INTERNATIONAL TROPICAL TIMBER ORGANIZATION

PROJECT COMPLETION REPORT

ITTO PROJECT PD 21/95 REV. 2(1)

COMPREHENSIVE STUDIES ON THE STRUCTURE AND PROPERTIES OF RATTANS FOR EFFECTIVE UTILIZATION

INSTITUTE OF BOTANY
CHINESE ACADEMY OF SCIENCES
XIANG SHAN, BEIJING 100093
THE PEOPLE'S REPUBLIC OF CHINA

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PROJECT COMPLETION REPORT

PROJECT IDENTIFICATION

(a)Title:

COMPREHENSIVE STUDIES ON THE STRUCTURE AND PROPERTIES OF RATTANS FOR EFFECTIVE UTILIZATION

(b) Serial Number:

ITTO PROJECT PD 21/95 REV. 2(1)

(c) Implementing Agency:

INSTITUTE OF BOTANY

CHINESE ACADEMY OF SCIENCES

(d) Host Government(s):

THE PEOPLE'S REPUBLIC OF CHINA

(e) Starting Date:

March, 1996

(f) Duration (Months):

48 months

(g) Project Cost (US$):

Expected Project Costs:	144,620	
ITTO Contribution:		88,620

PART I--EXECUTIVE SUMMARY

1. Background Information About the Project

(a) The key problems it intended to solve (Pre-project situation)

Rattans are spiny climbing palms comprising the subfamily Calamoideae. The subfamily consists of 22 genera, of which 13 genera are rattans with about 650 species. Rattans are mainly distributed in two tropical regions: West Africa, with 4 genera(Calamus, Eremospatha, Laccosperma and Oncocalamus) of which three are endemic, and Southeast Asia, the much larger and more important area with ten genera(Calamus, Calospatha, Ceratolobus, Caemonorops, Korthalsia, Myrialepis, Plectocomia, Plectocomiopsis, Pogonotium and Retispathaa).

Rattan stems are one of the remarkable Non-Timber Forest Products(NTFP) used for furniture and handicrafts. Owing to the lack of resources, many consuming countries had to import millions of tons of raw materials or processed canes from tropical regions. With this, the development of rattan resources offers much employment opportunity to the local people and has become one of the important source of foreign-revenue in the countries like Malaysia, Indonesia, Papus New Guinea, The Philippines and Nigeria.

Rattan stems have been a topic of many investigations for several decades. As early as in 1845, Mohl described the large metaxylem vessel of its vascular bundle of Calamus as peculiar in comparison with the other genera of the Palmae. Tomlinson (1961) gave a description of the nine genera of rattan in "Anatomy of Monocotyoedons". Siripantandilik(1974) and Teoh(1978) investigated the anatomical structure with a view to differentiating of several genera. In 1990's, Weiner and Liese have made an analysis of the structural components of eight genera from Southeast Asia. For

the purpose of promoting better production and use of bamboo and rattan, a series of technical reports were issued and a large amount of information was collected by International Network for Bamboo and Rattan (INBAR) which is managed by IDRC and hosted by IDCR Regional Office in New Delhi. However, neither a comprehensive study concerning anatomical characterization, properties and utilization of rattan stems nor a comprehensive database to relate the anatomical structure of rattan stem to their known and potential uses is made. In order to encourage and emphasize the necessity of retaining a diversity in tropical forests and sustained use of a wide range of species, it is essential to further our investigation on structural characterization as well as properties of rattan stems so as to introduce their properties also to consumers and to extend their uses in the industry.

(b) The Specific Objectives and outputs

1)Development objectives

To make effective utilization of rattan stems in the industry by introducing and transferring the knowledge on their properties and utilization of rattans to the units of producing countries.

To reduce the pressure on the major tropical timber species by expanding the uses of rattans in the industry.

To enhance the international trade between rattan-producing and consuming countries by providing a comprehensive database with a large quantity of useful information.

2). Specific Objectives

To make systematic studies on structure, properties and utilization of rattans imported from Southeast Asia and West Africa.

To establish a comprehensive database which can be questioned commercially from many different view points.

To compile information and knowledge of rattans and to disseminate to producing countries and users in the world.

3). Output

To submit a research report on structure, properties and utiliation of important rattan stems imported from Southeast Asia and West Africa.

To establish a database as information resources including name of species, habitat, external morphology, distribution, stem structure (construction of vascular bundles, frequency of component elements, fiber length etc.), stem properties (density, shrinkage, durability and processing) and utilization. The database can be questioned from many different view points.

To edit, publish and disseminate a treatise on stem structure, properties and utilization of rattan canes collected from Southeast Asia and West Africa.

(d) The strategy adopted in carrying out the project:

The main strategies in carrying out the project include: sample collection in the field, structural and property analyses in the laboratory and database establishment.

The sample collection was designed to conduct in three main regions: west Africa, southeast Asia and tropical regions in China. Therefore, samples were collected from Forestry Institute of Ghana at Accra,

Forestry Research Institute of Malaysia, Xishanbanna Botanical Garden at Yunnan Province, Research Institute of Tropical Forestry in Guangzhou, Chinese Academy of Forestry, Forest Farm at College of Tropical Crops in Hainan, Forest Farm of Xiamen city in Fujian Province. In addition, Department of Wood Biology, Hamburg University provided us with a number of rattan specimens.

Structural analysis in the laboratory was conducted in Institute of Botany, Chinese Academy of Sciences. First of all, the samples collected from different regions and places were labeled to species name with locality, from which small blocks were cut and fixed in FAA(Formlin 5%, Acetic acid 5% and Alcohol 90%). Then, all the samples were boiled and softened with chemicals, and cut into 15-20um in thickness. Sections were counter-stained with Safranin and fast green, and dehydrated through 30%, 50%, 70%, 85%, 95% and 100% ethanol and xylin. Finally the sections were mounted into slides with Canadian balsam. For maceration, a mixture of acetic acid and hydrogen peroxide were used. For ultrastructure, the transverse and longitudinal surfaces to be observed were cleanly cut with a new razor blade. Consequently, they were soaked in a 20% solution of sodium hypochlorite until the surface lost colour, followed by washing in running water. After dehydration through a graded alcohol series, they were mounted on stubs and coated with carbon and gold in a high vacuum evaporation unit. They were examined and pictured at 20kV under a scanning electron microscope. For property determination, specific gravity

of rattan canes is the ratio, expressed in kilogrammes per cubic meter, between the oven-dry weight and the weight of an equal volume of water. It was determined on oven dry weight to green volume basis, calculated from water displacement method. Longitudinal shrinkage is the dimensional variation in the longitudinal direction. It was expressed as percentage of air dry dimension, measure from air dry state to oven-dry condition. Natural durability is the ability of a rattan species to resist against the attack of biological agents. It was assessed according to the following grading system: very good, good, moderate, poor.

The softwares were established to contain three independent databases of anatomical structure, external morphology and utilization property. In the database of anatomical structure, there are 50 records and it can be retrieved by scientific name, metaxylem vessel number, number of phloem bundle and parenchyma type. In the database of external morphology, there are 72 records and it can be retrieved by scientific name and geographic location. In the database of utilization property, there are 20 records.

(d) Project's planned duration and planned overall costs

The project was planned for 48 months, starting from the March of 1996 and being completed in the December of 1999.

The project's planned over cost was US$ 144,620 in which ITTO contributed US$88,620 and Chinese Government contributed US$ 56,000.

(e) Specific sector at country or regional level to which the project relates

Rattan species were naturally distributed in the southern parts of China, mainly in Hainan, Guangdong, Fujian, Yunnan and Guangxi Provinces. In accordance with the recent inventory information, about 2000 ha of rattans were planted in the past ten years, some has become mature which can be collected for utilization. With supports from INBAR and IDRC, rattan industry developed very fast and rattan canes have become an important Non-timber Forest Products. Although local processing workers have long experience in rattan utilization, only a few so called good species, largely belonging to genus Calamus, are familiar to local people. With establishment of INBAR headquarter in Beijing, Chinese Government paid an increasing attention to rattan development. As a result, several new forest farms mainly on rattan cultivation and management were set up. It can be expected that rattan industry in the southern China would become a major cause of money raising for farmers in the region.

2 Project Achievements

(a) Outputs achieved

The following technical reports were produced resulting from the research activities conducted:

1) A technical report on structural analysis of rattan stems, which contains five parts:

--- An introduction of rattan plants with its distribution worldwide and early history about research in taxonomy and classification of rattan stems.

--- Research techniques used: preparation of three-dimensional

sections for light microscopy, preparation of samples for scanning electron microscopy, resin replication of vascular elements, maceration of vascular elements, measurement of length and size of vascular element.

--- Anatomical description of 13 genera: Calamus, Daemonorops, Plecotomia, Pogotium, Plectocomiopsis, Ceratolobus, Calospatha, Korthalsia, Oncocalamus, Retispatha, Myrialepis, Laccosperma, Eremospatha.

--- Variability of anatomical features: structure of vascular bundles, parenchyma tissues, vessel, cortex, fibers, epidermal cells, cell inclusions.

--- Identification keys based on anatomical features to the generic level.

--- Relationship between anatomical features and distribution.

--- Relationship between anatomical features and habitats

---Relationship between anatomical features and taxonomy classification.

--- Evolution of anatomical features.

--- Legends and explanation to figures.

2) Three comprehensive databases were established including the databases of anatomical structure, external morphology and utilization property.

In the database of anatomical structure, 19 characteristics are included. They are scientific name, number of epidermal cell, length of epidermis, lumen, shape of epidermis, cuticle, Yellow cap, type of ground parenchyma, shape of ground parenchyma, width of vascular bundle, length of vascular bundle, density of vascular bundle, number of sieve, number of phloem bundle, diameter of sieve, number of metaxylem

vessel, number of protoxylem vessel, type of protoxylem vessel and diameter of protoxylem vessel.In the database of external morphology, 14 characteristics are included. They are scientific name, vernacular name, geographic distribution, habit, stem diameter, internode length, leaf-sheath spine, leaflet arrangement, climbing organ, flower type, row of seed scale, type of endosperm, type of embyro, use. In the property datebase, there are 4 characteristics in this database, i.e. scientific name, basic density, shrinkage, natural durability.

3) Study Tour Reports:

--- From April 8 to April 17, 1996, Prof. Jinxing Lin and Prof. Yushi Hu visited Jodrell Laboratory and Herbarium, Royal Botanical Garden Kew and Forestry Institute of Oxford University, United Kingdom. From the tour, they got sectioning slides from Dr. David Cutler and basic literature of rattans from a taxonomist in the herbarium. Then, they visited Department of Wood Biology at Hamburg University, Germany, to get a Ph.D dissertation of Dr. Gudrun Weiner and a number of publications from Prof. Dr. Walter Liese.

--- From September 24, 1998 to October 2, 1998, research members Prof. Yushi Hu and Dr. Chenggang Liu visited Malaysia, during which time they visited Natural Forest Division, rattan processing mill at Jinjiang, rattan manufacturing factory and secondary forest in field, Forest Research Institute and other relevant organizations in Malaysia. They collected 18 species of rattan from local forest and wood anatomists in Malaysia, and acquired general information on the status of rattan industry and research in southeast Asia.

4) Reports of Attending International Workshop

On April 23-24, 1998, Prof. Jinxing Lin and Dr. Chenggang Liu were invited to participate in the workshop of Chinese Bamboo and Rattan Experts hely by INBAR in the Scientific Meeting Hall of Chinese Academy of Forestry. During the workshop Prof. Lin presented a lecture on Rattan Structure and Property.

5) An academic paper published in Acta Phytotaxonomica Sinica based on a part of our research.

(b)Specific objectives achieved

A pamphlet entitle "Comprehensive studies on the structure and properties of rattans for effective utilization--Part I. Structural analysis of rattan stems" was completed in Chinese based on the observation and results of this project. The pamphlet will be useful to the public and individuals who wish to make an identification of rattan stems. The pamphlet was distributed to INBAR headquarter in Beijing, the related government sectors and organizations in China such as National Library of China, Library of Chinese Academy of Sciences, etc. Thus, it is accessible as a reference book to taxonomists, wood scientists, forest breeders and university students.

A comprehensive software containing three independent databases of anatomical structure, external morphology and utilization property were established. In the database of anatomical structure, there are 50 records and it can be retrieved by scientific name, metaxylem vessel number, number of phloem bundle and parenchyma type. In the database of external morphology, there are 72 records and it can be retrieved by scientific name and geographic location. In the database of utilization property, there are 20 records.

(c) Contribution to the Achievement of the Development Objectives

With the output achieved after the implement of the project, it is possible to roughly know the mechanical properties and physical properties based on the anatomical features, then to make a selection for a specific purpose. With this knowledge, it is also possible to use some non-popular species to substitute the widely explored species, therefore to retain a diversity in tropical forests and sustained use of a wide range of species. Furthermore, the knowledge accumulated will be beneficial to the forest breeders who are currently engaged in cultivation of foreign species introduced to China.

(d)The Situation Before and After Project Completion

Before the implement of the project, many rattan processing workers, forest breeders knew very little about the relationship between rattan properties and anatomical features. They used twisting and bending properties to evaluate the rattan processing quality, but found no other criteria to appraise the relationship between morphology and processing quality. Thus, forest breeders had to wait for a long growth period until rattan plants became mature and then to test the quality. Rattan processing workers knew little about variability of rattan stem structures within a stem or different cane from different environmental conditions and differences in anatomical features among different genera or species.

With the implement of this project, we not only collected a number of literatures available in this topic, but also made a comparative analysis on rattan stem quality from commercially important species and non-commercially important species. We noticed the twisting and bending

properties of a cane depend largely on the distribution of the vascular bundles, the wall structure of fibers and quantitative composition of tissues. By presenting the results in a meeting for experts on bamboo and rattan held by INBAR, several processing workers and forest breeders came to conclude that our results are useful and effective for practical application.

3 Target Beneficiaries Involvement

The beveficiaries of this project include the non-government organizations, local forest authorities and international organizations.

(a) Non-government organizations:

1) Chinese Academy of Sciences allocated a grant to purchase a cryo-microtome, costing US$ 46.000.
2) Xishanbanna Botanical Garden at Yunnan Province provided us with 12 plants of rattans for cutting stem specimens during our field trip in 1997.

(b) Local forest Authorities:

1) The Research Institute of Tropical Forestry in Guangzhou, Chinese Academy of Forestry provided us with 8 rattan stem specimens.
2) Forest Farm at College of Tropical Crops in Hainan province provided us with 19 plants for cutting stem specimens.
3) Forest Farm of Xiamen city in Fujian Province provided us 12 plants for cutting stem specimens.

(c) International Organizations:

1) INBAR provided us with a number of publications and literatures about rattan morphology, growth character, anatomy and identification.

2) Federal Institute of Forest and Wood Research, Germany provided us a number of rattan specimens they collected from Africa and Southeast Asia.
3) Jodrell Laboratory, Royal Botanic Gardens at Kew, United Kingdom provided us with a number of literature about stem structure of rattan and several slide sections they prepared.
4) Royal Herbarium at Leiden University, The Netherland provided us with a number of literature and slide sections.
5) Forest Institute of Ghana at Accara provided us with a number of rattan canes.
6) Forest Research Institute of Malaysia provided us with 17 species of rattan canes.

In return for the assistance and involvement of this project implement, the organizations were given the relevant research results and findings of this project. They can use the results for various purposes.

4. Lessons Learned

(a) Development Lessons

The project was designed to promote better understanding the relationship between anatomical structure and properties so as to extend the knowledge to consumer and processing workers. In order to establish such relationships, the specimens and materials of rattan stems were crucial for the implement of this project. In the project design, we tried to collect as many materials as possible, however, it was not easy to collect the samples and specimens partly because most of the rattan species are mainly distributed in Africa and Southeast Asia.

Additional arrangements should have been made with a view to improving cooperation such as cooperation with Bamboo Information Center in Chinese Academy of Forestry and Research Institute of Tropical Forestry in Chinese Academy of Forestry which had collected various information and established a breeding farm. Possible studies on growth rate and design for the end use of rattan canes should be encouraged. Furthermore, weathering test and colour change under different sunlight and ultra-violet radiation should be strengthened.

Factors which will most likely affect project sustainability after completion include scarcity of good quality rattan cane, high cane price, competition with other construction and handcraft materials such as bamboo and chemically modified timbers. The market acceptability for the broad use in handicrafts would be another factor. Thus, the market study and marketing should be enhanced as well.

(b) Operation lessons

The project organization and management was proper and efficient since the responsibilities of every project members were defined and confirmed ever since the beginning of the project execution. With the financial support of this project, a well-trained Ph.D student and a Master student were recruited in 1996, so they can concentrate all their efforts on the project and executed as planned. As the completion of this project, they successfully got degrees from implementing agency.

Project documentation was completed by the project leader together with his group researchers and graduate students including preparation progress reports and technical reports. The reports were

sent to ITTO head quarter every six months at the end of March and September throughout the project duration. The original copies of these reports were kept in the Research Planning Office, Institute of Botany, Chinese Academy of Sciences.

The project monitoring and evaluation carried out half yearly by the ITTO Project manager was very effective and regular. In addition, any minor changes on the proposed research activities were reported to ITTO project manager before the implementation.

The quality of project planning was good and well adopted. In order to reach the development objectives, some additional activities were also planned, such as making weathering tests under natural and ultra violet enhanced conditions, making scanning records and posters. However, the study tour to Southeast Asia as a part of project was postponed due to the belated contact with the host organizations.

The rules and responsibilities of the institutions involved in the project implementation were clear and well defined. Institute of Botany, Chinese Academy of Sciences was the implementing agency involved in carrying out the research activities, data collection, document and report preparations as stated in the project. The project leader was the department director, which brought this institution in practice as a part of the project execution body with laboratory facilities available throughout the duration of project implementation.

Variation between planned and actual implementation was reduced to a lesser extent. Regular meetings and discussions between the project leader and research group members were organized to meet the schedule and modify any deviation from the planned activities and any expenses.

There were no external factors that negatively influenced the project.

5. Recommendations:

The project was designed to collect basic knowledge of anatomical structure together with properties and utilization of rattan canes with a view to extending the current extent of utilization and to exploring the potential use of lesser-known species of rattan. With this goal, the sustainability of naturally grown rattan should be considered in rattan producing countries and establishment of demonstration areas in rattan consuming countries such as in China should be enhanced. To keep the balance, more market study should be strengthened to promote the sustainable development of rattan industry.

Technically, more attention should be paid to the analysis of structural features and processing properties of lesser known species. For researches in the future, efforts should be concentrated on selection of principal criteria which can be easily handled by processing workers. Except for the principal criteria, some extra criteria in relation to the post utilization should be further developed, for instance, the colour change and surface degradation after handicrafts were made because these criteria may largely affect the quality of rattan products and acceptability of consumers.

Part II. MAIN TEXT

6. Project Results

Situation existing at project completion compared to the pre-project

situation:

Rattan species are mainly distributed in Africa and Southeast Asia, there are some species in the tropical and subtropical regions in southern China. Although many consumers like the handicrafts made from rattan, only dwellers in the in the tropical regions have some senses or recognition in rattan morphology, growth habitats and utilization. Such senses or recognition mainly resulted from the common knowledge of plants rather than from practical experience or specific study. Thus, many consumers in the northern regions have little conception of rattan structure and properties, even many rattan processing workers, forest breeders knew very little about the relationship between rattan properties and anatomical features. Rattan processing workers frequently used twisting and bending properties to evaluate the rattan processing quality, but found no other criteria to appraise the relationship between morphology and processing quality. Thus, forest breeders had to wait for a long growth period until rattan plants became mature and then to test the quality. They had little conception of variability of rattan stem structures within a stem or different canes from different environmental conditions and differences in anatomical features among different genera or species.

For the purpose of establishing an objective pattern that can be used for common processing workers, we not only collected a number of literatures available in this topic, but also made a comparative analysis on rattan stem quality from commercially important species and non-commercially important species. By making descriptions of stem structure in comparison with their relevant properties, the important structural features of rattan canes were identified. It was noticed the twisting and bending properties of a cane depend largely on the

distribution of the vascular bundles, the wall structure of fibers and quantitative composition of tissues. By presenting the results in a meeting for experts on bamboo and rattan held by INBAR, several processing workers and forest breeders came to conclude that our results are useful and effective for practical application.

7. Synthesis of the Analysis

(a) Specific objectives achievement

Realized

Partly realized

Unrealized

(b) Outputs

Realized

Partly realized

Unrealized

©Schedule

In advance/on time

Delayed but not seriously

Seriously delayed

(d)Actual expenditures

Below planned

More than 10% above planned

More than 20% above planned

Part III. Conclusions and Recommendations

1 Development Lessons

The project should be designed to have wider coverage of lesser-known species of rattan canes. Particular attention should be paid to establish quality criteria based on the external morphology, growth characteristics, distribution of vascular bundles and percentage of tissue elements. In order to establish such relationships, the specimens and materials of rattan stems from different age and species would be crucial.

Efforts on establishment of a comprehensive database needed to be enhanced for the purpose of identifying which species are known to be used for a particular purpose, what are the known uses for so called good canes in common, which other species in database have similar characters to those in an unknown species. Possible studies on growth rate and design for the end use of rattan canes should be encouraged. Furthermore, weathering test and colour change under different sunlight and ultra-violet irradiation should be strengthened.

Additional arrangements should have been made with a view to improving cooperation such as INBAR, Royal Botanical Garden Kew, United Kingdom and Department of Wood Biology, Hamburg University, Germany which had long experience in rattan taxonomy, identification.

There are some factors affecting project sustainability after completion, including scarcity of good quality rattan cane, high cane price, competition with other construction and handcraft materials such as bamboo and chemically modified timbers. The market acceptability for the broad use in handicrafts would be another factor. Thus, the market study and marketing should be enhanced as well.

2 Operation lessons

The execution of this project can be considered well performed as the responsibilities of every project members were defined and confirmed ever since the beginning of the project execution. As a result, variation between planned and actual implementation was reduced to a lesser extent. Regular meetings and discussions between the project leader and research group members were organized to meet the schedule and modify any deviation from the planned activities and any expenses. These should be kept in the future project.

With the advance of computer science, it seemed necessary for ITTO to provide a software for the project finance execution, even for progress reports and completion report. Exchange between ITTO headquarter and executing agencies through internet should be encouraged.

3 Recommendations:

The project was designed to collect basic knowledge of anatomical structure together with properties and utilization of rattan canes with a view to extend the current extent of utilization and to explore the potential use of lesser-known species of rattan. For the purpose, the sustainability of naturally grown rattan should be considered in rattan producing countries and establishment of demonstration areas in rattan consuming countries such as in China should be enhanced. To keep the balance, more market study should be strengthened to promote the sustainable development of rattan industry.

Technically, more attention should be paid to the analysis of structural features and processing properties of lesser known species. For researches in the future, efforts should be concentrated on

selection of principal criteria which can be easily handled by processing workers. Except for the principal criteria, some practical researches in relation to the post utilization should be further developed, for instance, the colour change and surface degradation after handicrafts were made because these criteria may largely affect the quality of rattan products and acceptability of consumers.

Recommendations for Future Projects

(a) Identification:

Future projects should be related to the following aspects: substitute of widely used rattans from less known species and the mechanism of surface changes of rattan stems during weathering.

(b) Design:

The projects should be designed in narrower terms, for instance, to find easily-accepted criteria to identify and to maintain the quality of rattan handicrafts against surface degradation during weathering and post-utilization.

(c) Implementation:

The implementing agency should have enough experience in rattan cultivation and property analyses for finding easily accepted criteria. To keep the surface quality, it seemed that the agency should find chemical agents which are useful to maintain the original colour with less degradation.

(d) Organization:

The project should be organized by the representative of a research institute or non-government organization collaborated with relevant forest research units and relevant experimental stations/farmers for common criteria.

(e) Management:

The projects should be managed based on well-planned activities and executive timetable. Hopefully, the projects can be executed with the guidance of specialized personnel rather than general administrative staff.

Responsible for the Report:

Name: Jinxing Lin, Ph.D

Position held:
Director, Research professor

Date: August 28, 1999