsinger and Gottlieb, 1991). Further, a plant is defined as threatened when “not presently endangered with extinction but likely to become endangered in the absence of special protection and management” (The 1984 Amendments to the California Endangered Species Act in Holsinger and Gottlieb, 1991).
The rarity concept clearly indicates the importance of genetic diversity, which may become the real basis for conservation efforts. Although *Cyrtostachys lakka* may only be a variation of a more widespread *C. renda*, it still harbours its own unique genetical information and it may well be that the former species is diverging towards a separate species. This notion raises the question of should we just try and protect typical forms of a rare species, or should we also consider the other forms. Focus on the typical forms likely to result in a substantial loss of genetic variation, and also of evolutionary potential. This then may lead to the need to conserve both the typical form and the variation that occurs within a species.

2.2.2 Categories or Forms of Rarity (Rarity Classification Systems)

Rarity is not a simple concept and different classification systems (categories) of rarity have been recognised. However, the most recognised and accepted system is by far the IUCN Red List Categories published in 1994, which was then revised in 2000. The criteria can be applied to any taxonomic unit (taxon) at or below the species level. Although the criteria are most appropriately applied to whole taxa at a global scale, they can be applied within any specified geographical or political area. If used at regional or national level, it must be noted that a global category of threat may not be the same as a regional or national category for a particular taxon, and two key points should be borne in mind: the global status category for the taxon and the proportion of the global population or range that occurs within the region or nation. In addition, the taxon and area under consideration should be made explicit (IUCN, 1994).

A taxon is Extinct (EX) when there is no doubt that the last individual has died. Extinct in the Wild (EW) when it is known only to survive in cultivation, captivity, or as a naturalised population outside the past range, Critically Endangered (CR) when it is facing an extremely high risk of extinction in the wild in the immediate future, Endangered (EN) when it is not Critically Endangered but is facing a very high risk of extinction in the wild in
the near future, and Vulnerable (VU) when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the medium-term future. All taxa listed as Critically Endangered, Endangered, or Vulnerable are classified as "threatened" (Fig. 2.2). Meeting any one of these criteria qualifies a taxon for listing at that level of threat, thus each species should be evaluated against all the criteria.

The 1994 IUCN category of Lower Risk (LR, which was previously separated into three subcategories of Conservation Dependent - cd, Near Threatened - nt, and Least Concern - lc, which included taxa that have been evaluated but do not satisfy the criteria for any of the categories Critically Endangered, Endangered, or Vulnerable) is no longer necessary (IUCN, 2000). The change results in a new structure for the IUCN categories (Fig. 2.2). The current use of Conservation Dependent (comprising taxa which are the focus of a continuing conservation programme, the continuation of which would result in the taxon qualifying for one of the threatened categories within a period of five years) is no longer necessary, and the taxon can be both threatened and conservation dependent. A taxon is Data Deficient (DD) when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution.
and/or population status. Such a taxon may be well studied and its biology well known, but appropriate data on abundance and/or distribution is lacking. A taxon is **Not Evaluated (NE)** when it has not yet been assessed against the criteria (IUCN, 1994).

![IUCN Red List Categories Diagram]

**Figure 2.4 New Structure for the IUCN Red List Categories.**

**Source:** IUCN (2000).

### 2.2.3 Causes of Rarity and Threatening Processes

Rarity can be the result of a species biological strategies or historical events. The biological strategies that influence survival of a plant include dispersal, longevity, pollination requirements, and tolerance to stress. If the biological factors are the causes of rarity, the species may be able to spread and become commoner if its environment changes to a better adapted habitat. In this case, the species is rare because of its own biological restrictions (Cropper, 1993). Lahti *et al.* (1991) identified three biological differences between 83 rare plant species and their more common relatives: *observability, length of flowering*
season, and edaphic requirements. Regardless observability, the rarity of the species might be largely due to their failure to adapt to the available habitats.

Historical reasons for plant rarity can be due to three main causes: natural environmental changes, man-caused environmental changes, and species over-exploitation (removal) from the wild (Cropper, 1993). Climatic change and movement of the continents have caused large changes to the vegetation found in any one area. Based on fossil records, cycad-dominated rainforests are one example found in areas now occupied by grasslands and woodlands. Species dependent on these forests would therefore have lost a lot of their original habitat (Cropper, 1993). Rare species can be considered as either ancient relics of a previously widely dispersed species or as a new species that has not had the chance to spread (Preston, 1948 in Cropper, 1993). Using a complex floristic and habitat analysis, Prober and Austin (1990) found that habitat peculiarity was a contributing factor to the rarity of *Eucalyptus paliformis*. The habitat uniqueness was defined by a combination of environmental factors that appeared to be related to moisture, acidity, and temperature. Habitat fragmentation and isolation of common ancestors through increasing aridity can lead to the restriction of messic taxa. A stream-dependent herb *Collomia rawsoniana* (Taylor et al., 1987) and three closely related species of *Silene* (Taylor and Palmer, 1987) were the examples of the relics of the common ancestral species that have become rare due to the habitat fragmentation and isolation.

The influences of human activities have caused large changes in the world flora. Although more than 99% of the species that have occurred on Earth become extinct mostly as a result of natural events (Ehrlich and Ehrlich, 1981), such as volcanism, tectonic movements, and major climatic change, and also minor stochastic events like drought, floods, and insect attacks (Cropper, 1993), the rate of extinction has increased dramatically as a result of human activities.

Because the rate of speciation is relatively constant and the amount of new habitat suitable for colonisation and speciation is small, the new levels of extinction would result in the loss of a large amount of the world’s genetic
resources (Lucas and Synge, 1978; Frood and Calder, 1987 in Cropper, 1993). While many messic species were reduced in range or even became extinct, some areas of new habitat became available for new species to establish. Land clearing for grazing stock, growing crops and plantations, building cities, roads, settlements, dams, and necessities of urbanisation are all in many cases the major causes of plant decline. Habitat loss and changes due to human activities undoubtedly to be the most serious threat to plant survival. In Kerumutan Reserve, alteration of water regime can be a big threat to the populations of *Cyrtostachys renda* in this protected area. Investigations throughout the reserve indicated that the species is confined to relatively well drained sites but is dependent on the existing streams for its moisture requirements. Clearing forests at the upper reaches of the existing rivers within the sanctuary or any alteration to the adjacent watersheds and streams would have significant effects on the spatial distribution and abundance of the species, as well as threaten the sustainability of the other plant populations in the area.

Over-exploitation or collection of plants is in some cases also a serious threat. Orchids, palms, and timbers are the three Indonesian common groups that have been seriously threatened by over-collection. In Kerumutan Sanctuary, Riau, and Marang Forest, Central Kalimantan, young plants of *Cyrtostachys renda* have been frequently collected, while many of the mature individuals in the transects investigated were removed by the local communities for developing pondok and logging supporting rails.

Illegal trade in collected palms is expanding. This locally could cause a serious effect on natural populations, especially in areas where the sources of traded plants come from wild populations. Evidence of extraction was scarce because of the lack of commitment to protect sites and very little money allocated to provide adequate patrolling. Kerumutan Wildlife Sanctuary includes an area of 120,000 hectare, most of which is swamp area, but only has four forest rangers (jagawana) with no basic vital guarding equipments, such as machine boat (pompong). The only evidence that plants have been removed was
the cut stem bases of adult individuals and circular depressions in the soil (young plants). With the increasing demand for Indonesian native plants for the ornamental plant industry, horticultural collecting is most likely to become a bigger threat to the country rare plants.

Based on the level or extent of the threatening factors, Cropper (1993) divided rare plants into three groups:

1. Species that have several large populations and are not considered to be at risk of extinction. Their rarity is usually the result of the destruction of a large proportion of their habitat, or because the species are restricted to particular habitats but are abundant in these areas. Populations are sufficiently protected so that further habitat loss is prevented and enough plants survive to allow natural population dynamics to continue.

2. Narrow endemic species where the number of the populations and the number of the individuals in each population are very low. These species are at risk of extinction because the occurrence of natural processes, such as insect attack and droughts, which may destroy the entire population at one time. A population of 1000 plants can tolerate 20 plants being killed by a pathogen, but not a population of 50 plants. Several years of constant infection can lead to extinction of this population.

3. Rare plants threatened by human activities which directly or indirectly affect their survival. The alteration or removal of a species habitat is one of the primary causes of decline in plant numbers. Large plantations, agriculture, forestry, roadworks, mining, settlement and urbanisation, and industrial development are all potentially threatening activities.