Priority species of bamboo and rattan

A. N. Rao, V. Ramanatha Rao *and* **J.T. Williams** *editors*




IPGRI is an institute of the Consultative Group on International Agricultural Research (CGIAR)

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The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of plant genetic resources for the benefit of present and future generations. IPGRI's headquarters is based in Rome, Italy, with offices in another 14 countries worldwide. It operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme, and (3) the International Network for the Improvement of Banana and Plantain (INIBAP). The international status of IPGRI is conferred under an Establishment Agreement which, by January 1998, had been signed and ratified by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mauritania, Morocco, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovak Republic, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.

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INBAR publishes an ongoing series of Working Papers and Technical Reports, occassional monographs, reference materials and the INBAR Newsmagazine. It also provides an on-line library featuring relational databases on bamboo and rattan products, organizations, projects, experts and scientific information.

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Contents

Foreword vii
Preface to the 1st edition viii
Acknowledgement ix

Introduction 1
Background 3
Genetic conservation of bamboo and rattan 6
Criteria for selection of species 8
The major priority species 9

Part I

Notes on Priority Bamboos 15
Bambusa balcooa 15
Bambusa bambos 15
Bambusa blumeana 17
Bambusa polymorpha 19
Bambusa textilis 22
Bambusa tulda 22
Bambusa vulgaris 25
Cephalostachyum pergracile 27
Dendrocalamus asper 27
Dendrocalamus giganteus 29
Dendrocalamus latiflorus 31
Dendrocalamus strictus 34
Gigantochloa apus 36
Gigantochloa levis 36
Gigantochloa pseudoarundinacea 39
Guadua angustifolia 41
Melocanna baccifera 41
Ochlandra spp 44
Phyllostachys pubescens 46
Thyrsostachys siamensis 48

Additional species 50
Arundinaria sp 51
Bambusa atra 51
Bambusa heterostachya 51
Bambusa nutans 51
Bambusa oldhamii 51
Bambusa pervariabilis 52
Lingnania chungii 52
Dendrocalamus brandisii 52
Dendrocalamus hamiltonii 52
Dendrocalamus hookerii 52
Dendrocalmus membranaceus 53
Gigantochloa albociliata 53
Gigantochloa atroviolacea 53
Gigantochloa balui 53

Gigantochloa hasskarliana 53
Oxytenanthera sp. 54
Phyllostachys glauca 54
Schizostachyum sp 54

References 55

Part II

Notes on Priority Rattan 59
Calamus manan 59
Calamus caesius 62
Calamus trachycoleus 64
Calamus sect.*Podocephalus* 66
Calamus andamanicus 68
Calamus burckianus 68
Calamus erinaceus 68
Calamus foxworthyi 68
Calamus merrillii 68
Calamus nagbettai 68
Calamus ovoideus 68
Calamus polystachys 70
Calamus warburgii 70
Calamus zeylanicus 70
Calamus zollingeri 70
Calamus palustris and relatives 73
Calamus inermis 77
Calamus nambariensis 77
Calamus deeratus 77
Calamus tetradactylus 79
Calamus hollrungii and relatives 81

References 83

Application of the priorities 87
A. Bamboos 89
B. Rattans 89
Further Research 90
Other Decisions 91

Epilogue 92

Appendix I 95

Foreword

Selecting a limited number of species of bamboo and rattan for priority research and development out of the several hundred that exist was not an easy task. Traditional methods helped to some extent to indicate the usefulness of certain species in different countries. However, there is no comprehensive account to consolidate their uses in many countries. An exercise to select bamboo and rattan species for further research was completed in 1993 with the assistance of a handful of experts in the fields of bamboo and rattan taxonomy, ethnobotany, silviculture, conservation and genetics. This collaboration resulted in the first joint publication, between INBAR and IBPGR issued in 1994. The contents included background details, criteria for selection of species, the major priority bamboo and rattan species selected and notes on them.

The publication was not conceived as an end in itself, but as an initial document to be updated from time to time. The first edition itself contained, besides the list of priority species, a list of additional species that were important. The document was widely circulated, inviting responses and initiating discussions on prioritizing bamboo and rattan species based on social, economic and cultural considerations.

The details given in the publication were very much appreciated and widely used. At the same time many valuable suggestions were made to include more species, that are economically important in several Asian regions, their characteristics and economic values.

The INBAR Bamboo Rattan Working Group on Genetic Diversity and Conservation decided last year to bring out a second edition of Priority Species of Bamboo and Rattan. This new edition is a result of further review of information from different countries as well as new information gathered by IPGRI and INBAR.

The second edition also incorporates changes suggested by national programes. The revised list was prepared for the INBAR Biodiversity and Genetic Resources Conservation Working Group and spearheaded by Prof A N Rao of the International Plant Genetic Resources Institute (IPGRI).

We hope the research workers, institutions and authorities concerned with bamboo and rattan resources and utilization will welcome and use this new edition as well as they did the first one. Needless to say, planning and action are needed to save the existing bamboo and rattan resources in the forests and to promote their sustainable use. Such efforts will continue to assist to improve the incomes of rural people who are closely connected in harvesting, local trades and utilizing materials in home industries.

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Preface to the 1st edition

This is the first in a series of publications from the International Network for Bamboo and Rattan (INBAR). In the months ahead, we hope to offer bamboo and rattan researchers and enthusiasts alike a wealth of information about these increasingly important species. The publication of this book, therefore, marks an important stage in INBAR's evolution.

INBAR is the outgrowth of a network of bamboo and rattan research projects that have been funded since the early 1980's by the International Development Research Centre (IDRC) of Canada. Following months of study and consultation with donor agencies, IDRC approved a grant in late 1992 to establish INBAR. In 1993, the International fund for Agricultural Development (IFAD) approved major grant towards INBAR's activities, to be channelled through the Centre for International Forestry Research (CIFOR). In mid-1993, the International Board for Plant Genetic Resources (IBPGR) obtained funding from Japan and agreed to co-sponsor with INBAR a meeting aimed at identifying priority species of bamboo and rattan.

The idea for the INBAR-IBPGR Consultative Meeting on the Selection of Priority Species of Bamboo and Rattan had been proposed in mid-1993 at an INBAR networkshop of bamboo and rattan project collaborators from Asia. The meeting in Dehra Dun in December 1993 comprised a select group of Asian and international experts.

We hope that this publication will provide some useful guidelines in identification of bamboo and rattan species for establishing plantations, intercropping, and in social forestry programmes. The priority species of bamboo present a vast untapped potential for rehabilitating degraded waste lands, as do the rattan species for rehabilitating forests. The result will be an enhancement of the incomes of rural people and forest dwellers.

INBAR and IBPGR wish to thank Dr D N Tewari, Director General of the Indian Council of Forestry Research and Education, for offering the participants an inspiring setting for the deliberations. In addition, IBPGR sincerely wishes to acknowledge the funding received from the Government of Japan for its project on bamboo and rattan. Our thanks to the participants for the enthusiasm and dedication that they demonstrated in accomplishing the objectives set out for them. Finally, a special word of thanks to our principal editors, not only for their editorial efforts, but for their effective chairmanship of the meeting in Dehra Dun.

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We are thankful to Ms Mahaletchumy Arujanan and Ms Eleanor Gomez for their technical help.

Editors

Introduction

A Consultative Meeting to identify priority species of bamboo and rattan was held from 6–9 December 1993 at the Indian Council of Forestry Research and Education, Dehra Dun, by kind invitation of Dr D N Tewari, Director General.

The Meeting was held under the auspices of INBAR (International Network for Bamboo and Rattan) and IBPGR (International Board for Plant Genetic Resources). Two other international organizations participated : FORTIP (UNDP/FAO Regional Projects on Improved Productivity of Man-Made Forests through Application of Technological Advances in Tree Breeding and Propagation) and ICIMOD (International Centre for Integrated Mountain Development). A list of participants is given in Appendix 1.

Participants included experts in the field of bamboo and rattan taxonomy, sylviculture and variation. Additionally, advice on priority species had been solicited by INBAR from a number of national programmes and their data were made available to the meeting.

Current knowledge lists about 75 genera and 1250 species of bamboo. About 75% of these species are used locally for one or many purposes, and about 50 species are used extensively. There are about 600 rattan species, in 13 genera, of which virtually all are used locally but only about 50 are used regularly and commercially.

In order to enhance production, especially against a background of over exploitation, INBAR's research networking requires a much sharper focus on a limited number of high priority species. Past research has focused on better understanding of the resource base and better processing and utilisation of products. Current opinion is that the most urgent tasks are to increase production in cultivation and to sustainably manage natural stands so that resources are adequately available.

In view of the very large number of species and their diverse geographical ranges and ecologies, focus also has to be given to the conservation of genepools of more useful species. There is no one easy applicable method for conservation, and appropriate technology has to be developed which can be effectively used in a complementary conservation strategy for bamboo and rattan genetic resources. IPGRI recognizes that to conduct strategic research in this area requires clear focus on a limited number of high priority taxa.

Experts at the meeting agreed upon criteria for selection of species and their prioritization, categorized levels of priority for identified priority species and made recommendations on urgent tasks to be undertaken upon these species.

Need for revision

The publication of "Priority Species of Bamboo and Rattan" aroused much interest among bamboo and rattan researchers and conservationists. Many suggested that rating, evaluation and domestication need to be changed for certain species listed in Tables 1 and 2. Some of them felt that too few species had been included in the lists omitting a number of others that are yet traditionally used in many countries. Many suggested that bamboos growing in the colder climates like *Arundinaria* spp. should be included since many of them provide fodder, building and biomass materials for people living at very high altitudes. Still others thought there was not enough emphasis accorded to the real woody genera like *Gigantochloa, Guadua, Phyllostachys* sp., since they are the primary sources for building construction, wood and paper industries. Additions and amendments are made to cover many of the above points and to accommodate a wider coverage of greater number of economically important species and to provide more technical details on them. More species are included in the revised text, at the same time

the priority needs in terms of conservation and use are revised. Also additional technical details and recent research on many of the priority species have been added.

Process of revision

In the last 4–5 years, since the publication of the priority species, much progress has been made on socio-economics, selection, exchange of materials in an informal way and information generation and technology transfer. Many of the recent publications listed under references provide details (see the list of references). Because of economic implications and the greater need to use bamboos for low cost housing or construction of bamboo houses in earthquake prone areas the interest is increasing. Much technical information has also been generated, since the publication of the first edition. More researchers of different institutions in various countries have been encouraged to conduct research on bamboo and rattan. Many of these have participated in international meetings and training courses arranged in the last 3–4 years to pave the way to greater collaboration and exchange of information.

Problems are many in the conservation and perpetuation of bamboo and rattan, especially the selection of superior clones or materials. Lack of well trained staff in many countries is a serious handicap. Many of the deficiencies identified or highlighted earlier are yet to be well covered to fill up gaps. Progress made is slow for this reason but many projects in various countries are well supported.

Some of the recent researches include:

a) Distribution of bamboo and rattan species in China, India, Nepal and Thailand;
b) Guidelines for bamboo seed collection, germination and conservation;
c) Genetic assessment and analysis of rattan species in Malaysia and Thailand using biochemical methods;
d) Reproductive, phenological and macroproliferation methods for certain bamboos;
e) Slow growth *invitro* studies on certain bamboo species;
f) *Ex situ* and *in situ* conservation of bamboo and rattan germplasm in certain Asian countries;
g) Bamboo and rattan diversity in N E India and others.

Some of the data on these topics is already published and others are in press (see the list of references). The recent information is also abstracted in this revised edition.

The background papers of the first edition have been retained since much of the discussion there is still relevant. As noted earlier, despite limited human resources available, research on bamboo and rattan has continued to progress, though much needs to be done. The coordination and collaboration among scientists have greatly improved. Significant progress has also been made in resource assessment and identifying conservation areas. The 1993 consultation was the first serious attempt to address issues of conservation in a collaborative mode. The second paper focussed on identification of criteria to determine priority species. Since the criteria followed are sound, the relevance of this paper remains the same. The importance of complementary conservation strategies mentioned there has assumed greater significance today and our aim should be to develop holistic complementary conservation strategies for bamboo and rattan genetic resources and for their sustainable utilization.

Background

Bamboo and rattan research

J. T. Williams

It would be trite for me to open this consultation with facts and figures which emphasize the important role of bamboo and rattan in the lives of people, especially in the tropics. But it could be helpful to summarize what has happened in research on these non-timber forest resources since there has been rapid change in relation to the availability of materials and also major advances in the development of technologies.

Research and development of bamboo and rattan has accelerated since the early 1980s and many national programmes have strengthened their capability in this area. This was timely because the gradual diminution of supply sources from natural forests had received little or no attention until about the middle of the decade. At that time, shortages of raw bamboo were noted in numerous Asian countries and for rattan a number of bans on export were enforced. Concessional rates for supplies of materials were also introduced. Whatever the outcomes of such events and interventions, governments began to recognize the needs for increased production.

Scientists responded in a somewhat uncoordinated manner. Their research interests ranged from enhanced domestication to develop plantations to increasing attention on lesser-known local species. The latter effort was expected to reduce pressure on the natural stands of more desired and valuable ones. And a whole range of activities was pursued whilst unchecked cutting, logging, clear felling and habitat destruction continues at an accelerated pace.

By the end of the decade donors and several national programmes became concerned to see how the somewhat diffuse research efforts could be better focused. This entailed an assessment of all previous efforts and the identification of research gaps and the strategic research needed to fill them. An international review team carried out this assessment and the report was made to both donors and to national programmes in 1991.

Guiding principles during the review were sustainability and better protection of the resource base as well as the need to enhance technology required to improve the incomes of rural people. Four broad areas of research emerged:

- Socio-economics
- Production research
- Post-harvest technology
- Information generation and technology transfer including training.

Additionally, a fifth area was also clearly identified: resource assessment and conservation. However, in discussions which led up to the mobilization of funding, it was felt that core research on bamboo and rattan should focus on the first four areas. Due to the magnitude of the task for resource assessment and conservation it was agreed that this should be phased in, as and when special project funding became available.

By early 1993, funding from two major donors, IDRC and IFAD became available to strengthen the research networking , and I am delighted to say that IBPGR responded to the challenge to promote conservation. By September 1993, IBPGR had mobilized funding for research in Asia on this topic.

The research network became organized as INBAR with funding for a two-year period and it currently faces a list of onerous tasks. First of all, INBAR is charged with re-organizing the way scientists do business, so that inter-country research collaboration develops rapidly, rather than continuing solely the national efforts. In this way, critical mass of researchers in the region can better address urgent research problems. If I were to paraphrase the objectives of INBAR they would be "to expand sustainable use and cultivation of bamboo and rattan to more rapidly improve the lives and incomes of people". Clearly, the highest priority has to be to increase production and this means a shift of emphasis from naturally-gathered resources to one of harvested crops, and of course, to the sustainable management of natural habitats.

As the focus is changing in this way, it becomes a high priority to target a limited number of species – out of the hundreds available and the scores previously worked on. This is because enhanced production will surely demand genetic improvement, initially through the selection of superior strains and also improved silvicultural methods to increase economic production. I suspect in the early phases, we shall have to look more closely at adaptation of a number of selected species and to look for and exploit wider adaptability than hitherto.

This background will help IBPGR in developing appropriate genetic conservation strategies, and for that reason it is fully appropriate for INBAR and IBPGR to join together in this consultation to develop priorities among species and areas. Participants will be the first to stress that we still lack a great deal of taxonomic information; that studies on genetic diversity patterns within species and gene pools are virtually non-existent; indigenous knowledge on good cultivars; and as a result some of the priorities agreed may be somewhat arbitrary. However, they should be based on assessment of our current knowledge. We cannot afford to wait for extensive new research, and priorities, as determined by this consultation, can always be revised and changed as new light is thrown on the biodiversity of the resource.

I say that we cannot wait for two reasons. First, the need for priorities has been stressed numerous times: for instance, in the review of past research, by the fourth international bamboo congress in Chiang Mai, Thailand in 1991, by the orientation meeting of national programmes participating in INBAR earlier this year, and by a meeting of INBAR subject working groups in June 1993.

Second, as research moves into its new mode with joint research programmes involving more than one country, it is essential that the materials used in the research are indeed those which are known to be productive and which can be standardised with common provenances and attendant documentation.

Now I turn to the expectations of this consultation. First of all we need a broad consensus on highest priority taxa, but we also need to take note of other important species so that we are sensitive to the needs of national programmes. We need to consider priority species in relation to agro-ecologies and may be categorize them in this way rather than the traditional way of looking at them as they are distributed within political boundaries. For instance, it would be helpful to highlight particular species for use in soil stabilization and production in semi-arid zones, or on reclaimed degraded acid soils or sloping lands. Such areas merit urgent action , and these types of agro-ecologies are only a few of the many, but they do illustrate the way we would like you to consider species. Such an approach is essential in the post-UNCED climate.

Decisions on species need to be amplified by pooling knowledge on putative centres of diversity, wide and narrow adaptability, the degree to which primitive cultivars have been selected and identification of where selection has proceeded much further. Much of this information is known to many but it is not available in the literature.

Finally we should crystallize the information we collate into tasks which need to be done in the short to medium-term to implement the priorities. Even if these tasks do not relate directly to those which INBAR and IBPGR can fund, these organizations can draw them to the attention of development assistance donors if the research proposed is applied, to national programmes if it is adaptive research and to other donors if it is more basic research. Such research will need to be well defined; for instance, research on domestication of a minor species which is long-term and risky is unlikely to attract major support.

We all have high expectations that bamboo and rattan research will become a model for other minor forest products and achieving the objectives of this consultation will set the scene for action on other commodities. Surely, the major follow-up will be the need for carefully established provenance trials with common methodologies across regions and the input to these of the right priority species. The results of this consultation could be an important step in this direction.

Genetic conservation of bamboo & rattan

V. Ramanatha Rao

In general, the methods of conservation of genetic diversity can be divided into *ex situ* and *in situ* approaches. However, conserving the genetic diversity of bamboo and rattan presents many challenges because the methods of conservation and techniques required for use of conserved material later on differ markedly from crops and similar plant groups. There is, therefore, a need to develop an appropriate integrated conservation strategy and new techniques for use of conserved material of this group of species.

While considering an appropriate balance of *ex situ* and *in situ* approaches, we should remember that the approaches required for the conservation of bamboo and rattan genetic material can be markedly different from approaches to ecosystem conservation. This may especially be true for bamboo which generally occurs outside of the primary forests and in disturbed forest sites.

Whereas much of the effort on crops and their wild relatives has been made so that ranges of genetic variability are stored for long periods in genebanks, any similar approach – if it were feasible – would present major problems when it came to regeneration of stored stocks, especially in the context of use. Even field genebanks of bamboo and rattan accessions, where vegetative materials are maintained over the short – to medium- term periods, may not be very appropriate since very little material can be maintained and large areas of land and fairly intensive management are required. These problems may be common for most perennial tree species, and it is accentuated as bamboos tend to be weedy and colonizing species as well. As these conventional methods of conservation cannot be easily applied to bamboo and rattan, *in vitro* methods whereby tissues are maintained in culture are thought to be viable alternative. However, although methods have been developed for *in vitro* propagation, they have not been applied to conservation under conditions of slow growth, nor has genetic stability in culture been adequately researched. Furthermore, rattans are grown from heterogeneous seed lots and not from clones, and bamboos represent a range from seed lots to clonal materials.

The constraints outlined above provide compelling reasons to consider appropriate and integrated conservation methodologies specific to these resources. No single method could be used to conserve bamboo and rattan genetic resources.

Given the very large number of species of both commodities, it would also be difficult to think of conserving all of them when there are limited financial resources available. For this reason, IBPGR fully supports efforts to prioritize either species or gene pools for urgent conservation action.

For genetic conservation, criteria would include:

- Degree and extent of perceived/projected genetic erosion.
- Known and potential values in terms of both commercialization and local uses.
- Value applicable to large numbers of people, not just local value.
- Degree of domestication and potential for domestication.

The criteria for enhancing utilization germane to the interests of INBAR will differ somewhat from those of IBPGR. This Meeting needs to consider the diverse criteria and balance them in reaching consensus conclusion. Against this background, we can ask "is it possible to develop a list of priority species?" Should the list be limited to a few globally-important gene pools, supplemented by some regionally important ones

associated with climatic zones, and by some nationally important ones? If this is so, where do we fit species of commercial value?

In many ways, genetic resources conservation is action mobilized on the basis of crisis, and in many cases we may not have all the information required to initiate the most appropriate action. However, action is required urgently with some ground rules for the present and these could be improved when more and better information becomes available. For instance, for bamboo and rattan we need good descriptive categories, especially at the infra-specific and genetic level. Descriptors need to be, as far as possible, highly heritable. The current state of knowledge needs to be assessed to see whether we can move in this direction.

One of the pressing research needs is to initiate studies on patterns of genetic diversity within gene pools. This will require conduct of ecogeographical surveys. Another area of research must surely be related to seed production in bamboos, which, in many species, is often rare or non-existent. Storability of seeds of both bamboos and rattans need to be investigated. This is because, despite the difficulties encountered with flowering cycles, some species may flower but not produce seeds, others may produce seeds in very small quantities or seeds produced may have high inviability. This would facilitate *ex situ* conservation of seed material of those species for which such storage and increased viability are possible. It would be necessary to conduct work on how to induce flowering in young bamboo and rattan plants, as it will greatly influence the use of genetic resources at a later stage.

It can be seen that there is an extensive research agenda necessary before genetic conservation of these resources is in hand. However, the highest priority is the identification of those species on which the efforts should be targeted. Prioritization of species will be of inordinate value to both INBAR and IBPGR, but will also be of value to research institutions, universities and others, on the understanding that any list developed by this meeting will not be definitive for all time, but will represent a starting point that can be modified as more information becomes available. Collaborating institutes should be stimulated to work in this area so that the research networking is strengthened.

Criteria for selection of species

Criteria agreed to be used during discussion on individual species included the following:

1. Utilization

1.1 Relative importance to countries in terms of current use
1.2 Relative importance to regions in terms of current use
1.3 Potential importance for expanded use in countries
1.4 Potential importance for expanded use in regions

2. Cultivation

2.1 Knowledge on degree of domestication and commercialization
2.2 Potential for generation of knowledge

3. Products and processing

3.1 Products currently valued
3.2 Products likely to increase in value
3.3 Enhanced processing shows clear potential

4. Germplasm and genetic resources

4.1 Material currently available or expected to be readily available
4.2 Degree of genetic erosion of the resource base
4.3 Needs for genetic resources conservation programmes

5. Agro-ecology

5.1 Suitability for agro-ecological zones
5.2 Suitability for use in special circumstances e.g. degraded lands, and mountainous areas

These criteria agreed in 1993 and used still remain valid. In addition to the five criteria listed above, the actual situation in each individual country has been reviewed and additional taxa have been added in this revision.

The major priority species

From the beginning it was recognized that a consensus on the major priorities for regional and international action would, of necessity, not include many of the other species which are used locally and many of which are the subject of research by national programmes. It is stressed that research on these should continue to receive attention from national programmes. However, one or more locally and some what regionally or sub-regionally important species can be added.

The following 20 taxa of bamboos are accorded high priority for international action based on the criteria discussed earlier:

Bambusa balcooa Roxb.
B. bambos (L.) Voss
B. blumeana J A and J H Schultes
B. polymorpha Munro
B.textilis McClure
B. tulda Roxb.
B. vulgaris Schrad. ex Wendl
Cephalostachyum pergracile Munro
Dendrocalamus asper (Schultes f.) Backer ex Heyne
D.giganteus Wallich ex Munro
D.latiflorus Munro
D. strictus (Roxb.) Nees
Gigantochloa apus J A and J.H. Schultes
G.levis (Blanco) Merrill
G.pseudoarundinacea (Steud.) Widjaja
Guadua angustifolia Kunth
Melocanna baccifera (Roxb.) Kurz
Ochlandra Thw. (Spp.)
Phyllostachys pubescens Mazel ex H. de Leh [11] including *P.bambusoides* Sieb. and Zucc and *P. edulis* Makino
Thyrsostachys siamensis (Kurz) Gamble (Table 1)

Table 1 illustrates the value of these species for utilization and for environmental rehabilitation, their degree of domestication, climatic ranges and needs for genetic conservation and further survey.

A further 18 taxa were noted to be important and the information available on them have been updated (Table 3). See page 50 onwards.

Arundinaria spp
Bambusa atra Lindl. (Neololeba atra (Linn) Widjaja)
B. heterostachya (Munro) Holtum
B. nutans Wall. ex Munro
B. oldhamii Munro
B. pervariabilis McClure
Lingnania chungii McClure
Dendrocalamus brandisii (Munro) Kurz
D. hamiltonii Nees
D. hookeri Munro
D. membranaceus Munro
Gigantochloa albociliata (Munro) Kurz

Bamboos

Table 1. Priority species and species of national and regional importance (Commercial and local use)

Taxa	Value			Domestication	Climate & Ecology		Genetic resources				
	C	RI	E		C1	S1	GE	S	IV	E	Survey
Bambusa balcooa	++	++	++	D	h, d	m, r	H	H*	H	H	H
Bambusa bambos	++	++	++	D	h, d, s	r, m, p	H	L	M	M	H
B. blumeana	++	++	++	D	h, d, s	r, m, p	H	L	H	H	H
B. polymorpha	+	+	–	D	h, d	r, m	H	H	M	H	H
B. textilis	+	++	+	D	st	r, m	M	L	H	H	L
B. tulda	+	++	+	D	h, d	r, m	H	M	H	H	H
B. vulgaris	–	–	++	D	h, d, s	r, m, p	L	L	L	L	L
Cephalostachyum pergracile	+	++	+	W	h, d	m	M	L	M	H	M
Dendrocalamus asper	++	+	++	D	h, d	r	H	H	M	H	H
D. giganteus	+	+	+	D	h	r	H	H	M	H	H
D. latiflorus	++	+	+	D	h	r	M	L	M	H	L
D. strictus	++	+	++	D	d, s	m, p	M	L	L	H	M
Gigantochloa apus	+	++	++	D	h	r	H	H	M	H	H
G. levis	+	++	++	D	h	r	H	L	H	H	H
G. pseudoarundinacea	++	+	+	D	h, d	r	M	L	H	H	L
Guadua angustifolia	++	++	++	W	h	r, m	H	H	H	H	H
Melocanna baccifera	+	++	+	W	h	r	H	M	H	H	M
Ochlandra sps	+	+	+	W	h	r	H	H	M	H	H
Phyllostachys pubescens	++	++	++	D	t	r, m	M	M	L	L	L
Thyrsostachys siamensis	++	++	++	D	d. (h)	m, (r)	M	M	L	H	L

KEY *Value*

C = commercialization potential: High (++), medium (+), and little (-).
Survey = need for further field survey: High (H), medium (M), low (L).
RI = rural industries: High (++), medium (+), and little (-).
E = environmental rehabilitation: High (++), medium (+), and little (-).

Genetic resources

GE = genetic erosion: High (H), medium (M)., low (L).
S = need for research on seed storage: High (H), medium (M), low (L).
IV = need for research on in vitro storage: High (H), medium (M), low (L).
E = need for wider exchange. High: (H), medium (M), low (L).

Domestication

Wild = W, domesticated = D.

Climate and ecology

Cl = climate: humid tropics (h), dry tropics (d), subtropics (st), semi-arid (s), temperate (t).
Sl = soils: rich (r), medium (m), poor (p)

G. atroviolacea Widjaja
G. balui Wong
G.hasskarliana (Kurz) Back. ex Heyne
Oxytenanthera spp. Munro
Phyllostachys glauca McClure
Schizostachyum spp. Nees

It was agreed that the following seven taxa of rattans should be accorded high priority for international action.

Calamus manan Miq (including *C. tumidus*, Furtado a related species)
C. caesius Blume (including *C. optimus* Becc).
C.trachycoleus Becc. this includes about 14 closely related species from different areas of Asia, some of which have not yet been fully described; however, they are all closely related.
Calamus Section *Podocephalus* Furtado
C. subinermis H. Wendl. ex Becc (including relatives)
C. palustris Griff. (this complex includes *C. inermis* T. Anders., *C. latifolius* Roxb., *C. nambariensis* Becc. and others such as *C.platyacanthus* Warb., *C. egregius* Burret and *C. simplicifolius* Wei. This complex presents tremendous scope for genetic improvement.
C.tetradactylus Hance including a number of related species such as *C.cambojensis* Becc., *C. rotang* L. and *C. viminalis* willd; there is need for taxonomic revision.

Table 2 illustrates the value of these species for utilization, their degree of domestication, climatic ranges and needs for genetic conservation and further survey.

Further, it was agreed that the following two taxa require more study or are probably of lower value for expanded production. These are:

Calamus deeratus G. Mann and H. Wendl
C. hollrungii Becc., and relatives
These taxa are also included in Table 2.

The priority taxa mentioned above are listed using the currently correct nomenclature. It should be noted that there are many synonyms widely used and in a number of cases research results cannot always be applied to the correct taxonomy. The value of keeping a voucher specimen cannot be over-stressed. It will also be important to refer to wherever possible, to the collectors' number while presenting results to avoid any ambiguity.

In general, some level of *ex situ* conservation through developing ex situ stands or collections in field genebanks or in botanical gardens is suggested for most of the priority species of bamboo and rattan. Promoting research on *in vitro* conservation can help in developing an additional method for *ex situ* conservation. However, the major component of a complementary conservation strategy should include *in situ* conservation of most of the species with *ex situ* stands and *in vitro* methods to promote studies on different species and propagations as well as to promote use and exchange in the case of *in situ* conservation of bamboo and rattan. There is the need to link conservation with extract protected area systems in different countries.

A general outline map showing South, Southeast and Far east Asian countries (Fig. 1) and maps showing distribution areas for various species are included. Many of the species are introduced and grown in Australia, tolerant or well adapted to cold climate and are frost resistant (Cussack 1998)

Rattans

Table 2. Priority species and species of national and regional importance (Commercial and local use)

Taxa	Value			Domestication	Climate & Ecology		Genetic resources			
	CS	C	RI		C1	H	GE	IV	E	Survey
Calamus manan	L	++	+	D	h	d	H	L	H	M
C. caesius	S	++	++	D	h	d/w	H	L	H	H
C. trachycoleus	S	++	++	D	h	seas.f	L	L	M	L
Calamus Sect. *Podocephalus*	M-L	++	+	SD	h, s	saline mangrove to montane	H	L	H	H
C. subinermis (and relatives)	M-L	++	+	SD	h, s	dry (coastal hills)	H	L	H	M
C. palustris (and relatives)	M-L	+	++	SD	s (monsoonal)	varied	H	L	H	H
C. tetradactylus	S	+	++	D	Cool	d	L	L	L	L
C. deeratus	S-M	(+)	++	W	h, s	w	H	L	H	H
C. hollrungii (and relatives)	M-L	+	+	W	h	d	H	L	H	H

KEY *Value*

CS = cane size: Large (L), medium (M), and small (S).
C = commercialization potential: High (++), medium (+), and not fully known (+).
RI = rural industries: High (++), medium (+).

Domestication
Wild = W, semi-domesticated = SD, domesticated = D.

Climate and ecology
Cl = climate: humid tropics = h, subtropics = s.
H = habitat: dryland = d, wet = w, seasonally flooded = seas. F.

Genetic resources
GE = genetic erosion: High (H), low (L).
IV = need for research on *in vitro*: Low (L).
E = need for exchange: High (H), medium (M), low (L).
Survey = need for further field survey: High (H), medium (M), low (L).

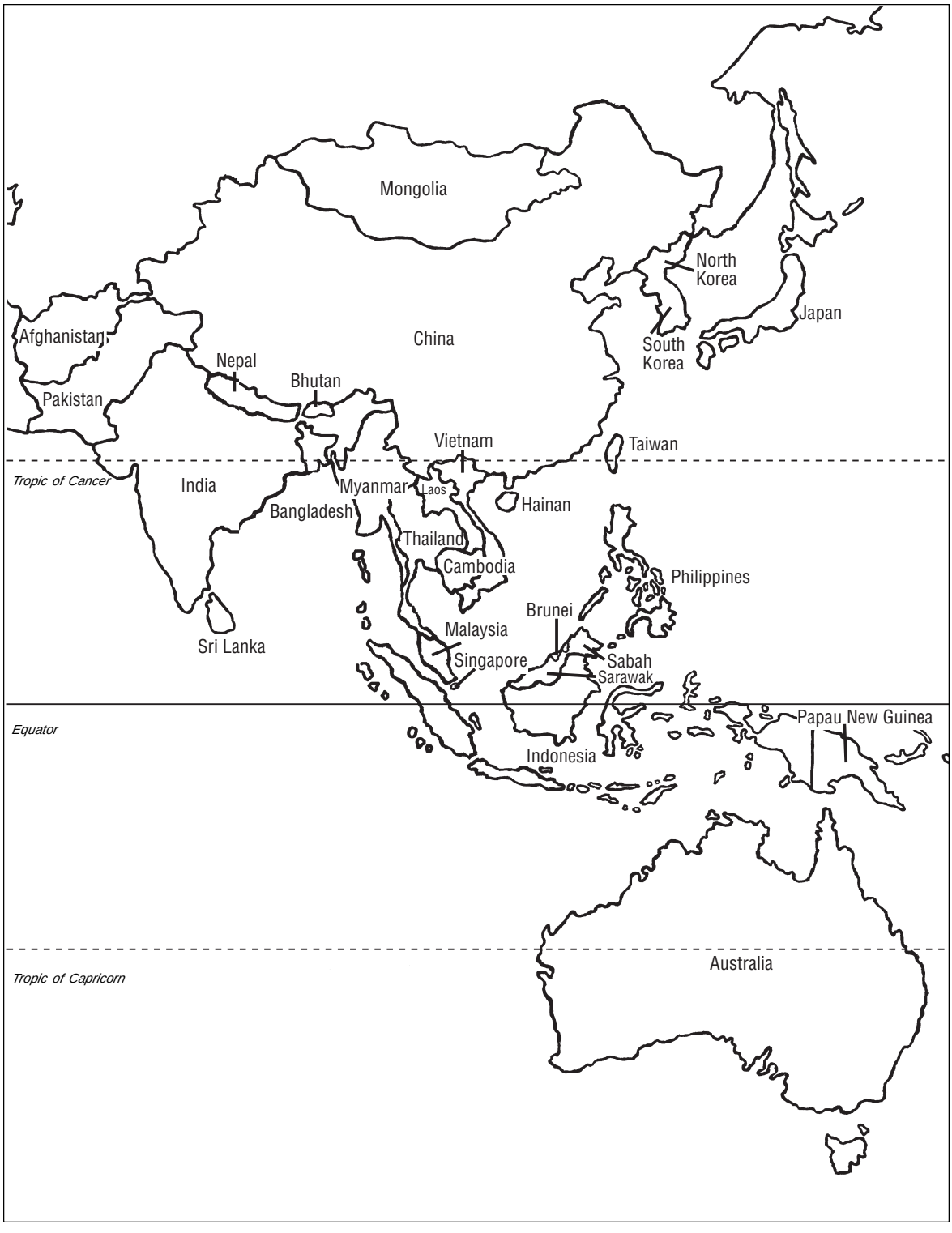


Fig. 1 South, Southeast Asian countries and Australia

Part I

Notes on priority bamboos

Bambusa balcooa (= Dendrocalamus balcooa)

Tall bamboo, forming distinct tufts, groups or clumps, culms 20–24 m long, 8–15 cm diameter, greyish green to light white,thick walled 2–2.5 cm, nodes prominent with white ring above node, internodes 30–45 cm long, leaf blade oblong lanceolate ± 25 x 4 cm, Inflorescence compound panicle, with 6–8 spikelets on nodes, flowers well described, fruits not known. Vegetative propagation – culm cuttings, rhizome and branch cuttings, growth regulators like NAA are used for root induction, tissue culture protocol well-outlined.

DISTRIBUTION: Origin is said to be from N E India, native of Bengal; at present mostly cultivated in different countries, introduced to Australia (Fig. 2).

CLIMATE AND SOIL: Tropical bamboo of monsoon climate, lowland to 600 m, can withstand dry period, suitable for different soils, grows better on heavy clay soil, well drained, can withstand –5°C.

CURRENT RESEARCH: Basic methods for propagation and planting are established but they need to be improved, especially the water requirements for young plants in dry regions. Cytology 2n = 70 (aneuploid).

UNTAPPED POTENTIAL: This species is well cultivated, utilised in Bangladesh and India, but has great potential for cultivation in other countries with similar climatic conditions. Unexplored or underexplored regions of Bangladesh, India and Myanmar should be surveyed to collect superior plant materials.

CONSERVATION: Small germplasm collection in India, Bangladesh. Larger germplasm collections recommended. Culm characters variable although vegetatetively propagated.

USES: Structural bamboo, average quality, building materials for homes, bridges, agricultural implements, furniture of good quality, paper pulp, shoots edible but not of good quality, leaves provide fodder.

RESEARCH NEEDS:
1. Studies on physical and chemical properties.
2. Selection of superior varieties to obtain better fodder.
3. Provenance trails.

Bambusa bambos (= B. arundinacea, B. spinosa)

Common Name: Spiny bamboo, Thorny bamboo, Indian bamboo

This is a thorny bamboo densely tufted, with curving branches, graceful, upright, shining culms 15–30 m tall; nodes swollen, culm tip bending slightly, internodes 20–40 cm long, diameter 15–18 cm and wall thickness 1–1.5 cm, but sometimes almost solid near the base especially in dry climates and poor soils; lower branches spreading, recurved spines, in groups of 3 spines each, leaves lanceolate 6–22 x 1–3 cm, gregarious flowering, flowering cycle 30–45 years, Inflorescence panicle, stamens exerted, anthers yellow, ovary elliptic – oblong, fruit (caryopsis) 4–8 mm long, persistent glume and palea, embryo prominent. Methods suggested for vegetative propagation – culm cuttings, layering, marcotting and macroproliferation of seedlings.

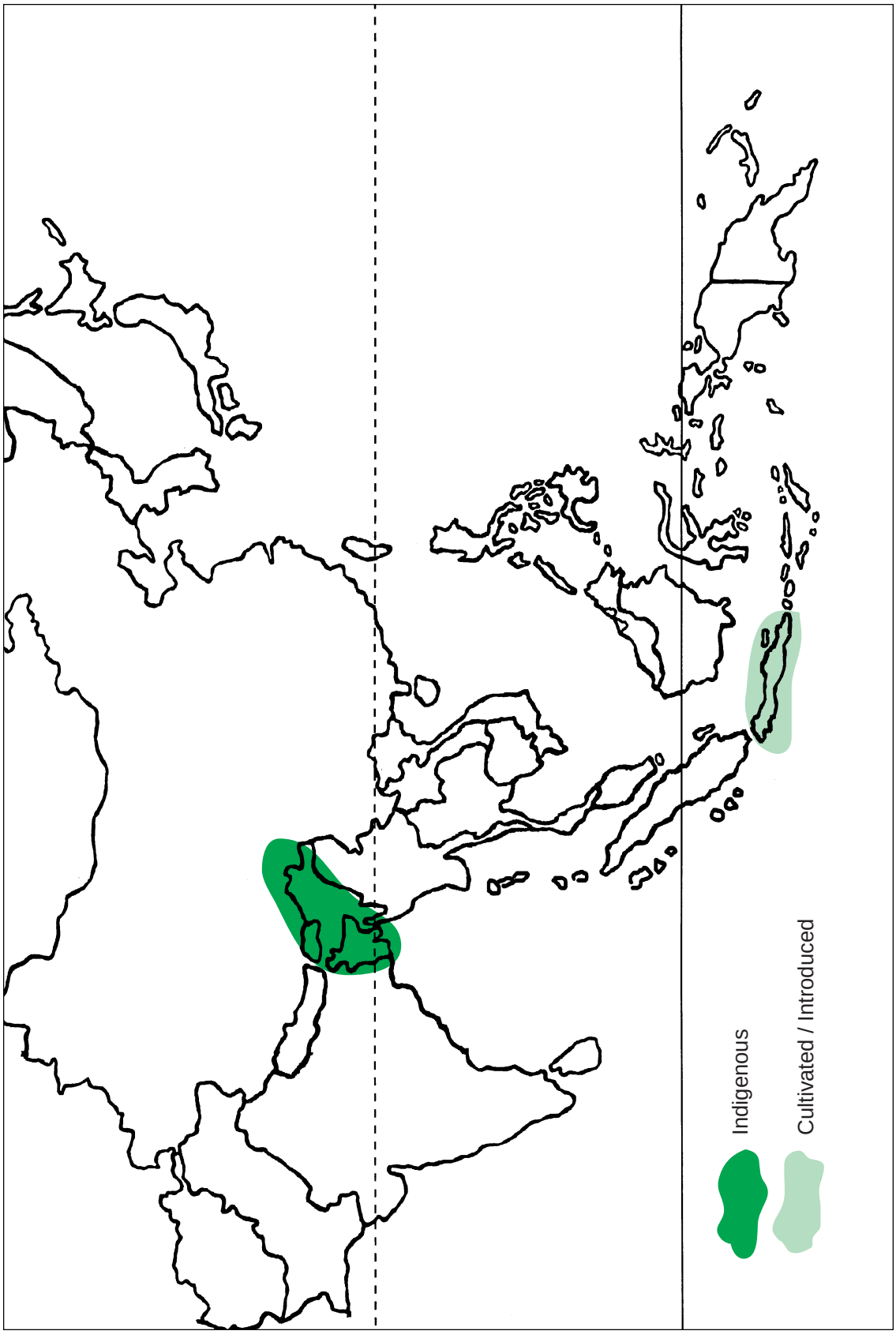


Fig. 2 *Bambusa balcooa*

DISTRIBUTION: Extends from India, sub Himalayan and Indoganetic plains, scattered in Assam and Bengal, Thailand to Southern China, major commercial species in Thailand; planted in Nepal, Indonesia, Vietnam and the Philippines, cultivated throughout tropics (Fig. 3).

CLIMATE AND SOILS: *Bambusa bambos* thrives in both humid tropical and not very dry tropical climates, flourishes in flat alluvial areas, grows on rich to poor soils but prefers acid soils, abundant and grows well in moist forest, extends up to 1200 m in altitude, tolerates –2°C.

CURRENT RESEARCH: Studies on use for bamboo board, pulp and paper have been carried out. Mass propagation through tissue culture and vegetative propagation have been studied. Some work has been done in studying distribution in different countries but not very extensive. Some work has been done on seed storage and seed ageing, Cytology 2n = 70, 72.

UNTAPPED POTENTIAL: This species has great potential for rehabilitation of degraded lands, and it could be recommended for an agroforestry system. It has also been reported to be an ideal species for commercial plantations.

CONSERVATION STATUS: No work has been done. It is urgent to collect and conserve a wide range of possible varieties, commonly cultivated, one variety *gigantea* has been identified in S. India.

USES: General purpose, structural bamboo, medium quality, shoots edible both superior and poor quality, this species is used as building materials and for making bamboo board, pulp and paper (useful because of long fibres), furniture of superior quality, and also planted as windbreaker and major commercial species in many countries, seeds edible, leaves have medicinal value used for different ailments.

RESEARCH NEEDS:
1. Exploration of both primitive and superior cultivars.
2. Selection for quality improvement (including for pulp and paper).
3. Propagation management.
4. Seedlings of 4 types, some better than others, selection needed.
5. Tissue culture (TC) work done, more research needed for mass propagation and *in vitro* conservation.
6. Studies on insect pests.
7. Taxonomic status of varieties and genotype evaluation.
8. Distribution of diversity and location in protected areas.
9. Testing for degraded areas.

Bambusa blumeana (= B. spinosa, B. pungens, B. arnendo)

Common Name: Spiny bamboo, thorny bamboo, lesser thorny bamboo.

This is a thorny bamboo with culms 15–25 m tall. The internodes are 25–60 cm long, with 6–10 cm diameter and wall thickness of 0.5–3 cm, but mostly solid at the base especially in dry areas or poor soils, leaf lanceolate, 15–20 x 1.5–2 cm, leaves very fine, Inflorescence on leafy branches, fruits not known. Vegetative propagation methods: Culm cuttings, rhizome planting, layering and marcotting.

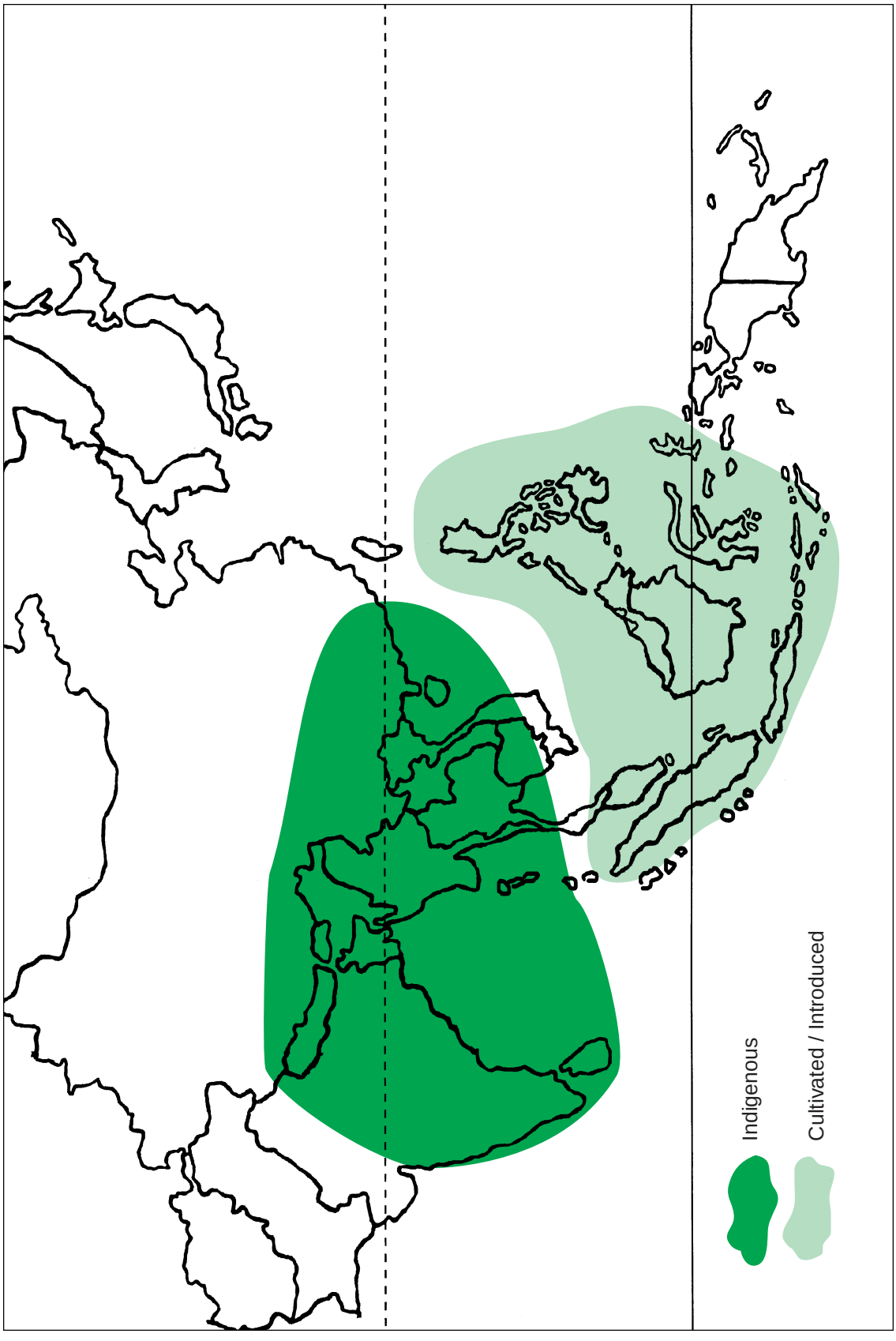


Fig. 3 *Bambusa bambos*

DISTRIBUTION: Exact origin of this species is unknown, but said to be native of Indonesian islands, cultivated in PNG, Northern part of Peninsula Malaysia, Thailand and the Philippines (Fig. 4).

CLIMATE AND SOILS: *Bambusa blumeana* grows in humid tropical or dry tropical areas and on rich to poor soils, heavy saline soils not suitable, tolerates –7°C.

CURRENT RESEARCH: Studies on physical and mechanical properties, have only used materials from limited areas. Some research on vegetative and tissue culture propagation has been carried out. Some work on its use in rehabilitation of denuded forest lands has been carried out. Harvesting techniques have been worked out. Cytology 2n=78

UNTAPPED POTENTIAL: This species has great potential for rehabilitation of marginal lands and can be used as borders to agricultural areas.

CONSERVATION STATUS: No work has been done, one variety luzonensis has been found in the Philippines.

USES: General purpose, in furniture industries medium to poor quality, chopsticks industries, local handicrafts, baskets and occasionally as a vegetable after processing of edible shoots, good quality, planted as windbreaker.

RESEARCH NEEDS:
1. Exploration for primitive and superior cultivars.
2. Selection for quality improvement
3. Propagation management, tissue culture work needed.
4. Sustainable management of natural stands, tissue culture for propagation.
5. Rarely flowers, seed production, seed storage studies.
6. Limited germplasm collection in Sumatra, need to be improved.
7. Testing for degraded areas.
8. Study on genetic diversity of the species.

Bambusa polymorpha

This is a medium to large size bamboo with culms up to 25 m tall, diameter of culms up to 15 cm, wall thickness 1–2 cm, relatively thick walls, occasionally solid, leaf 10–20 x 8–2 cm, inflorencence long with pseudospikelets arranged in bunches, flowering cycle 50–60 years, flowering gregarious and sporadic, ovary obovate, fruit ovoid, 5 mm long. Vegetative propagation methods: Culm cuttings, rhizome planting, branch cutting, layering and marcotting.

DISTRIBUTION: Native to Bangladesh, India, Myanmar and Thailand, cultivated elsewhere (Fig. 5), grows along with Teak in Myanmar

CLIMATE AND SOILS: *Bambusa polymorpha* grows naturally in semi-humid areas on medium to rich soils, well-developed soils.

CURRENT RESEARCH: Very little, tissue culture work done. Cytology 2n=64, 72 anueploid.

CONSERVATION STATUS: Needs investigation, germplasm collections in India and Myanmar.

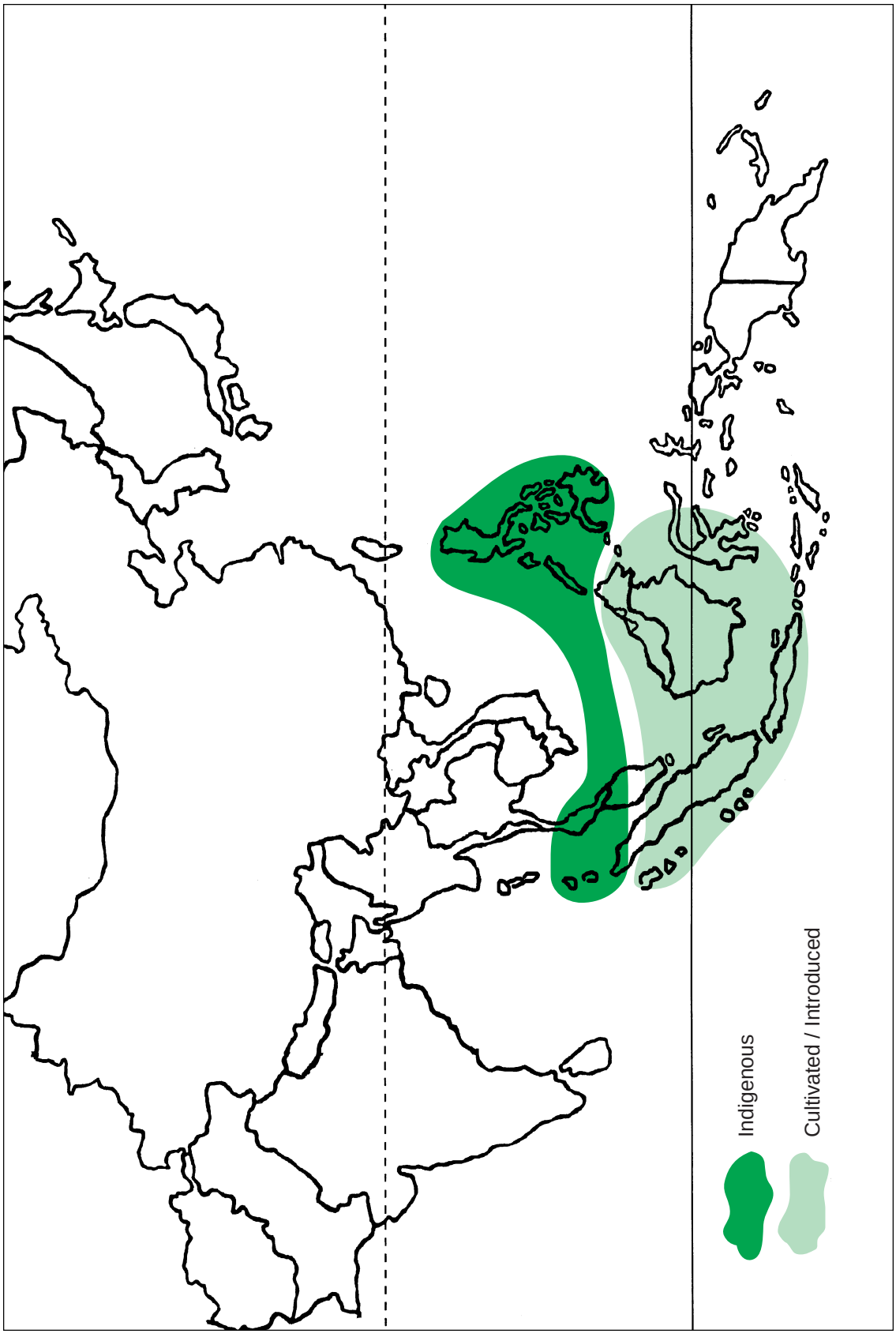


Fig. 4 *Bambusa blumeana*

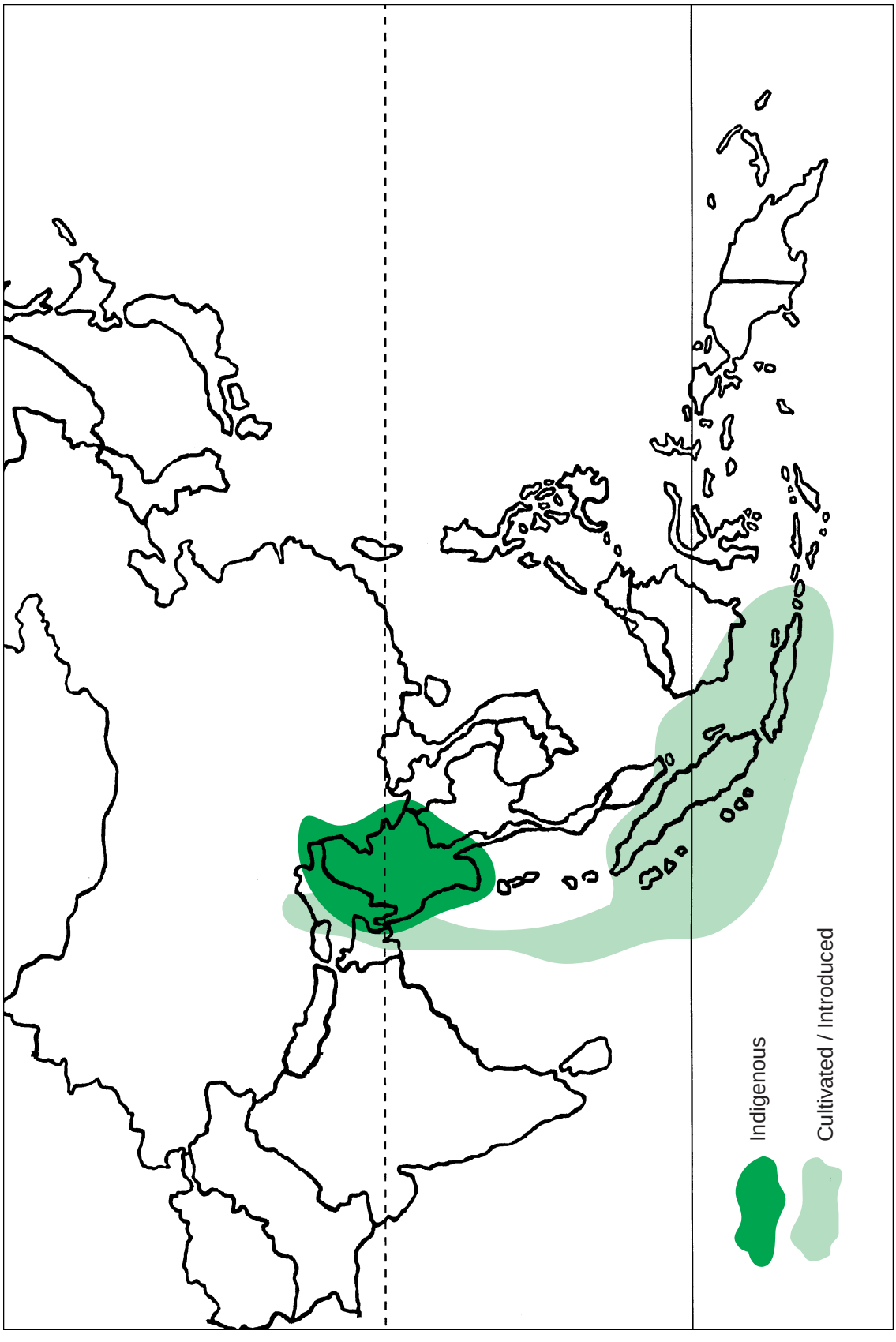


Fig. 5 *Bambusa polymorpha*

USES: Primarily used as building material, structural timber, medium quality, decorative timber; shoots are edible; it is also used locally for making baskets, paper pulp, land scaping, furniture average quality.

RESEARCH NEEDS: All aspects, including cultivation.

Bambusa textilis

Common Name: Weavers bamboo

This is a medium-sized sympodial bamboo with culms up to 15 m tall, straight and smooth, diameter 3–5 cm, internode 35–60 cm, leaves lanceolate 9–25 x 1–2.5 cm; Little information on flowering and fruiting. Several cultivars and varieties recognized cv. Albostriata, var, glabra, var, gracilis.

DISTRIBUTION: South China, including Guangdong, Guangxi, Fujian provinces introduced to other provinces (Fig. 6).

CLIMATE AND SOILS: *Bambusa textilis* is native and cultivated in China in subtropical areas on moderately rich soils, usually growing on hills.

CONSERVATION AND RESEARCH: Need attention, some hybrids produced crossing with *Bambusa pervariabilis* and D*endrocalamus latiflorus*. Three botanical varieties identified, cv, 'Albo striata', var glabra, var. gracilis.

USES: Structural bamboo, light quality, largely used for making handicrafts and kitchen utensils, weaving splits, and land scaping, edible shoots of average quality, cultivar albostriata, general purpose furniture, edible shoots average quality, var glabra – structural timber, light quality, furniture medium quality, edible shoots average quality, var gracilis, structural timber, light quality, small diameter bamboo for furniture, edible shoots, average quality.

RESEARCH NEEDS: Flowering and fruiting, propagation methods, cultivar development.

Bambusa tulda (= Dendrocalamus tulda)

Common name: Bengal bamboo, Spineless Indian bamboo, Calcutta cane.

This is a medium-sized tufted bamboo, clump forming, evergreen, rarely deciduous, growing up to 30 m, but often less; fast growing culms, 0.4–0.7 cm thick walls with diameter ca 5–10 cm, internodes 40–70 cm long, leaf 15–25 x 2–4 cm, leaf size variable on the same culm. Inflorescence on leafless branches and pseudo spikelets, fruit 7–5 mm long. Flowering spordic, isolated and gregarious, flowering cycle 25–40 years, fruit oblong 7.5 mm long. Vegetative propagation methods – culm cuttings, marcotting, offset rhizomes, macroproliferation of seedlings, tissue culture method known.

DISTRIBUTION: Native of India, Bangladesh, Myanmar and Thailand. Introduced to other parts, cultivated in N. India, Terai, Nepal, introduced to Java, Vietnam, and the Philippines (Fig. 7).

CLIMATE AND SOIL: Frequently found to grow as an undergrowth sporadically or in patches in the mixed semi-deciduous forests. Sometimes form patches of a pure to semi-pure vegetation. Grows well in moist and moderately high rainfall (4000–6500

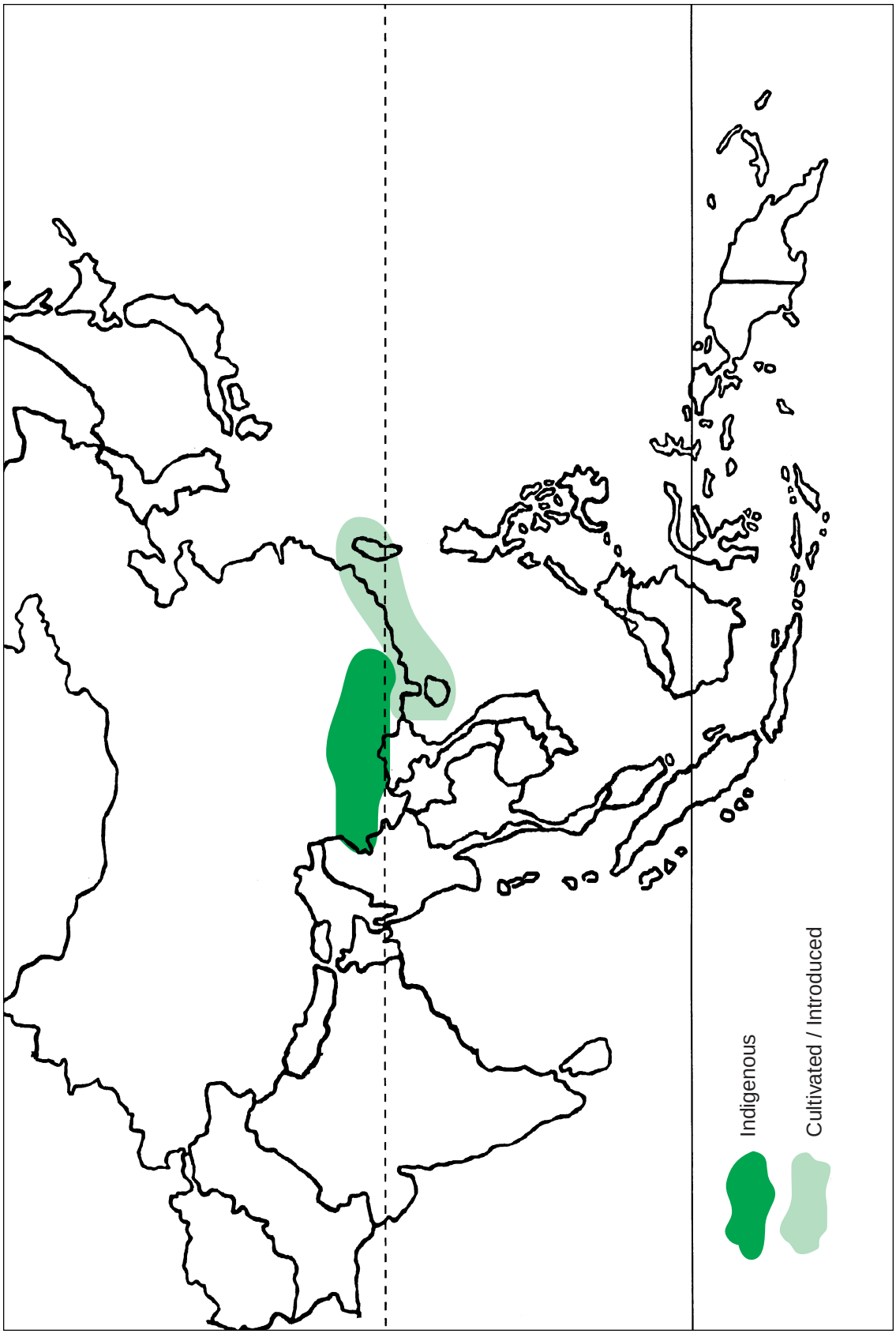


Fig. 6 *Bambusa textilis*

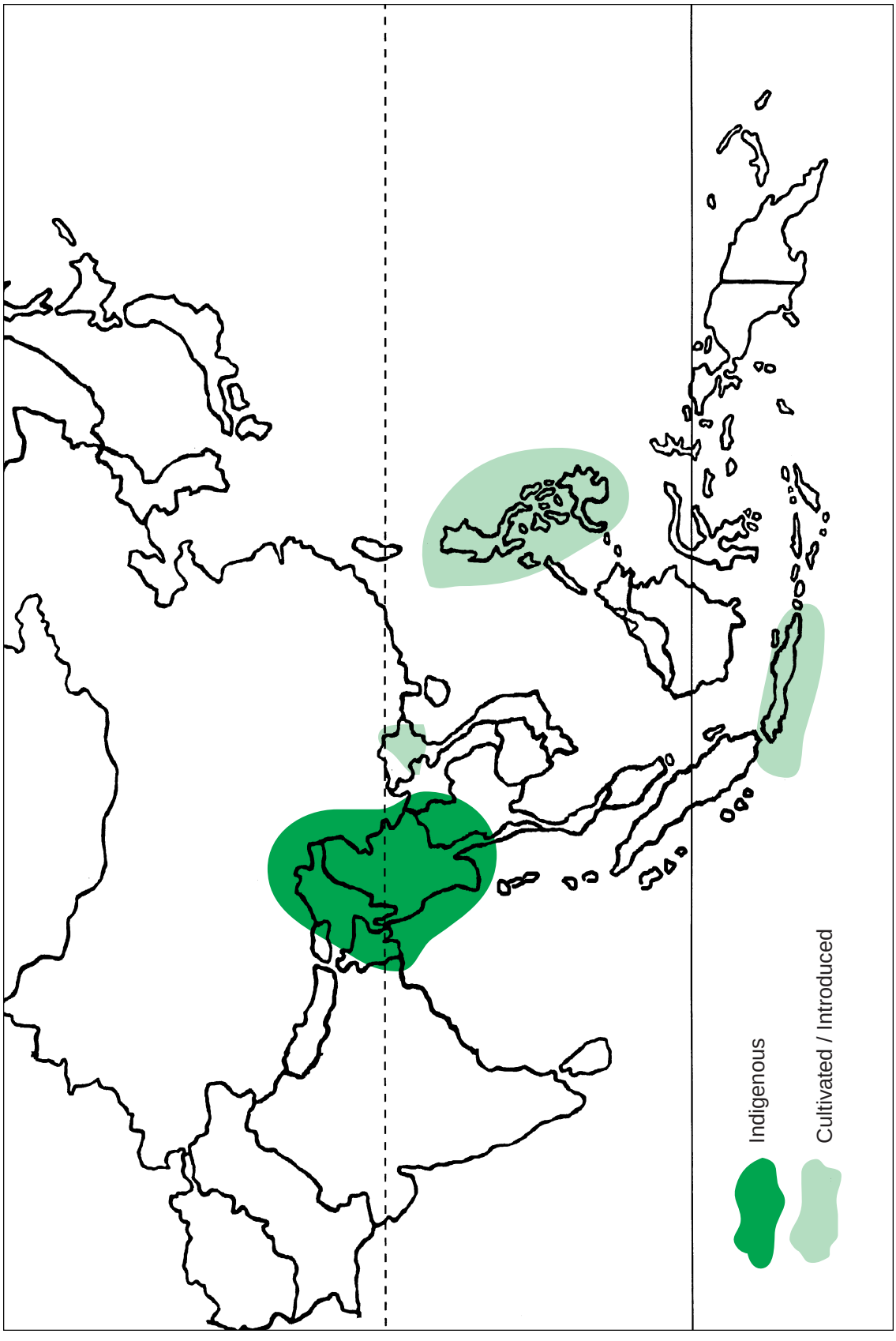


Fig. 7 *Bambusa tulda*

mm) areas with temperature range from 4 to 37°C. It commonly grows on the flat alluvial deposits along the hilly streams inside the forests also along the banks of rivers, water courses, grows up to 1500 m altitude.

CURRENT RESEARCH: Germplasm collection in N.E. India, more research needed on all aspects. Cytology 2n = 70, 72 aneuploid.

CONSERVATION STATUS: Conservation programme not yet planned. The local people have been conserving the species to some extent in their homestead and settled forest areas. The species is domesticated in the villages as well as grows wild in the forest, varieties found at low and high altitudes, need to be properly identified and conserved.

USES: Structural timber of medium quality, varied uses of the material from this species include for building materials, thick walled material for furniture, edible shoots (also for pickles) average quality, pulp for paper and a very wide range of handicrafts and implements, wind breakers, flute making, fishing rods.

RESEARCH NEEDS:
1. Germplasm characterization for *in situ* and *ex situ* Conservation.
2. Propagation methods, selection and multiplication.
3. Exploration and identification of diversities in the region.
4. Identification of out of phase flowering types.

Bambusa vulgaris (= B. surinamensis)

Common Name: Common bamboo, Golden bamboo, Buddha's belly bamboo

This is a medium-sized bamboo, not densely tufted with culms 8–20 m tall. Culms with yellow or green stripes, flowering not common. Internodes 25–35 cm long, 5–10 cm diameter and thickness of wall ranges 7–15 mm. Inflorescence panicle, with many spikelets, no seeds. Vegetative propagation methods – culm cuttings, rhizome planting, branch cutting, layering, marcotting.

DISTRIBUTION: *Bambusa vulgaris* is a pantropical species. Origin of the species is unknown but most commonly cultivated everywhere, especially the horticultural varieties with yellow culms (Fig. 8), green culm varieties common in naturalized populations.

CLIMATE AND SOILS: It grows in a wide range of climates and on a range of soils; up to about 1500 m, frost hardy up to –3°C; plants with green culms are more common, drought resistant, very vigorous on moist soil.

CURRENT RESEARCH: Significant amount of work has been done on various aspects – harvesting techniques, biology, physico-chemical and medicinal properties etc. *In vitro* work, including *in vitro* plant regeneration via callogenesis and organogenesis. Cytology 2n=72.

UNTAPPED POTENTIAL: Adaptation to semi-arid areas, and on degraded and flooded lands. Three groups are recognized; a) green culm group *B. vulgaris,* var *vulgaris,* b) yellow culm group – thicker walls than green culms, *B. vulgaris var vittata*, c) Buddha's belly *group – B. vulgaris,* cv wamin, indigenous to South China.

CONSERVATION STATUS: Not threatened since it is weedy, easy to propagate by using rhizome, culm branch cutting and layering.

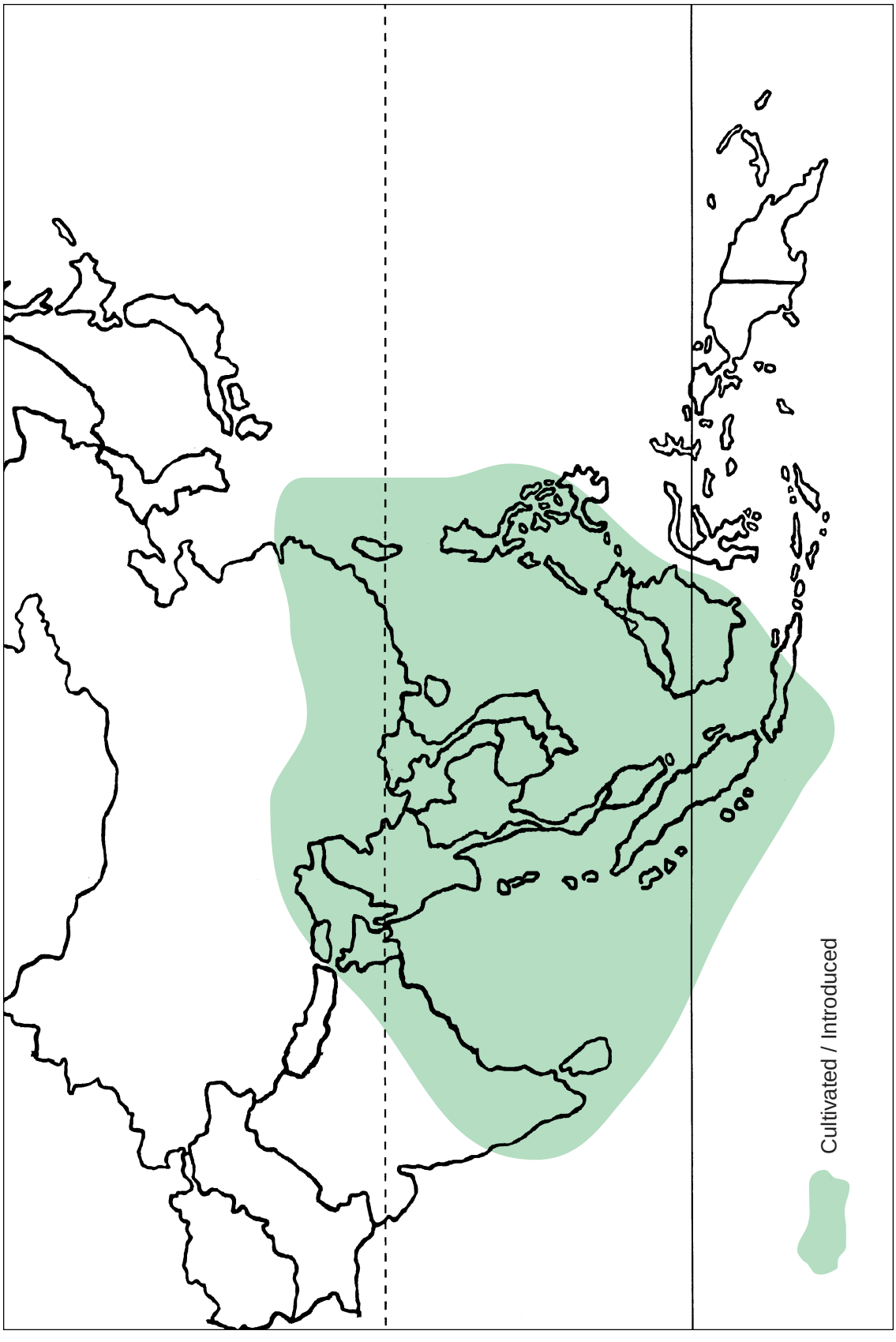


Fig. 8 *Bambusa vulgaris*

USES: It is used for a variety of purposes: building, culm is comparable with best timber, used most commonly, fencing, scaffolding, furniture, handicrafts, paper and pulp, ornamental, edible shoots of average to poor quality, medicinal value, planted for soil conservation.

RESEARCH NEEDS:
1. Quality and durability need to be improved since it is easily attacked by insects, limited germplasm collection in Sumatra.
2. Studies on adaptability, matching the variety with soil type.
3. Studies on variability and germplasm in various countries.
4. *In vitro* conservation, tissue culture for rooting of shoots.
5. Use in degraded areas.

Cephalostachyum pergracile (= Schizostachyum pergracile)

Common name: Tinwa bamboo

This is a medium-sized densely growing bamboo up to 7–30 m tall; culms have thin walls, leaf linear lanceolate, 10–35 x 1.5–6.0 cm; flowering gregarious or sporadic, few or no seeds in sporadic flowering plants; inflorescence long, drooping, fruits ovoid 1 cm long. Vegetative propagation by culm cutting. Tissue culture work done.

DISTRIBUTION: N E India, Nepal, Myanmar, Northern Thailand and Yunan Province, China, cultivated elsewhere (Fig. 9).

CLIMATE AND SOILS: *C. pergracile* occurs in semi-humid to semi-arid regions on a range of soils, it is most common in well-drained loamy soils in Myanmar.

CURRENT RESEARCH: Some work on the identification of varieties using isoenzymes has been carried out. Cytology, 2n=72, 48, 54, 60, Hexaploid.

CONSERVATION: Need attention.

USES: Structural timber, light quality, used largely for buildings, thatching and walling, general purpose furniture, handicrafts, but also for matting, basket making and temporary construction, horticultural value, culms used for cooking.

RESEARCH NEEDS:
1. Population survey;
2. Genetic analysis;
3. Selection of superior plants;
4. Germplasm collection;
5. Genetic erosion is very high in certain countries.
6. Improved methods for seed storage.

Dendrocalamus asper (= Bambusa aspera, Gigantochloa aspera, Dendrocalamus flagellifer, Dendrocalamus merrillianus)

Common name: Giant bamboo, Bamboo Betung

This is a large bamboo with culms 20–30 m tall; lower nodes covered with a circle of rootlets; internodes 20–45 cm long with a diameter of 8–20 cm and with relatively thick walls (11–20 mm), but thinner towards the top of the plant; leaf 30 x 2.5 cm; inflorescence long, clustered pseudo spikelets, flowers sterile, fruits collected from hybrids. Vegetative propagation – culm and branch cutting.

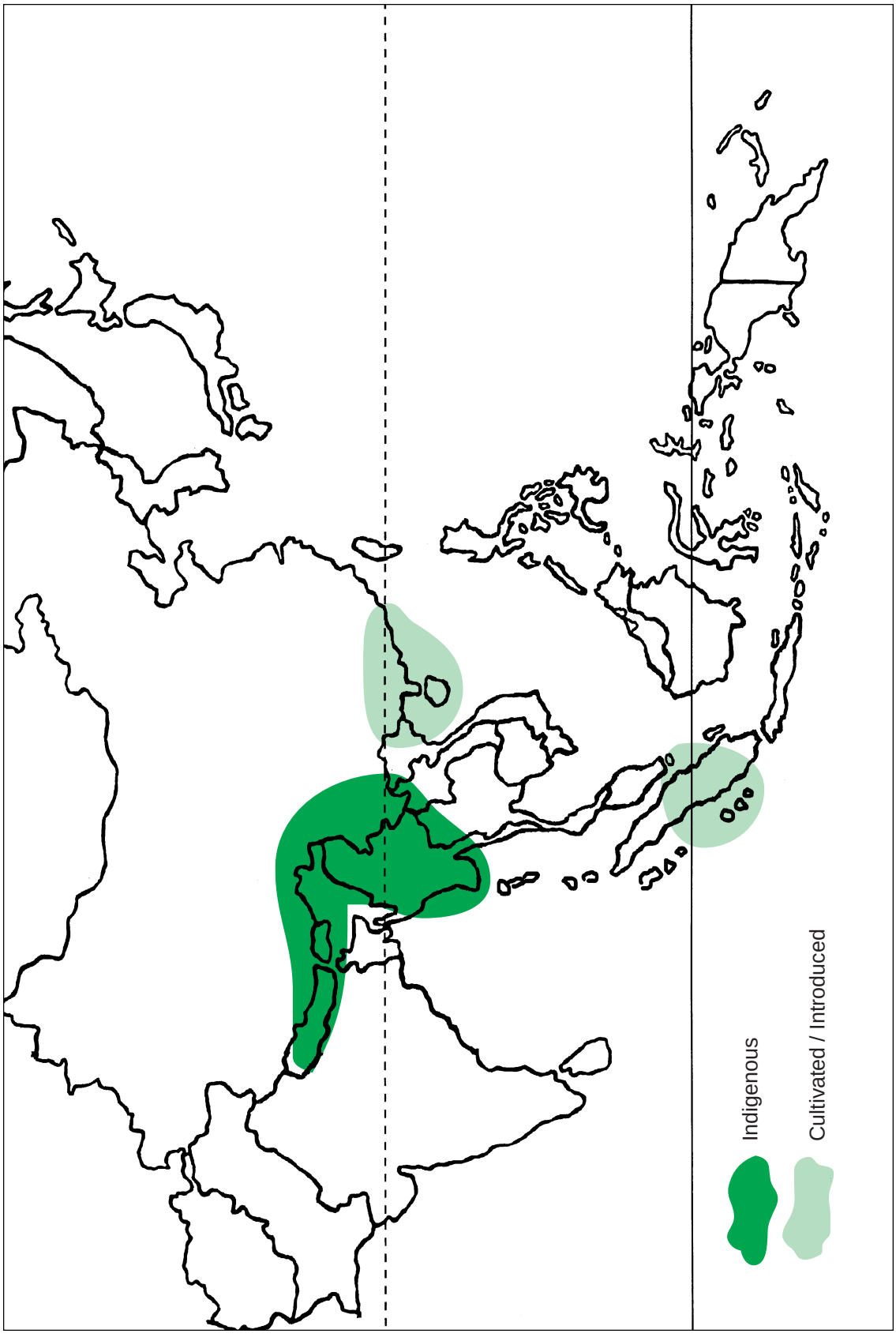


Fig. 9 *Cephalostachyum pergracile*

DISTRIBUTION: Commonly planted in Thailand, Vietnam, Malaysia (Peninsular and East), Indonesia and the Philippines; commercially important in eastern parts of India; widely introduced elsewhere in tropical and subtropical botanic gardens, origin somewhere in S E Asia (Fig. 10).

CLIMATE AND SOILS: This species grows best in rich and heavy soils of the humid regions from the lowlands to 1500 m altitude, but it also grows well in semi-dry areas in Thailand, grows best with good drainage or sandy soil, tolerates –3°C.

CURRENT RESEARCH: Propagation methods and management for shoot production have been studied. Use in rehabilitation of degraded forest lands has been studied. Preservation of culms has also been researched, propagation using rhizome, culm and branch cuttings, some in vitro work done.

UNTAPPED POTENTIAL: There is clear potential for use of this species in agroforestry systems and also for use in manufacturing bamboo boards.

CONSERVATION STATUS: Poor and needs priority attention, limited germplasm collection in Sumatra.

USES: Structural timber, strong, large, very good quality. General purpose, one of the most useful bamboos for heavy construction in rural communities. However, it is mainly used for building due to the strength of the culms which are relatively durable. It is also used in making good quality furniture, musical instruments, containers, chopsticks, household utensils and handicrafts. The young shoot is sweet and considered delicious; plantations for shoot production have been established in Thailand and other countries. Six cultivars recognized, *D.asper,* cv betung wulung, large black bamboo of Indonesia; cv Thai green, suitable for plantations as used in Thailand, cv Phai Tong Dam, less popular than Thai green, slightly black in colour.

RESEARCH NEEDS:
1. Primitive cultivars need to be sampled and characterized.
2. Genetic improvement for shoot production and culms; initial efforts could be based on selection of primitive cultivars.
3. Production management research on diverse soils and for continuous production of shoots.
4. Studies on floral biology to improve seed production.
5. More plantings because of the wide variety of uses by rural communities.
6. Studies on physical, mechanical and chemical properties in relation to bamboo board production.
7. Provenance trials should be established for selecting the elite strains.

Dendrocalamus giganteus (= Bambusa gigantea)

Common name: Giant bamboo

This is a gigantic large bamboo 24–60 m tall, green to dark bluish green, internodes are 40–50 cm long, with diameter 10–20 cm and thick walls 2.5 cm, but can vary according to height; leaf 20–40 x 3–7 cm. Inflorescence 4–5 cm long with crowded spikelets; fruit oblong, 7–8 mm long, hairy. Vegetative propagation methods: culm cutting, rhizome planting, branch cutting, layering, marcotting and macroproliferation of seedlings. Propagation possible by tissue culture.

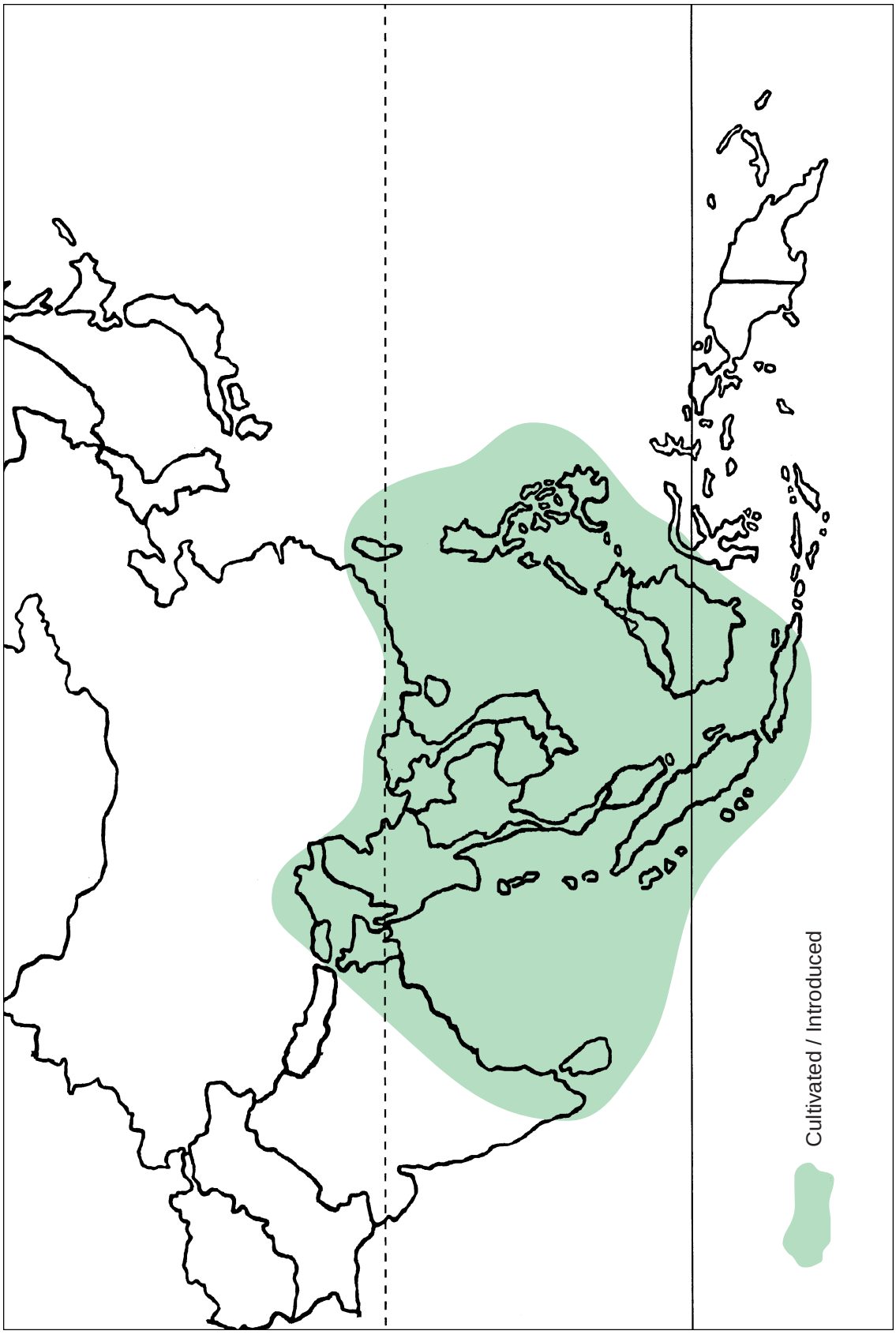


Fig. 10 *Dendrocalamus asper*

DISTRIBUTION: Native of Southern Myanmar and N W Thailand, introduced and cultivated in various countries including: India, Sri Lanka, Bangladesh, Nepal, Thailand, Vietnam, South China, Indonesia, Malay Peninsula and the Philippines (Fig. 11).

CLIMATE AND SOILS: *D. giganteus* grows in humid tropical to subtropical regions, usually on richer soils, up to 1200 m, tolerates –2°C.

CURRENT RESEARCH: A range of basic information including physico-chemical and mechanical properties available; tissue culture work done, germplasm collection in India and Bangladesh, superior plants identified. Cytology 2n=72, Hexaploid.

UNTAPPED POTENTIAL: Shoot production could be enhanced and use in the bamboo board industry can be expanded.

CONSERVATION NEEDS: Need to be investigated in different countries, especially in Myanmar and North West Thailand.

USES: Structural timber, strong superior quality, mostly used for building and for making bamboo board. It is also useful for making pulp and household implements, furniture very good quality, shoots can be eaten, canned, very good quality.

RESEARCH NEEDS:
1. Clonal selection and improvement
2. Population diversity survey
3. Cultivation methods

***Dendrocalamus latiflorus* – (= *Bambusa latiflora*, *Sinocalamus latiflorus*)**

Common name: Taiwan giant bamboo, Mabamboo

This is a medium-sized bamboo; 14–25 m tall, internodes 20–70 cm, 8–20 cm diameter. thick walls, leaf 15–40 x 2.5–7.5 cm, Internodes 20–70 cm long, wall thickness 0.5–3.0 cm, inflorescence 80 cm long with many spikelets, caryopsis 0.6 – 1.2 cm cylindrical to avoid. Vegetative propagation – culm cutting, layering, marcotting.

DISTRIBUTION: Distributed wild in Myanmar and parts of neighbouring countries, Cultivated in South and South West China, Taiwan; it has been introduced to the Philippines, Indonesia, Thailand, India, Vietnam and Japan (Fig. 12) one cultivar Meimung in China.

CLIMATE AND SOILS: Mostly subtropical, up to 1000 m, frost resistant, tolerates –4°C. It grows on rich soils in the humid tropics, with high rain fall.

CURRENT RESEARCH: Work is underway on improvement for shoot production, germplasm collections in Yunnan, China, including Taiwan. Cyctology 2n=72.

UNTAPPED POTENTIAL: It can be more widely cultivated on sandy loam soils.

CONSERVATION STATUS: Limited work done, good collection in Xishuangbanna area both wild and cultivated, two cultivars recognised.

USES: Structural timber, medium quality, commercially valuable species, shoots are sweet, edible, very good quality. Other uses include production of quality furniture,

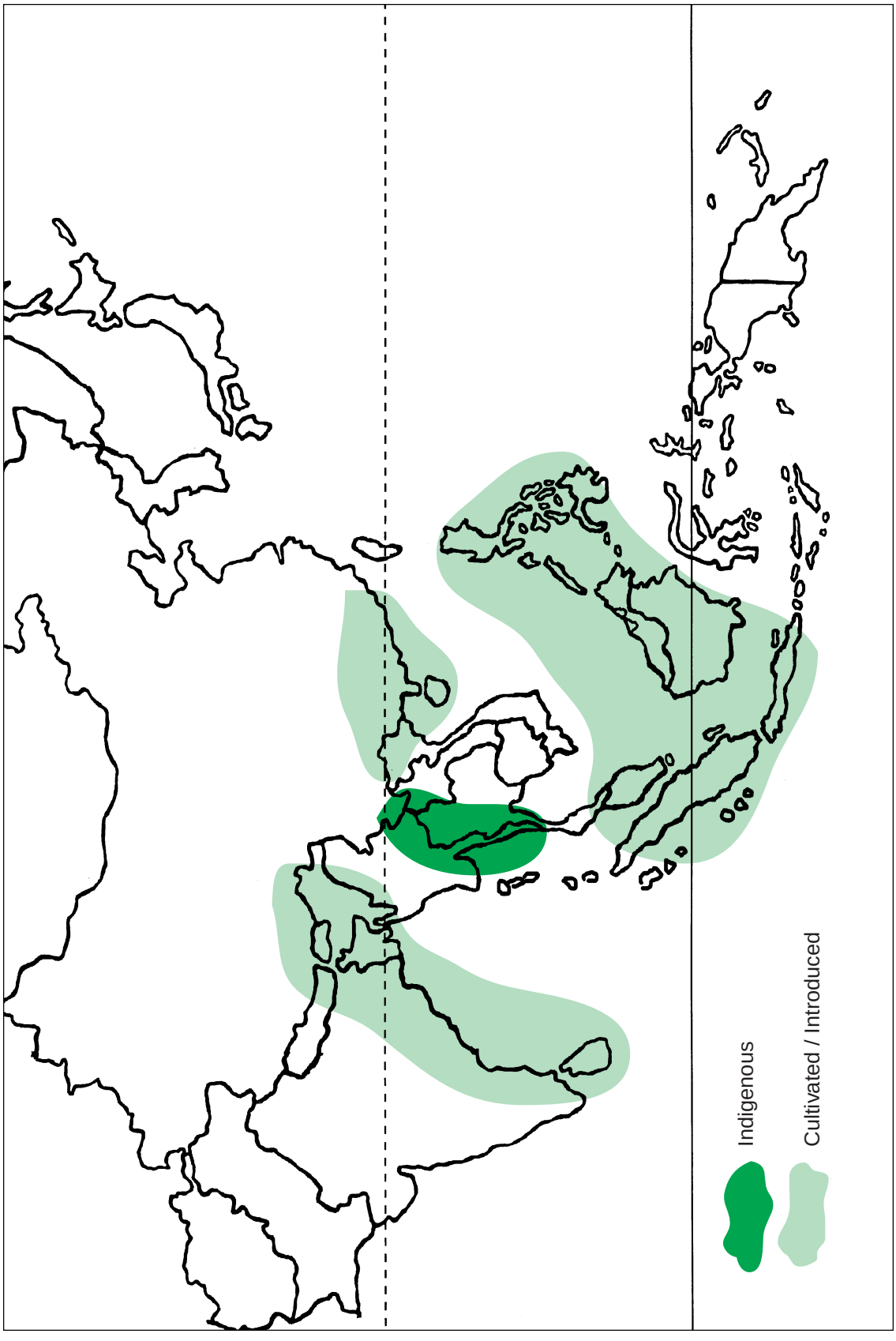


Fig. 11 *Dendrocalamus giganteus*

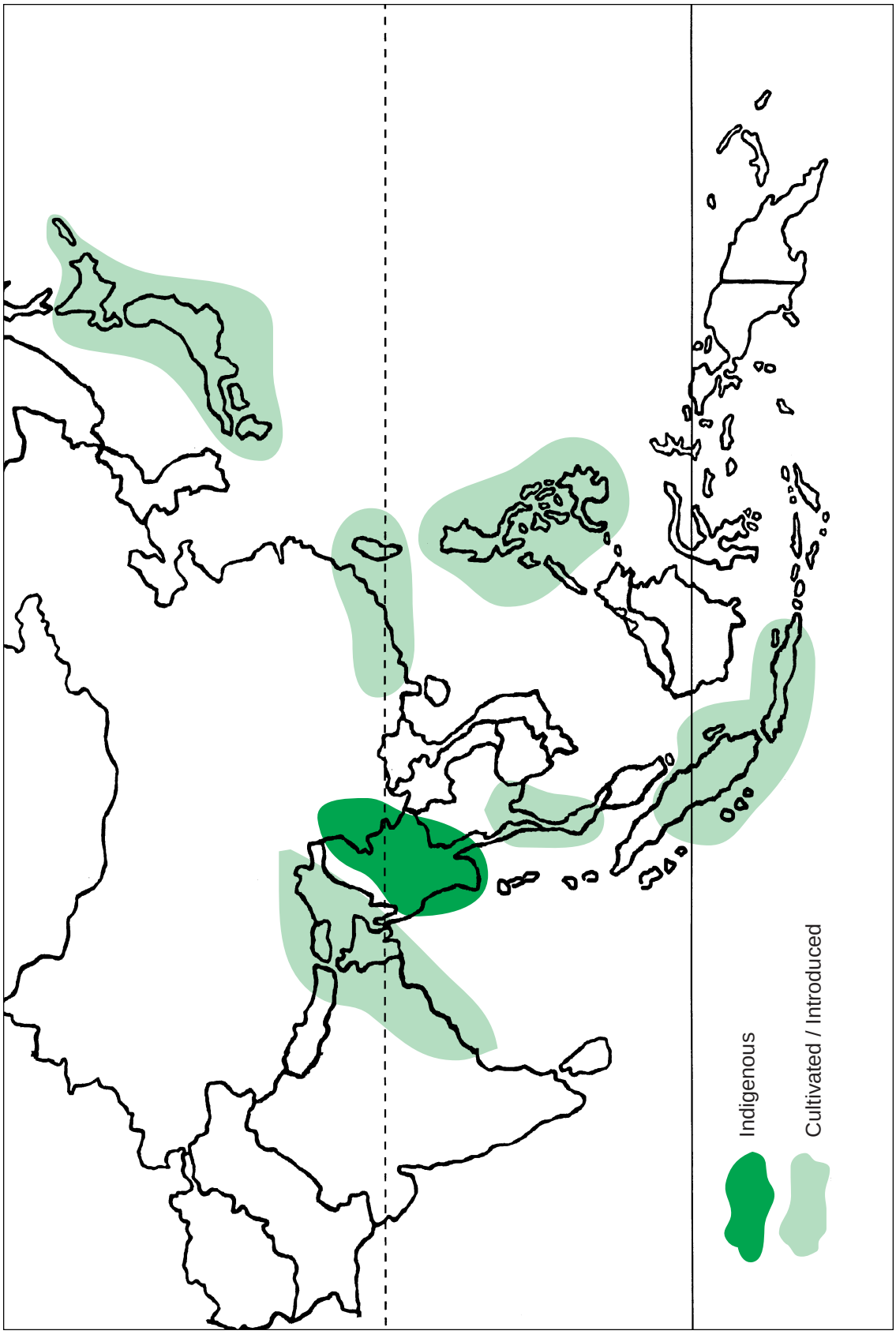


Fig. 12 *Dendrocalamus latiflorus*

chopsticks, crafts, basketry, construction, paper pulp, thatching and ornamental. Leaves used for cooking rice. Cultivars mei mung provides strong structural timber, suitable for good quality furniture and superior edible shoots.

RESEARH NEEDS:
1. Sylviculture
2. Conservation needs
3. Selection of superior clones and cultivar development.

Dendrocalamus strictus (= Bambos stricta)

Common Name: Male bamboo, solid bamboo

This is a medium-sized bamboo with culms about 8–20 m tall, internodes 30–45 cm long, 2.5–8 cm diameter, with thick walls, although slightly 'zig-zag', culms are strong; leaf lanceolate 25 x 3 cm; gregarious (20–40 years cycle) and sporadic flowering, inflorescence dense with globular heads, distinctly apart, hairy; fruit ovoid 7.5 mm long. Vegetative propagation – culm cutting, rhizome planting, layering, marcotting, macroproliferation of seedlings, *in vitro* propagation well known.

DISTRIBUTION: *D. strictus* is native to India, Nepal, Bangladesh, Myanmar and Thailand. Cultivated in many other countries of S E Asia (Fig. 13).

CLIMATE AND SOILS: This species is found naturally in pure or mixed forests in semi-arid or dry zones of the plains or hilly areas very productive up to 150–180 culms/clump; drought resistant, however, it adapts well when planted in humid tropical zones and subtropical regions, extends up to 1200 m, grows well on different soils with good water source and drainage, frost resistant, tolerates –5°C.

CURRENT RESEARCH: Work has been carried out on propagation (seed, vegetative, micro-propagation and mini-clump division); planting techniques, physical and chemical properties, forest management, use in reinforced concrete, suitability for reclamation of degraded lands, grows on variety of soils. Three varieties recognised – *D. strictus* var. *argentea*, var *proimiana*, var *sericeus*. Some information is available on floral biology and breeding behaviour of this species in India. Cytology 2n = 56, 70, 72, Hexaploid.

UNTAPPED POTENTIAL: More use is justified in agroforestry and in land reclamation, use of marginal, infertile soils.

CONSERVATION STATUS: Requires urgent attention. Germplasm collection in India. Tissue culture work done, varieties in each country to be identified and conserved.

USES: Structural timber, medium to light quality, edible shoots of poor quality. An important source for paper pulp, average quality furniture, but solid and thick walled, used also for making boards, agricultural implements and household utensils. Leaves are good as forage, edible shoots of poor quality.

RESEARCH NEEDS:
1. Genetic improvement and conservation of germplasm.
2. Genetic diversity evaluation.
3. Taxonomic status of varieties.
4. Development of cultivars.
5. Use on degraded areas.

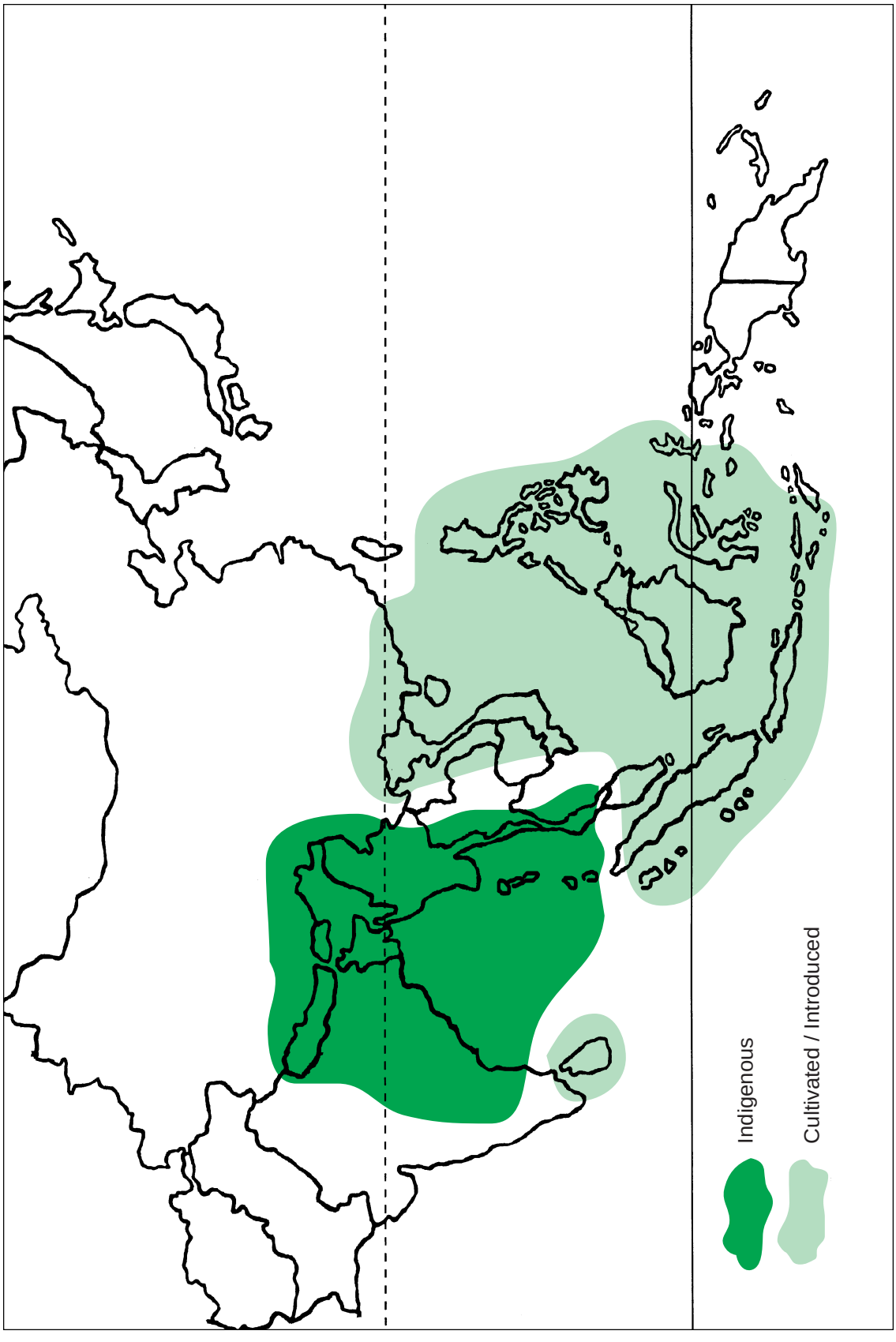


Fig. 13 *Dendrocalamus strictus*

Gigantochloa apus (= Bambusa apus, Gigantochloa kurzii)

Common Name: String bamboo, Pring tali

This is a good-sized bamboo, 8–30 m tall, 4–13 cm diameter, strongly tufted with internodes 36–45 cm, medium wall thickness 1.5 cm and very flexible. It is a multi-purpose bamboo. Leaf lanceolate, 13–49 x 2–9 cm; inflorescence long, spikelets arranged like stars, closely arranged, fruit 12 x 2 mm, glabrous with a furrow on one side. Vegetative propagation – culm cuttings.

DISTRIBUTION: It has been reported to be wild in Myanmar and Southern Thailand but is cultivated in Indonesia and in Malaysia (Peninsular and East); introduced to Meghalaya (Garo Hills) in India (Fig. 14).

CLIMATE AND SOILS: This is a species of rich soils of the humid tropics up to 1500 m above sea level, tolerates –2°C

CURRENT RESEARCH: Micropropagation through tissue culture done, and uses in bamboo board industry have been investigated, propagated by seed, rhizome and branch cutting. Cytology 2n=72

UNTAPPED POTENTIAL: It could be useful in agroforestry. It is also known to survive in drier areas (although growth is less) but needs more testing for specific adaptations and to various soils.

CONSERVATION STATUS: Genetic diversity is said to be low; most of the *ex situ* material in cultivation. The wild material has not been investigated, small germplasm collection in Sumatra.

USES: This species is used for building materials, structural timber of medium quality and for making furniture of both good and average quality, handicrafts, musical instruments, kitchen utensils and baskets. Shoots are edible, poor quality, bitter, buried in mud for 4–5 days before use to reduce the bitter taste.

RESEARCH NEEDS:
1. Studies on physical and chemical properties.
2. Improved management of stands.
3. Seed technology.
4. Provenance trails.
5. Genetic analysis.

Gigantochloa levis (= Bambusa levis, Gigantochloa scribneriana, Dendrocalamus curranii)

This is a large bamboo, culms are up to 30 m tall with diameter 5–16 cm and relatively thick walls 1–1.2 cm, internodes 45 cm long, leaf 8–35 x 7 cm; inflorescence long with many spikelets at each node, fruit set unknown. Vegetative propagation – culm cutting.

DISTRIBUTION: Origin unknown, cultivated in the Philippines, Eastern Indonesia, Northern and Western Kalimantan, East Malaysia, China and Vietnam (Fig. 15).

CLIMATE AND SOIL: *G. levis* is naturalized in humid tropical areas with rich soils, common in homesteads and village gardens in the Philippines.

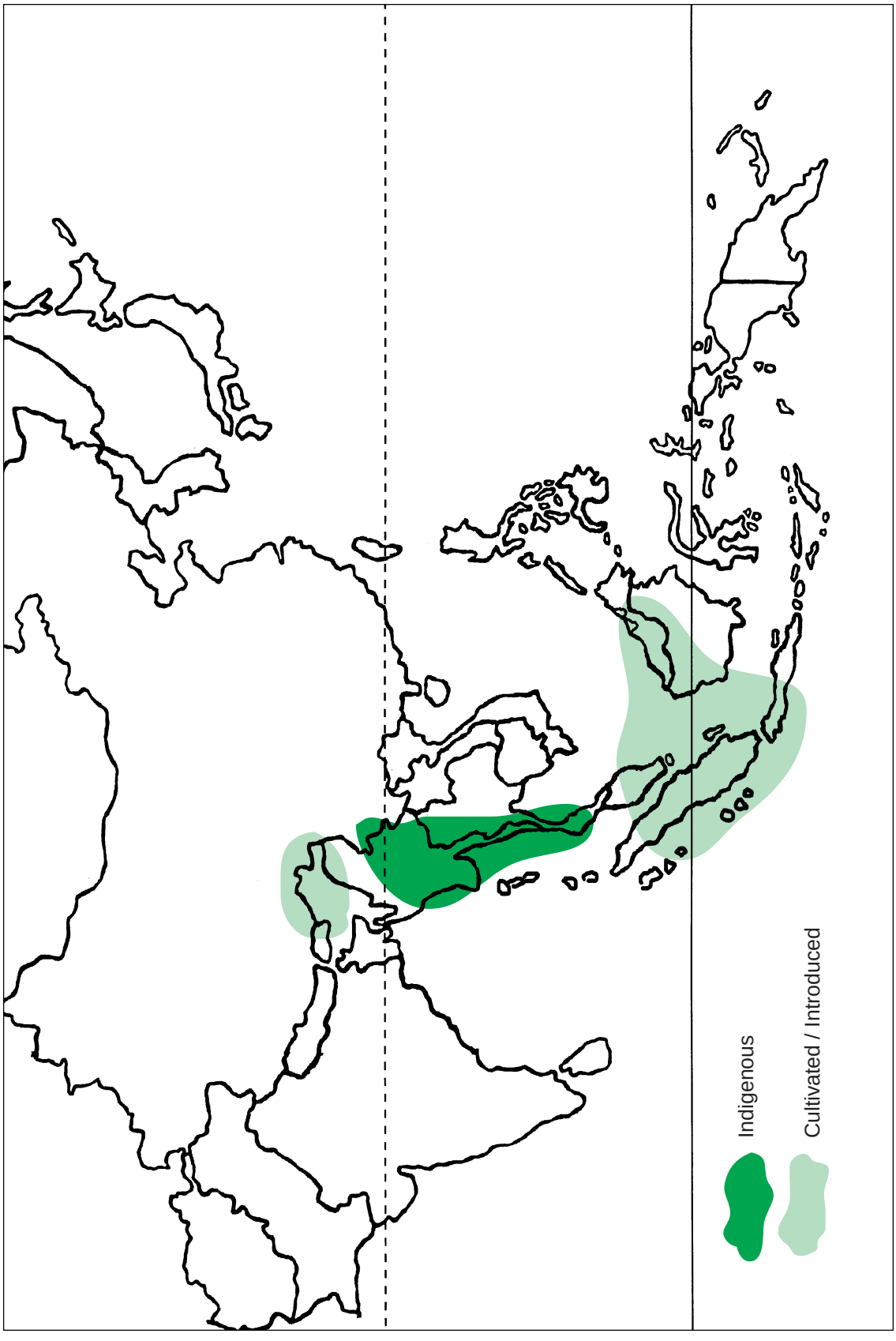


Fig. 14 *Gigantochloa apus*

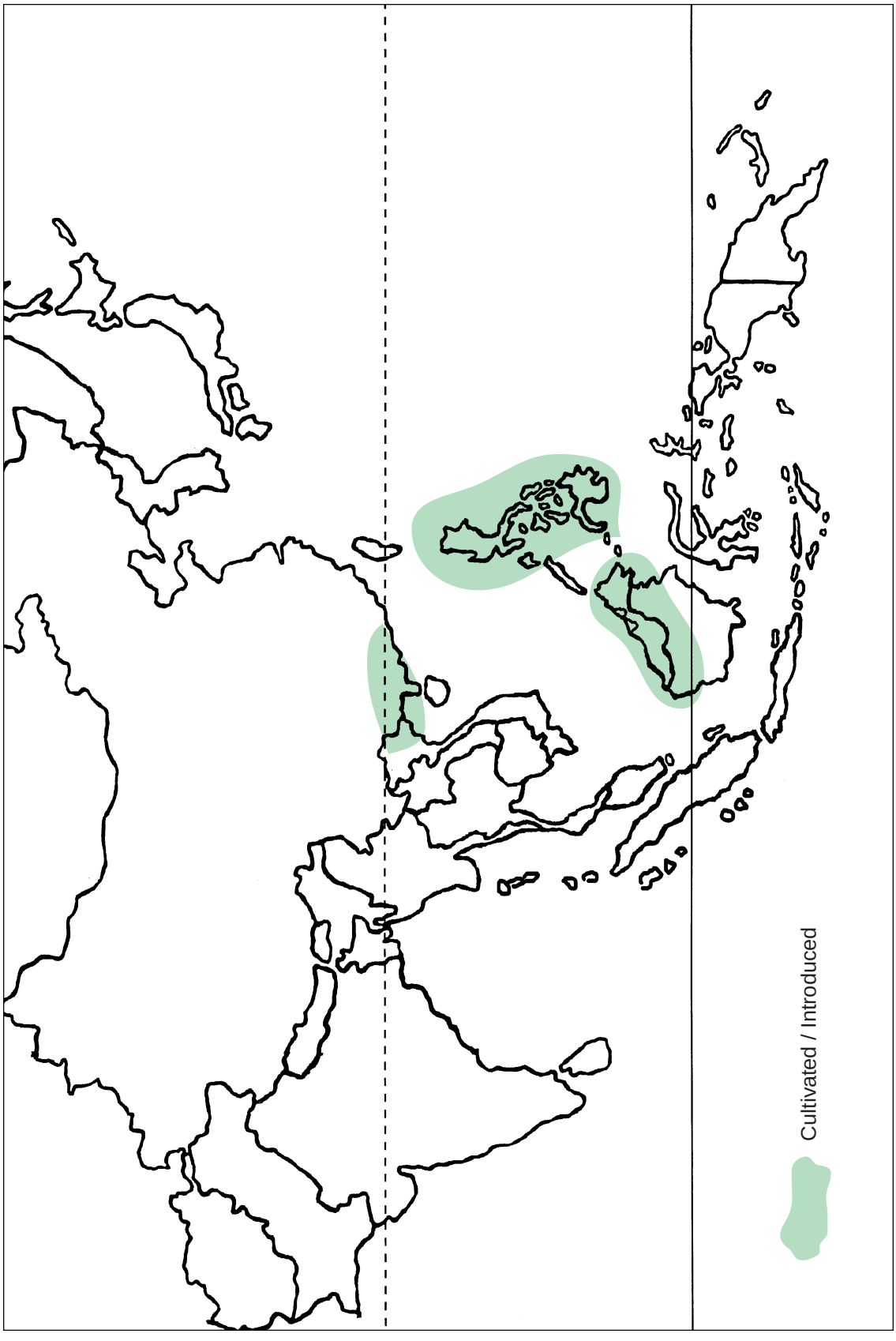


Fig. 15 *Gigantochloa levis*

CURRENT RESEARCH: Very little is known about growth requirements and need attention. Reproductive biology needs to be studied. Some information is available on the use of this species in rehabilitating denuded forest lands in the Philippines, tissue culture work in progress.

CONSERVATION STATUS: Very little information.

USES: Structural timber, strong superior quality, edible shoots of good quality, also used for making kitchen utensils of good quality, furniture, craft paper, water pipes, fencing and other uses.

RESEARCH NEEDS: Information required on all aspects especially propagation in tissue culture.

Gigantochloa pseudoarundinacea (=Bambusa pseudoarundinacea, B. verticillata, Gigantochloa verticillata, G. maxima)

This is a medium-sized bamboo 7–30 m tall, aerial roots on lower nodes, with internodes 35–45 cm, diameter 5–13 cm, medium to thick wall, 2cm thick and is very strong; leaf blade 25 x 5 cm; inflorescence 75 cm long, spikelets on nodes, seeds not known. Vegetative propagation – culm cuttings, branch cuttings.

DISTRIBUTION: Origin not known, said to be native of Java, found in cultivation in Sumatra and Java, introduced to India, and Peninsula Malaya, China and Vietnam (Fig. 16).

CLIMATE: Mainly grows in humid tropics but it can also grow in dry areas and up to 1200 m above sea level, sandy loam and alluvial soils, tolerates –2°C.

CURRENT RESEARCH: Work is underway to evaluate its suitability for bamboo board, manufacturing. Cytology 2n = 72

UNTAPPED POTENTIAL: Its value as processed building material can be exploited.

CONSERVATION STATUS: Requires attention. There are some germplasm collections in Bogor, Java and Lampung, Sumatra, Indonesia. Natural hybrids in Sumatra have been observed to produce seeds. Tissue culture work not done.

USES: Structural timber, building materials, medium quality, used as water pipes, for making handicrafts, furniture of very good quality, household articles, chopsticks, toothpicks, edible shoots of very good quality.

RESEARCH NEEDS:
1. Suitability in agroforestry
2. Floral biology and induction of seeding
3. Basic properties (physical, chemical, mechanical)
4. Provenance trials
5. Tissue culture

Gigantochloa sp. Var: Malay dwarf, var. malay dwarf variegated, both varieties from Malaysia, both perhaps closely related to *Bambusa heterostachya,* culms green to cream coloured, cultivated as ornamentals, good economic value. (Wong, 1995).

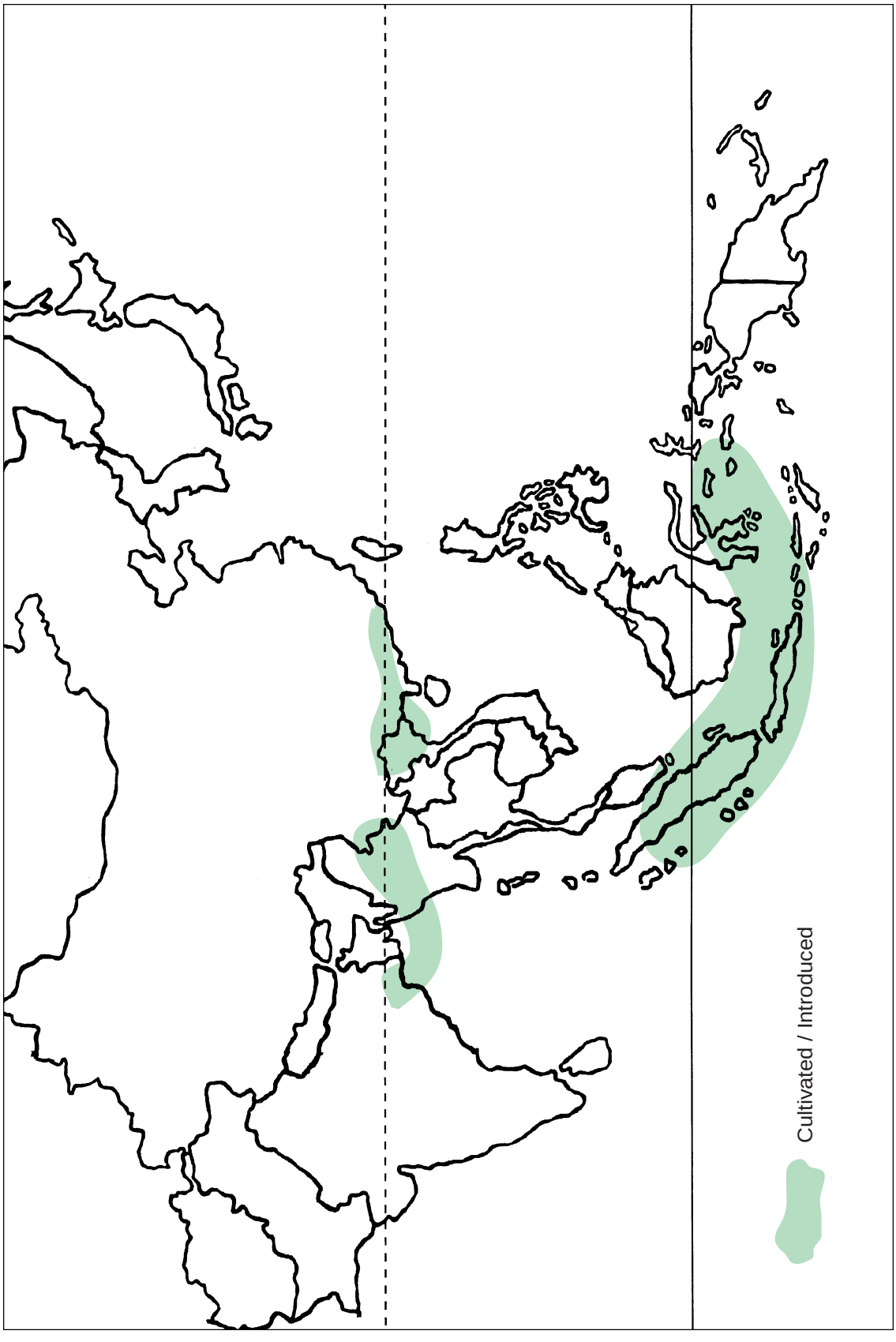


Fig. 16 *Gigantochloa pseudoarundinacea*

Guadua angustifolia

This is a large spectacular, sympodial bamboo with culms reaching 30 m, dark green colour, white bands at nodes, diameter up to 20 cm; leaves medium size. It is considered outstanding in stature, with superior mechanical properties and durability of culms. Plays an important role in rural economics and house or building construction.

DISTRIBUTION: Origin South America, well distributed and cultivated in Central and South America (Fig. 17). Introduced to many other countries.

CLIMATE AND SOILS: Grows on rich to medium soils, especially along rivers and on hilly ground, tolerates –2°C.

CURRENT RESEARCH: Present research efforts are limited to studies on culm preservation and determining the physical properties.

UNTAPPED POTENTIAL: Valuable on sloping lands, and for soil conservation

CONSERVATION STATUS: Unknown.

USES: Structural bamboo, large, strong, superior quality, it is a multipurpose bamboo. Though most extensively used as building material for low-cost housing or even for big buildings, it has many other uses in rural communities and is used for general purpose furniture making, handicrafts. Most popular bamboo in Central American countries; houses and large buildings built of this bamboo have withstood the shocks of earthquakes, and related factors. Commercial plantations are increasing.

RESEARCH NEEDS:
1. Survey of patterns of variation in natural populations and to generate more information on conservation status.
2. Sustainable management of natural stands.
3. Provenance trials.
4. Propagation technology
5. Use of young shoots.

Melocanna baccifera (= Bambusa baccifera)

Common name: Muli, berry bamboo

This is a medium-sized ever green bamboo, 10–20 m tall, clump open and diffuse and culms have relatively thin walls 0.5–1.2 cm, internode 20–50 cm long, diameter 5–7 cm, culm tips pendulous. Leaf blade lanceolate, 14–28 x 3–5 cm; inflorescence 15–45 cm long, compound panicle drooping, spikelets 1–1.5 cm long, stamens three, anthers yellow, elongated style with 2–4 lobes; fruits large 7.5 – 12.5 cm long, 5–7.5 cm broad, beak curved with thick fleshy pericarp; flowering interval 30–35, 45–48 and 60–65 years, both sporadic and gregarious flowering. Fruits fleshy viviparous, germinate easily producing seedlings, vegatative propagation: Culm cutting.

DISTRIBUTION: The species naturally growing throughout the hill forests of Bangladesh, Myanmar and North East (Assam, Arunachal, Meghalaya and eastern part of Tripura, Nagaland, Manipur, Mizoram) of India. The natural home of this bamboo is believed to be Chittagong Hill Tracts where this species grows gregariously covering large tracts of land. Also cultivated in south-eastern Terai part of Nepal and southern border of Bhutan, probably introduced from Bangladesh; occasionally cultivated or introduced and planted in many botanical and private gardens all over the world, including, Hong Kong, Indonesia, Taiwan and South America (Fig. 18).

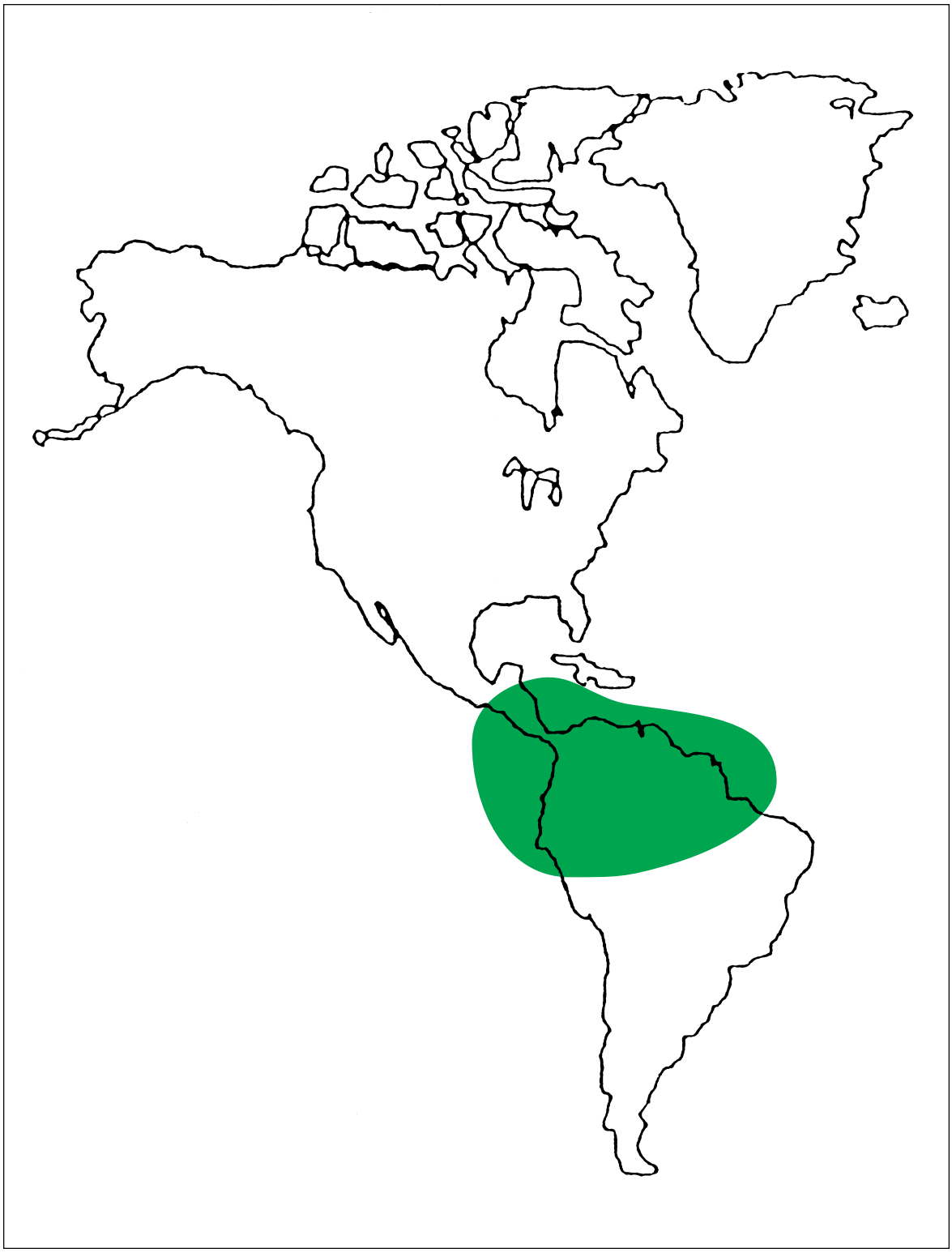


Fig. 17 *Guadua angustifolia*

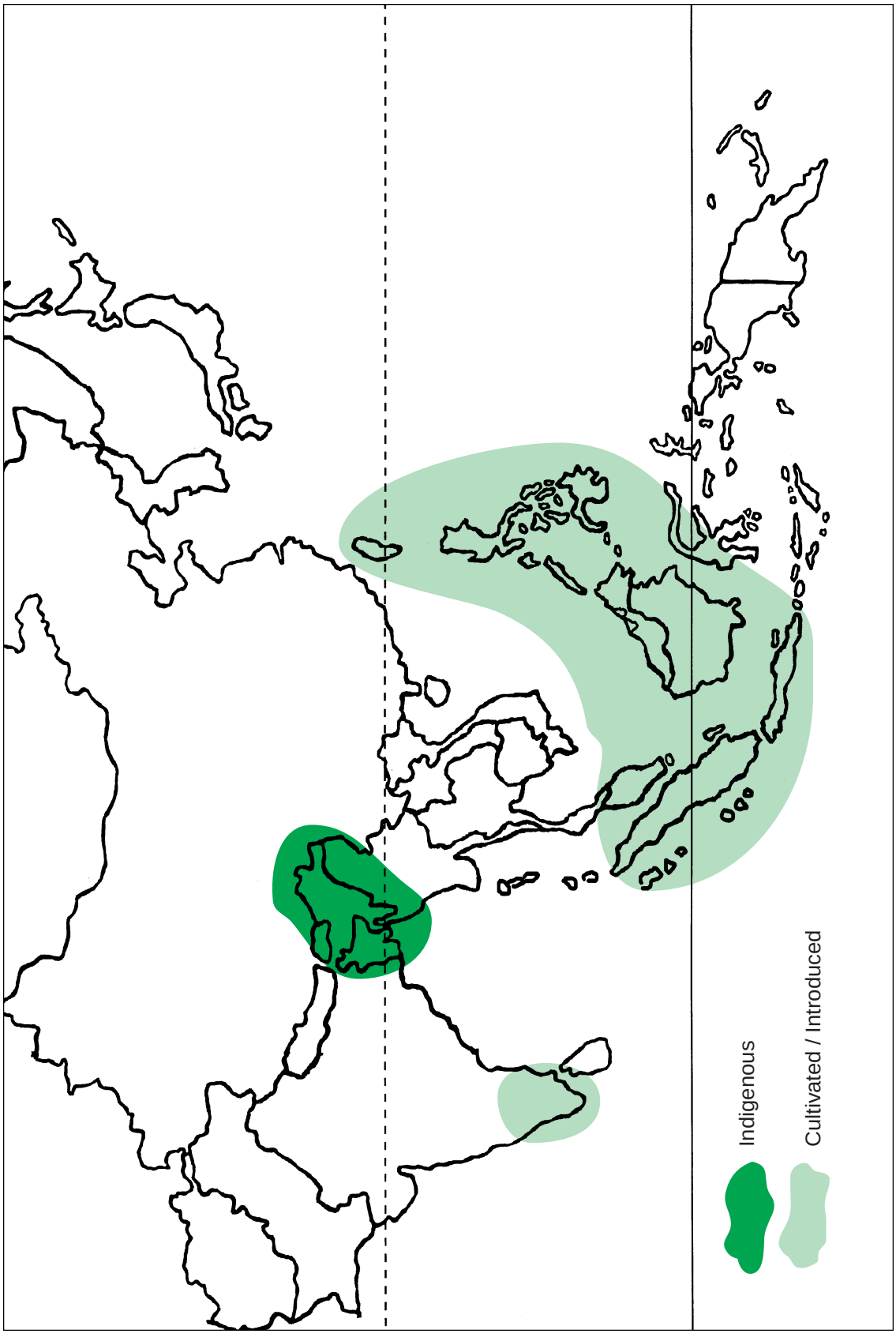


Fig. 18 *Melocanna baccifera*

CLIMATE AND SOILS: The species can grow on highly weathered deep clay soil to shallow, to very deep loamy soils with pH4.5–6.0 and rainfall 3000–5000 mm, with temperature range of 5–37°C, *Melocanna* occurs as an undergrowth to many tree species and also forms a pure stand by aggressive nature of its underground rhizome in areas after burning. The plant thrives satisfactorily on moist sandy, clay loam alluvial soils, on well drained residual soils, sandy rough slopes and the top of the hills. It indicates the wide adaptability and hardy nature of the species, good coloniser on lands cleared of forests.

CURRENT RESEARCH: Grows well under different conditions, has great potential, more research needed. Cytology 2n =72

CONSERVATION STATUS: Conservation work needed. The local ethnic people have been conserving them only in the settled forest areas. The species is still wild and not yet well domesticated.

USES: Plants naturally durable, much used for roofing, thatching, matting and in house construction. Thus great demand in cottage industries, pulp and paper and rayon mills. Young shoots are edible. All the ethnic people of Chittagong Hill Tracts use it as a tasty vegetable and also sell in the market, fruits fleshy and edible, leaves used for preparing liquor.

It is reported that in *M. baccifera* two types of clumps exist in nature, judged on the basis of emerging shoot characters. In one type, shoots possess a yellowish culm-sheath and are usually preferred as edible shoots. In the other, the sheaths are comparatively deep brown and not usually favoured as food due to their bitter and astringency taste. Selection of cultivars is needed.

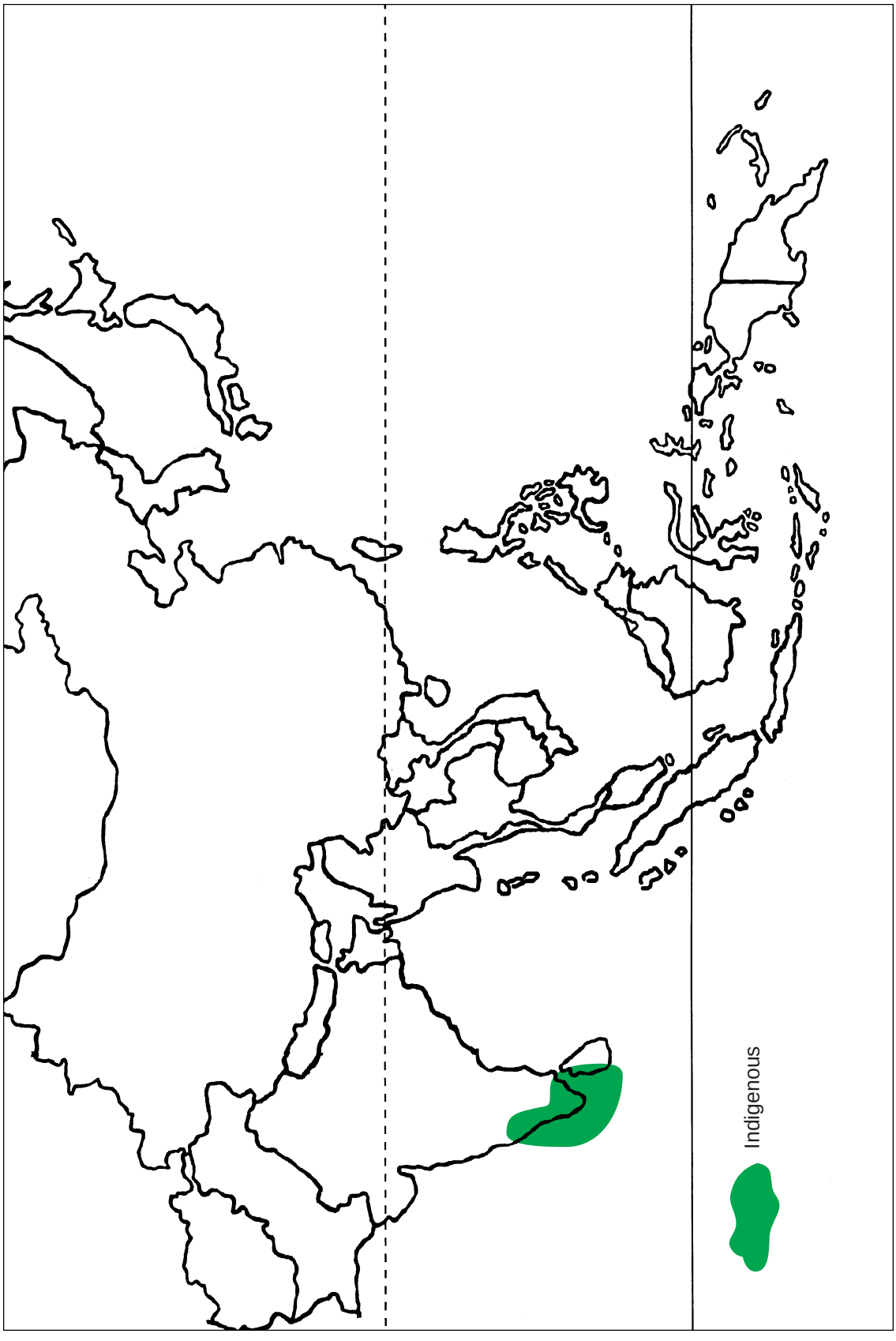
RESEARCH NEEDS:
1. Exploration and identification of different flowering populations existing in the region and the fruit types.
2. Identification of diversities and their conservation.
3. Selection and multiplication of elite types.
4. Identification of out-of-phase flowering "types" and their characterization.
5. Scientific management of vast areas of *Melocanna* forests for sustainable use.
6. Role in soil conservation on the hill slopes along with water resources management in the catchment areas.
7. Use on degraded areas.
8. Tissue culture for multiplication of new cultivars.

Ochlandra sps

Common name: Elephant grass

This genus includes about nine species and eight are endemic to Western Ghats of S India, shrubby, gregarious, reed-like bamboos, usually 5–10 m high and culms with 2–5 cm diameter and thin walls, leaves small to medium, oblong lanceolate, flowering gregarious and sporadic. Inflorescence long spicate panicle, stamens many, free filaments, ovary with long style, stigma 4–6, fruit large, ovoid, with long beak, pericarp thick fleshy. Important species include *O. beddomei* Gamble, *O. ebracteata* Raizada and Chatterji, *O. scriptoria* (Dennst.) C.E.C. Fischer, *O. setigera* Gamble, *O. stridula* Moon ex Thw, *O. talboti* Brandis and *O. travancorica* (Bedd.) Benth. ex Gamble, *var travancorica, var hirsuta.* (Seethalakshmi and Kumar 1998). Vegetative propagation: Culm cutting.

DISTRIBUTION: Western Ghats of South India and in the south west region of Sri Lanka, up to 1000 m, grows well with heavy rain fall (Fig. 19).



Fig, 19 *Ochlandra* spp.

CLIMATE AND SOILS: Species belonging to *Ochlandra* mostly occur in rich loamy soils especially along perennial or semi perennial streams, on sloping lands of India. Occurrence in the Western Ghats is also in evergreen and semi-evergreen forests up to 1500 m and in wet lowlands in Sri Lanka.

CURRENT RESEARCH: Some work is in progress on seed storage and sylvicultural aspects of a few species of this genus. Intensity of flowering, seed charecteristics, moisture content, seed longevity have been worked out, smallest fruits in *O. scriptoria* 640/Kg, largest in *O. travancorica* 40/kg, seed germination upto 75%, longevity up to 120 days *Och. travancorica* (Seethalakshmi, 1998). Cytology 2n = 72.

UPTAPPED POTENTIAL: There are excellent species in this group for binding soil which can be used to reclaim degraded land and for soil conservation.

CONSERVATION STATUS: Conservation programmes not yet organized whilst over-extraction continues.

USES: Mainly for pulp in the paper industry but used locally for house construction, most important for thatching and walling and handicrafts, most useful for local people for various household uses.

RESEARCH NEEDS:
1. Genetic improvement, superior plants.
2. Physical and mechanical properties.
3. Matching the species and varieties to specific soil conditions.
4. Tissue culture for propagation and plant improvement.

Phyllostachys pubescens (= P.heterocycla, var. pubescens, = Bambusa heterocycla, = P. edulis var. heterocycla (including P. bambusoides and P. edulis)

Phyllostachys is a large temperate, monopodial genus with about 70 recognized species, various species are extensively cultivated in China because of their many uses and economic importance; there are many taxonomic uncertainties in the limitation of various species. *P. pubescens* is changed to *P. heterocycla* with distinct variety *pubescens* (*P. heterocycla* var. *pubescens*).

Culm green, smooth, culm sheath brownish yellow, shoots edible, culms used as timber, cultivated including following varieties: *var castillonis, var. lacrima, var. mixta, var shoujhu yi*. This is a medium to large monopodial bamboo with culms 10–20 m tall and a diameter of ca 18 cm. Culms are straight, strong and suitable for heavy construction. Vegetative propagation: Culm cutting, layering, marcotting.

DISTRIBUTION: Native to China (Fig. 20). Extensively cultivated, in different provinces of China, Japan, Korea and Vietnam. Introduced to many Botanical gardens.

CLIMATE AND SOILS: This is a temperate species complex, planted on rich soil, also found as natural pure stands, suitable for many soil types.

CURRENT RESEARCH: A wide range of research is in progress, especially in China. Topics include distribution, site characteristics, sylviculture, agronomic pratices, *in vitro* culture, physico-mehanical properties of wood, industrial uses etc.

UNTAPPED POTENTIAL: Wider use in agroforestry and for use on degraded lands.

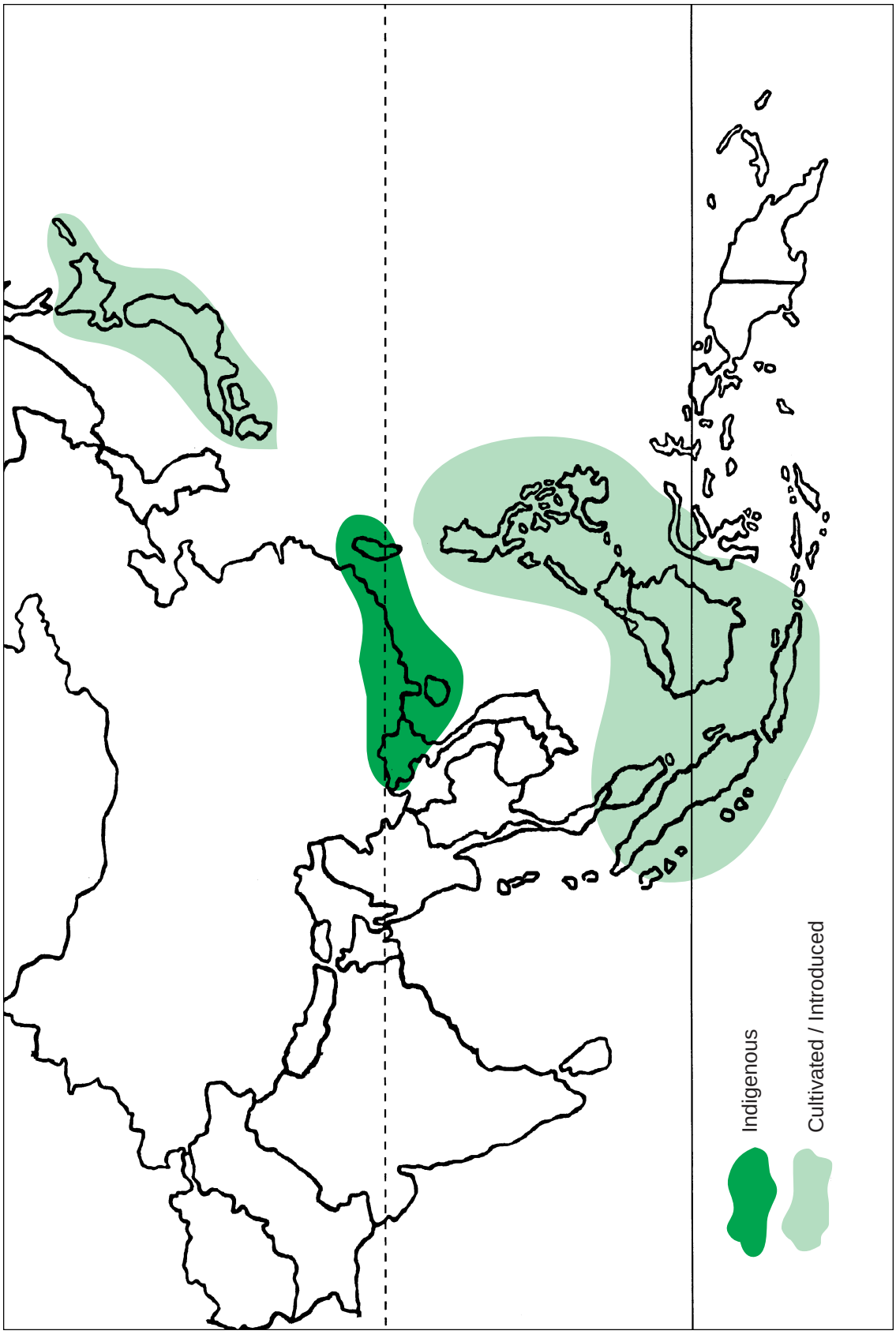


Fig. 20 *Phyllostachys pubescens*

CONSERVATION STATUS: Needs further investigation especially, population genetics and genetic diversity studies for the identification of genetically diverse populations.

USES: This species and different varieties are used as building material, for shoot production (especially in China), and for making agricultural and household implements, wood industry. Widely cultivated for shoots and timber in China, Japan and Korea.

RESEARCH NEEDS:
1. Selection of elite strains for use in industry, building material and for shoot production.
2. Exploration and determining conservation needs, matching the varieties with soil types.

Thyrsostachys siamensis (= Thyrsostachys regia, Bambusa regia)

Common name : Monastery bamboo, umbrella handle bamboo

Very graceful, tufted, sympodial bamboo, popular for cultivation, culms densely packed in clumps, culms 8–16 m tall, internodes 15–30 cm long, culm sheaths persistent, white ring below the nodes, leaf blade narrow, elegant 8–16 x 0.8–1 cm, pleasant light green, flowering sporadic, inflorescence long with many branchlets, fruits cylindrical, small, 5–2.5 mm, with long beak, sulcate on one side, gregarious, flowering interval up to 40 years. Seeds germinate well and seed viability extends up to 2–$2^1/_2$ years. Vegetative propagation: Culm cutting, macroproliferation of seedlings, off-set rhizome, tissue culture for propagation known.

DISTRIBUTION: From Myanmar through IndoChina (Fig. 21); introduced elsewhere, extensively cultivated in many countries in Asia.

CLIMATE AND SOILS: *T. siamensis* is found naturally in pure or mixed forests in dry areas with pronounced monsoonal climate. It adapts fairly well to humid areas of the tropics with rich soils, well adapted to poor soils also grows up to 400 m, tolerates –4°C.

CURRENT RESEARCH: Research on propagation, forest management, some work on seed storage are in progress.

UNTAPPED POTENTIAL: It is thought that selection of varieties for particular uses would not be difficult.

CONSERVATION STATUS: Needs investigation.

USES: Provides raw material for house construction, structural timber of light quality, pulp for paper, shoots for food, good quality, materials for handicrafts; thick walled bamboo for furniture, also used for fences and windbreaks and as an ornamental, planted as small clumps in gardens, look very elegant and graceful.

RESEARCH NEEDS:
1. Properties and preservation of culms, large scale cultivation
2. Sustainable management of forest stands.
3. Population genetics and conservation of superior germplasm.

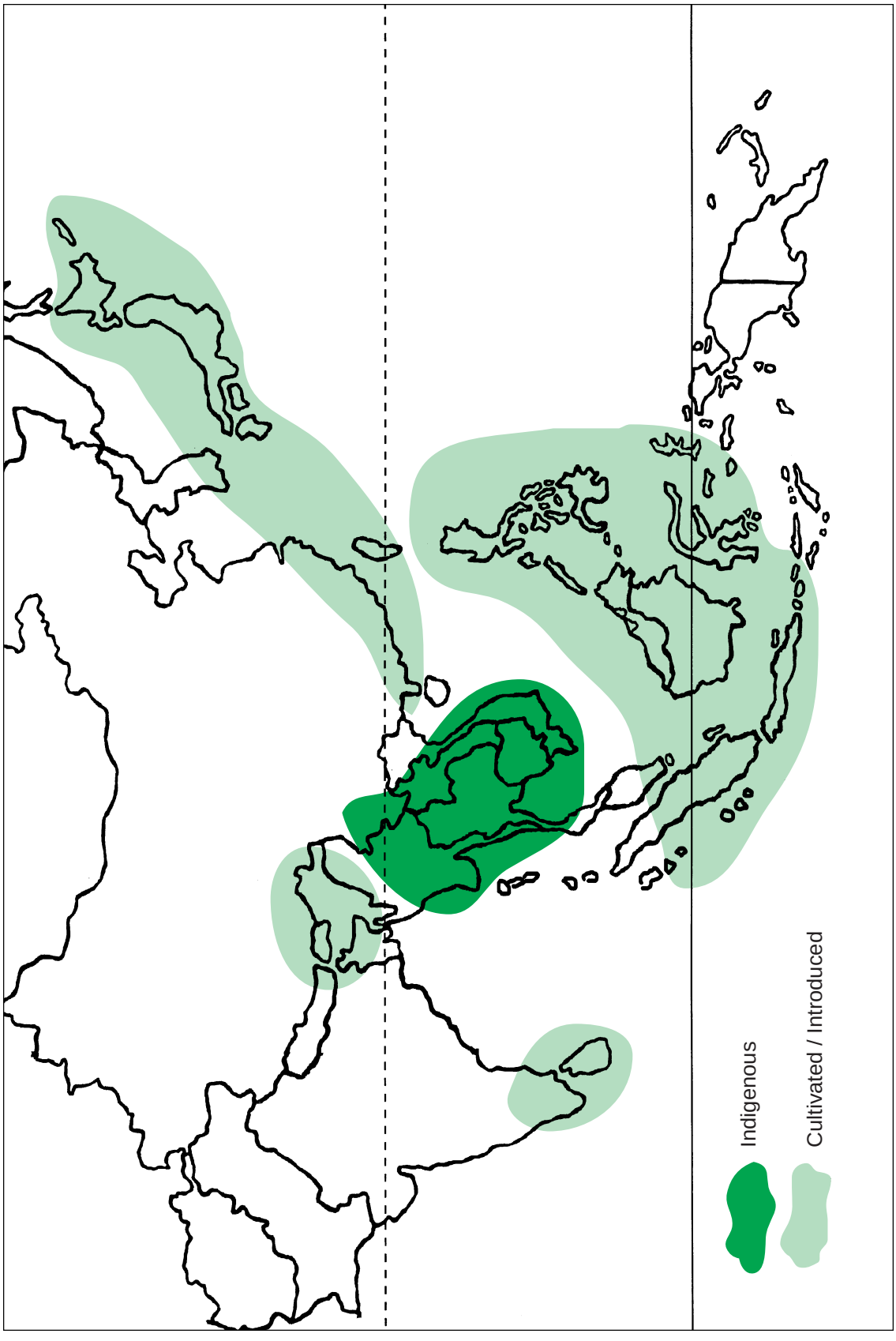


Fig. 21 *Thyrsostachys siamensis*

Additional species

As noted earlier, based on review and discussion with various partners in different countries, 18 additional taxa have been included with some level of priority within different countries of Asia. Table 3 gives some details on these 18 taxa.

Table 3. DistribuMtion and uses of additional taxa of bamboos. Short notes are given for various taxa

Taxa	Distribution	Major Uses
Arundinaria. Michaux	N.E. India, Sikkim, Nepal	Baskets, floor mats, fodder, thacthing
Bambusa atra Lindley	East Indonesia	Handicrafts, hedges, walls
B. heterostachya (Munro) Holttum	Malay Peninsula, all in cultivation; Indonesia	Handicrafts, poles
B. nutans Wall ex Munro	Nepal, India, Thailand, Bangladesh, Vietnam	Building construction
B. oldhamii Munro	China: South and Taiwan introduced to Indonesia and Philippines	Handicrafts, Construction, edible shoots, furniture
B. pervariabilis McClure	South China	Handicrafts, light construction, furniture
Lingnania chungii L.	Southern China to Northern Thailand, Vietnam	Handicrafts
Dendrocalamus brandisii (Munro) Kurz.	Southern China to Thailand	Building construction, handicrafts, edible shoots
D. hamiltonii Nees	India, Nepal, Bhutan, South China, Vietnam	Building construction, handicrafts, edible shoots.
D. hookeri Munro	India, Nepal	Building construction, handicrafts
D. membranaceus Munro	Thailand, Laos, Myanmar, China, Vietnam	Building, Bamboo board, furniture, paper pulp, shoots edible.
Gigantochloa albociliata (Munro) Kurz	India, Bangladesh, Thailand	Edible shoots, construction, furniture
G. atroviolacea, Widjaja	Indonesia	Furniture industry, handicrafts, building construction
G. balui K.M. Wong	Sabah, Sarawak, Brunei, Kalimantan	Building construction, handicrafts
G. hasskarliana (Kurz) Backer ex Heyne	South Thailand, Malay Peninsula, West Indonesia	Building construction, handicrafts, soil conservation
Oxytenanthera sp. THW	India, Vietnam, Ethiopia, African countries	Building construction, handicrafts, beverages, edible shoots
Phyllostachys glauca McClure	China, Japan, Vietnam	Edible shoots, chopsticks
Schizostachyum sps. Nees	South China, Vietnam, Thailand, Malaysia, India, Indonesia, Pacific Is, Bangladesh	Building construction, handicrafts, chopsticks, ornamentals.

Arundinaria spp.

The diversity and utilization of bamboo in the Himalayan region are very great. Substantial effort is needed to conserve them. Five species of *Arundinaria* namely *A. gracilis, A hirsuta, A. microphylla, A. racemosa* and *A. rolloana* are described from N E India; Nepal and Bhutan, *A. racemosa*, in Eastern Himalayas extends to 2200–3050 m, *A. falcata*, Western Himalayas to 1300 – 2200 m. They are all shrubby, gregarious, spreading bamboos, ± 3–5 m high, ± 1cm diameter, internodes 20–25 cm long, leaves ± 15 x 3 cm. Inflorescence is a panicle and some of them produce fruits that are ovoid oblong, 3–5 mm long. The plants provide biomass, used for many purposes; making household articles, mats, baskets, thatching materials, fencing, fodder for animals and others. They protect the soil on mountain slopes. Many of them grow on high mountains reaching 3000 m.

Bambusa atra (= B. farbesii, B. lineata, B. rumphiana, Dendrocalamus latifolius)

Native to eastern islands of Indonesia, up to New Guinea, including North Sulawesi, Moluccas, culms 8–10 m tall, 2–4 cm in diameter, thin wall, internodes 35–70 cm long; leaf blade lanceolate 50 x 8 cm; inflorescence terminal with many spikelets, fruits unknown. It is a lowland species growing well on hill slopes on wet soils and water margins. Used mostly for basketry and handicrafts, thatching, very well-suited to develop village industries, worth introduction to other countries for cultivation. The name of this taxa has been recently changed *Neololeba atra* (Widjaja 1997). This species was introduced to India a long time ago.

Bambusa heterostachya (= Gigantochloa heterostachya, Bambusa latispiculata)

Origin of this species unknown, only found in cultivation in Sabah, Peninsula Malaysia and Sumatera, Indonesia. Culms straight 8–16 m tall, 3–5 cm in diameter, with light green or white green stripes; wall 8–10 mm thick, internodes 30–80 cm long, nodes prominent; leaf blade lanceolate, 30 x 4 cm on average, inflorescence indeterminate with many spikelets, fruit cylindrical 5–6 mm long, hairy at apex. This species is recorded to flower regularly, well-adapted to lowland forest conditions, very useful for many purposes, such as poles for picking or collecting oil palm fruit bunches. Needs to be researched on cultivation and for adoption to different soil conditions and water regimes. Cultivation by seed and culm cutting.

Bambusa nutans

Commonly growing in the lower Himalayan region extending southwards to Bangladesh and Thailand. Important commercial species locally. Culms 5–15 m high, 5–10 cm diameter, straight, smooth and green, internodes 25–45 cm long; leaves linear lanceolate, 20 x 3 cm; inflorescence a panicle with many spikelets, fruit oblong and hairy. Flowering cycle 15–30 years both sporadic and gregarious, graceful bamboo with ornamental value, culms used in construction work and for paper pulp; furniture making, merits good exchange of materials and for wide cultivation.

Bambusa oldhamii (= Dendrocalamopsis oldhamii)

Origin S China, largely cultivated, fast growing species with erect culms, culm 8–12 m tall, young culms covered with white powdery substance, shoots edible of very good

quality, introduced to Australia and New Zealand, grown in orchards and as wind breakers, well used to the cold climate, Structural bamboo of medium quality, furniture making, extensively cultivated in China for shoot production.

Bambusa pervariabilis

Common Name: Punting pole bamboo

Origin S China, Guangdong province; culms straight 10–15 m tall, diameter 5–6 cm, internodes 20–45 cm long; thick walled, leaves ± 12 x 2 cm, lower surface covered with many bristles, flowers and fruits unknown or not described. It has many uses – farm tools, fishing rods, furniture, large poles, thatching and weaving.

Lingnania chungii (= Bambusa chungii)

Culms straight, upto 10 m tall, diameter 5 cm, internode pale yellowish, green, nodes swollen; leaves 7–21 x 1–2.8 cm, linear lanecolate. Mostly from S China, Guangdong and Guangxi provinces, medium sized bamboo, culms are extensively used for handicrafts, pulp for paper making.

Dendrocalamus brandisii (= Bambusa brandisii)

Mostly in South and N E India and Myanmar, introduced to S E Asia, cultivated, found in Yunnan, China on good soils, most localities, culms tall 20–34 m, 13–20 cm in diameter, internodes 30–40 cm long, thick walled, nodes swollen, lower nodes with many rootlets; leaves 25 x 5 cm, oblong lanceolate, hairy beneath; inflorescence huge panicle, with many spikelets on nodes, flowering gregariously, or sporadically, fruits ovoid 2–4 mm long, with many hairs at the tip. Superior bamboo for construction, baskets, furniture, handicrafts, shoots edible of very good quality; natural populations are rare, needs conservation efforts for germplasm collection. This is one of the largest bamboos like *Dendrocalamus giganteus.*

D. hamiltonii

N E India, Central and E Himalayas up to 1000 m, Myanmar, Thailand, Laos, Vietnam and Yunnan often cultivated, rich loams, moist places, culms tall and large, 15–20 m, 12–18 cm in diameter, internodes, 40–50 cm long, wall 1–2 cm thick; leaves variable in size 36 x 3.5 cm, rounded leaf base; inflorescence dense panicle especially at the tip, with purple spikelets, fruits ovoid, broad. Used for construction, baskets, handicrafts, household utensils, fuel, fodder, rafts and edible shoots. Easy to propagate and has great potential for cultivation. Some work on its introduction and establishment in East Africa has been carried out. Severe erosion of naturally distributed *D. hamiltonii* has been reported in Bangladesh.

Dendrocalamus hookerii

Distributed in N E India, Myanmar and Nepal, large bamboo 15–20 m high, 10–15 cm diameter, dark green, internodes 40–50 cm long; leaves large, oblong lanceolate; inflorescence large compound panicle, spikelets, compactly arranged at nodes, flowers variable in structure, fruits not known. Used in construction and for making baskets and household articles.

Dendrocalamus membranaceus

Native of Myanmar, distributed in N E India, Laos, Thailand, Vietnam and China, culms straight, 20–25 m high, 6–10 cm diameter, covered with white powdery material, nodes prominent with rings, basal nodes with rootlets, internodes up to 40 cm long, leaves 25 x 2.5 cm, hairy on midrib and beneath; inflorescence compound panicle, with distinct globular heads on nodal points, spikelets closely grouped, flower structure variable, fruit ovate, flat, 5–8 mm long, Flowering habit gregarious. Used for construction, medium quality, good quality furniture, paper pulp, chopsticks and handicrafts; the species has great potential for cultivation in plantations, edible shoots of very good quality.

Gigantochloa albociliata (= Oxytenanthera albociliata)

Supposedly introduced to N E India, Myanmar, Thailand, and other countries, especially W China. Densely tufted, evergreen or semi deciduous bamboo, culms 8–10 m high, 2–2.5 cm diameter, culms with grey or white stripes, internodes up to 40 cm long, walls 1–2 cm thick; leaves linear lanceolate, base rounded, 20 x 2.5 cm; inflorescence panicle, spreading, spikelets sparsely arranged, flower structure variable, fruit oblong, cylindrical, flowering habit sporadic. It has ornamental value, shoots edible, good quality, commercially cultivated, has great commercial potential, structural bamboo, medium quality, good for furniture making and edible shoots of good quality.

Gigantochloa atroviolacea (= Gigantochloa verticillata)

Common Name: Black Bamboo

Only known in cultivation, said to be a Javanese species, commonly cultivated, introduced to India more than 100 years ago. Culms 10–15 m high, 6–8 cm diameter internodes 40–50 cm long, wall thickness 8 mm, mature culms, dark brown, purplish, hence the common name black bamboo; leaf lanceolate, ± 25 x 4 cm, pubescent, white hairs when young; inflorenscence long with clustered spikelets, fruits unknown. Very popular to make musical instruments in Java, used to make handicrafts, furniture, also used in building construction and yields edible shoots.

Gigantochloa balui

Place of origin unknown, most probably Indo-China, but grows wild in Thailand, East Malaysia, Kalimantan and other places. Culms 10–12 m tall, diameter 5 cm, internodes 30–40 cm long, culms green with white and yellow stripes; leaves lanceolate ± 30 x 3 cm, inflorenscence on leafless branches, long with few spikelets in nodal regions, fruits unknown. Used in handicraft industry, basketery, culms for cooking, young shoots edible but not of very good quality. Germplasm collection needed, cultivation methods to be well established.

Gigantochloa hasskarliana (= Schizostachyum hasskarlianum)

Native and originates from Western Indonesia; introduced to botanic gardens in other countries, Malaysia, Thailand, Papua New Guinea. Culms 8–10 m tall, 3–6 cm in diameter wall thickness ± 1.2 cm, internodes 40–50 cm long; leaf lanceolate ± 30 x 4 cm, hairy on lower surface, inflorescence long with 4–6 clustered spikelets on each node, caryopsis, narrow cylindrical. Fast growing bamboo of humid tropics, grows up to 1500 m altitude, tolerates –2°C, easy to propagate by seeds and vegetative methods. Very suitable to grow in lowland forest areas, very suitbale for furniture making, useful for soil erosion control.

Oxytenanthera sps

Woody or climbing bamboos, mostly from the subtropical region of Asia and Africa. One species reported from tropical Africa *(Oxytenanthera abyssinica),* few from India *(O. abyssinica, O. stocksii,* (Karnataka, Maharashtra), *O. monostigma* (W.Ghtas), *(O. parvifolia* (N.E. India) *and O. alba, O. parvifolia* (Myanmar). (Liese 1998, Seethalakshami and Kumar 1998).

Culms 10–12 m long, 6–10 cm diameter, internodes 20 cm long; leaves ± 15 x 3 cm; long inflorenscences with many spikelets, caryopsis linear oblong 0.5–0.8 cm. Very useful bamboos, well used in handicrafts, cultivated to produce paper pulp, liquor extracted from young shoots. Flowering cycle 7–8 years, seeds unknown. Used in handicraft, basket making, poles. Research needs – rapid multiplication methods, development of a spineless variety.

Phyllostachys glauca

Mostly in South China, Japan, naturalized in Indonesia, culms 12–14 m, diameter 8–10 cm, culms dark green with black stains or patches, internodes 30–40 cm long; leaves pointed 12 x 3 cm; flowers and fruits details wanted. Edible shoots, used in handicrafts, farm tools, weaving, basketery and others. Like other monopodial bamboos of China, it is extensively cultivated in many places.

Schizostachyum spp

Schizostachyum is a large genus with about 30 species that are distributed in tropical and subtropical countries of Asia. Many of them are very useful, many cultivated to obtain the culms and foliage used for various purposes, ornamental bamboo.

Species reported in various countries are:

China – 9 species, *S. diffusum* is the tallest, culm height up to 40m, internode length 60 cm, others are of medium height 5–12 m; most of them are of ornamental value, others used in weaving, handicrafts, paper making. (Zhu Shi Linn 1993). The taxonomic identity of *S. diffusum* is uncertain (Dransfield 1998).

Indonesia and S E Asian countries – 9 species, *S. lumampao* (native of Philippines) *S. trachycladum, S. grande* and *S. zollingeri* are the tallest up to 20 m, other species range between 8–12 m in height. Most of them are used for construction, making household wares, umbrellas, small boxes, musical instruments, fishing rods, thatching, water containers, mats and baskets, handicrafts, props for banana plants, screens, containers to cook glutinuous rice, edible shoots (*S. grande*), planted for soil stabilisation, to control erosion and more commonly as ornamentals. The dark green or yellow culms with green stripes, persistent culm sheaths make them attractive as ornamental bamboos.

India – 14 species; some cultivated and plant materials used for various purposes as mentioned above

Bangladesh – *S. dullooa*, used for cottage industries.

S. brachycladum – S E Asia, culms 15 m x 5 cm, tolerates 3°C, gold yellow green striped, structural timber of medium quality, general purpose furniture, handicrafts, cooking, musical instruments, ornamental value; one cultivar 'green' recognized.

S. glaucifolium – 20 m x 5 cm, New Guinea, Pacific Is, Ivory green, striped, tolerates 4°C, ornamental Bamboo, most popular on seasides.

S. dumetorum – S E Asia, 8 m x 1 cm, tolerates 4°C, S E Asia, bushy bamboo, small diameter culms used to make ropes.

S. jaculans – S E Asia, 8 m x 3 m, tolerates 4°C, attractive garden bamboo, musical instruments and blow pipes.

S. zollingeri – S E Asia, 15 m x 6 cm, tolerates 3°C, densely clumping, shoots edible, average quality, beautiful bamboo with ornamental value.

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Part II

Notes on priority rattans

Calamus manan

C. manan is a robust single-stemmed rattan that produces the very best, most sought after cane for the furniture industry. It produces a strong durable cane of ca 20–80 mm diameter, of even texture, with good surface appearance; internode length can be as long as 40 cm. The mature plant can reach lengths long in excess of 100 m with leaves over 7 m long (including the whip-like cirrus). Altogether it is a massive plant. It is closely related to *C. tumidus* Furtado (smaller diameter, but traded usually mixed with *C. manan*). As currently understood, *C. giganteus* Becc. is synonymous with *C. manan*. However, recently *C. giganteus* var. *robustus* S.J. Pei & S.Y. Chen has been desrcibed from Yunnan. Whether this also is synonymous with *C. manan* (in which case this represents a major extension of its range) or represents a distinct species, has yet to be ascertained.

GEOGRAPHICAL DISTRIBUTION: In the strict sense, *C. manan* is found naturally in Sumatra, Peninsular Malaysia, Southern Thailand and South Kalimantan (Indonesian Borneo) (Fig. 22). *C. tumidus* is also distributed in Sumatra and Peninsular Malaysia.

CULTIVATION: There is a history of cultivation of this species for its fruits in South Kalimantan. Since 1975 it has been introduced into trials and commercial plantations in Sumatra, Java, Borneo and Peninsular Malaysia. It has also been tried in natural, logged over and man-made forests, and rubber plantations.

CLIMATE AND SOIL: The species is found in the wild in perhumid tropical areas between altitudes of 200-1000 m above sea level, usually on slopes on well-drained soils. However, in plantation, it has proved to be less demanding in its requirements and can be planted in the lowlands. However, it does not perform well on waterlogged soils.

CURRENT RESEARCH: *C. manan* has been the subject of intensive research on many aspects of its performance in trials and commercial sized plantations. Many aspects have been studied, ranging from taxonomy to growth rates, sex ratios, *in vitro* techniques, seed storage and ecophysiology. Some of the research results obtained recently from various workers that participated in EEC project are briefly summarised (Bacilieri 1998).

A large *ex situ* collection of *Calamus manan*, *C. Caesius, C. subinermis, C. ornatus* and *C. optimus* has been established in Luasong, Sabah spread over 69 ha. The project started in 1988 and more than 15,000 seedlings were used. In the observations made during 1992–1996 sex ratio of male and female plants was determined for C. manan. On an average about 875 plants were observed with 14% flowering in 1992 and 41% in 1996. Female to male plant ratio varied from 1:3.2 in 1992 to 1: 1.3 in 1996 indicating that ratio between the male and female plants was almost equal (Aloysius 1998).

In another study conducted, *Calamus manan* and *C. subinermis* showed considerable genetic diversity both at species and population levels. A geographic pattern of genetic diversity could be established in the two species. The plant populations of *C. manan* in Sabah were established from seeds collected and brought from Peninsular Malaysia and those in Kalimantan from Sumatra. *C. subinermis* is endemic to Sabah and the two populations in N.W. Sabah were genetically distinct from those in the east coast. The differences between the sub populations of *C. subernimis* were minimal (Bacilieri, 1998).

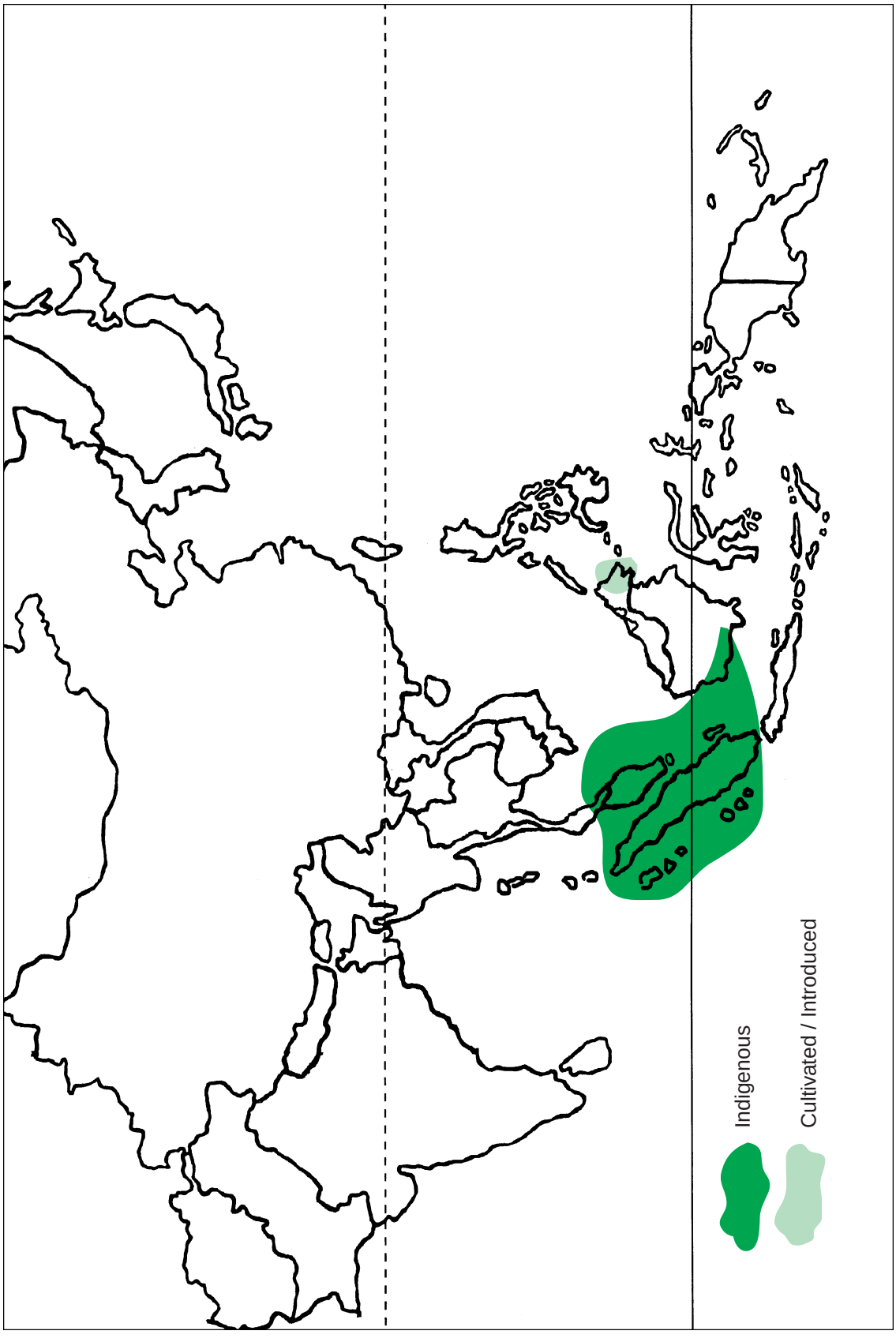

Fig. 22 *Calamus manan*

Abscision of flower buds was high reaching up to 95% in *C. manan* and *C. subinermis*. There was no gradient in pollen maturity among flowers on the same rachis. Pollen from unopened buds gave better percentage germination than at anthesis. Pollen viability could be well maintained by desiccating the unopened mature flower buds for 24 hours under vacuum and storing them at –18°C in vacuum sealed glass vials. Storing with this treatment, pollen remained viable for more than one year covering two flowering seasons. The results obtained would help the process of artificial pollination (Bacilieri 1998).

Pollen morphology of *Calamus caesius, C. manan, C. optimus, C. ornatus, C.palustris, C. scipiomum, C. subinermis, C. trachycoleus,* and *C. tumidus* was studied using voucher specimens deposited in Royal Botanic Gardens, Kew and Forest Research Centre, Sabah. Pollen in all the species are disulcate but the wall thickness and features of exine pattern vary (Harley 1998).

In vitro propagation methods to obtain plantlets have been well established for *Calamus manan*, *C. merrillii* and *C. subinermis*. Ms medium was used supplemented with growth regulators. Explants were obtained from seedlings obtained under in vitro or from seedlings raised in the nursery. Root explants of *C. manan* and *C. subinermis,* zygotic embryos and young leaves of *C. merrilii* responded well giving rise to *callus* that differentiated into somatic embryos. Tissues of *C. merrillii* were more responsive than of the other two species (Goh, 1998).

Genetic Assessment of Rattan Species – *Calamus manan, C. caesius* and *C. palustris*: Work on the genetic assessment of rattan species was completed, a research project undertaken in Forest Research Insttitute (FRIM), Kepong Malaysia and supported by IPGRI-APO. Seeds of eleven mother plants from each species were collected based on the availability of fruits. Leaf samples of mother plants and male plants were also collected; 11 and 17 for *C. manan*, 11 and 30 for *C. caesius*, 21 and 58 for *C. palustris*. About 30 seeds from each mother tree of *C. manan* (Bukit Lagong, FRIM and Sg. Yu, Pahang), *C. caesius* (Bukit Soga and Sg. Buluh) and *C. palustris* (Gopeng , Bukit Larik and Merapoh) were transferred to polybags. Isozyme analysis were carried out for *C. manan* mature plants (12 loci representing 9 enzyme systems) and seedlings (14 loci representing 10 enzyme systems), for *C. palustris* mature plants (8 loci representing 8 enzyme systems). The genetic variability measures (A, P, H_o and H_e) for *C. palustris* were generally very much higher than that for *C. manan* mature plants and seedlings, The final report is under preparation (Salwana, *et al*. 1996).

CONSERVATION STATUS: The species has been severely overexploited to the extent that is now in very short supply and other large diameter species of poorer quality are collected and traded as substitutes.

USES: This is the preferred large diameter cane for all furniture frame manufacturing.

RESEARCH NEEDS:

a) Further studies on the establishment of provenance trials for the selection of elite strains.
b) Breeding with related species, to introduce novel traits such as regular clustering behaviour.
c) Establishment and management of *ex situ* stands.

Calamus caesius

C. caesius is a densely clump forming, small diameter rattan that produces one of the very best canes of 7–12 mm diameter. The canes are resilient and durable and have a glossy siliceous surface that is sometimes intentionally removed during processing to make the cane more flexible. Stems may reach 100 m or more in length and growth rates of 4–5 m/year, exceptionally to 7 m or more, have been recorded. Clump establishment is rapid and after five or six years, there may be over 20–50 or more aerial stems depending on growing conditions and provenance. It is closely related to *C. trachycoleus* with similar diameter and the larger *C. optimus* Becc. (endemic to Borneo).

GEOGRAPHICAL DISTRIBUTION: This is a widely dispersed species occurring in the wild in Southern Thailand, Peninsular Malaysia, Sumatra, Borneo and Palawan (Philippines) (Fig. 23).

CULTIVATION: There is a long history of sporadic small-scale cultivation of this species in Borneo. In one system, it is planted in the fallow period of the shifting cultivation cycle, and harvested when the forest is felled again for rice-planting. Since the late 1970s, commercial rattan plantations have been established using this species.

CLIMATE AND SOILS: The natural distribution suggests that *C. caesius* is adapted to perhumid tropical climates. Attempts to cultivate it outside such climates have been disappointing. In Borneo, the species occurs from lowlands up to an elevation of 900 m; elsewhere it is confined to low elevations. Although found on a variety of soils, it performs best on rich alluvial soil.

CURRENT RESEARCH: *Calamus caesius* has been the subject of much research on growth, yields, pests and diseases. Cultivation of this species is better understood than any other, though much needs to be done. High heritability of characters was recorded in *C. caesius* including growth rate of the cane and number of stems formed per clump. (Bacilieri 1998).

Two types of suckers were produced in *C. caesius*, one with lanceolate leaflets and the other with vestigial leaflets. There was no correlation between canopy opening and the number or kind of suckers produced (Lee 1998).

Experiments were conducted using agar-water medium, to germinate rattan seeds under light and dark conditions. Seeds of *Calamus caesius, C. densiflorus, C. manan, C. nanodendron, Daemonorops longipes, D. periacantha* germinated in less than 10 days at 26°C with 12 hours light (12 hour photo period). Seeds of *C. palustris, C. paspalanthus, C. subinermis* and *C. tumidus* germinated after more than 30 days under same conditions (Pritchard and Davis 1998).

UNTAPPED POTENTIAL: The major untapped potential of this species is as a smallholder crop. It has been grown on this scale but there is great potential for expansion of smallholder cultivation, especially in village orchards, marginal lands and buffer zones.

CONSERVATION STATUS: Wherever the species occurs in the wild, it is harvested, often before flowering and fruiting can take place. This presents a great danger for its conservation.

USES: Wherever it occurs, *C. caesius* is regarded as the very finest small diameter cane for both commercial purposes (matting, chair cane, binding for furniture and furniture construction) and local handicrafts (especially high quality traditional basket making).

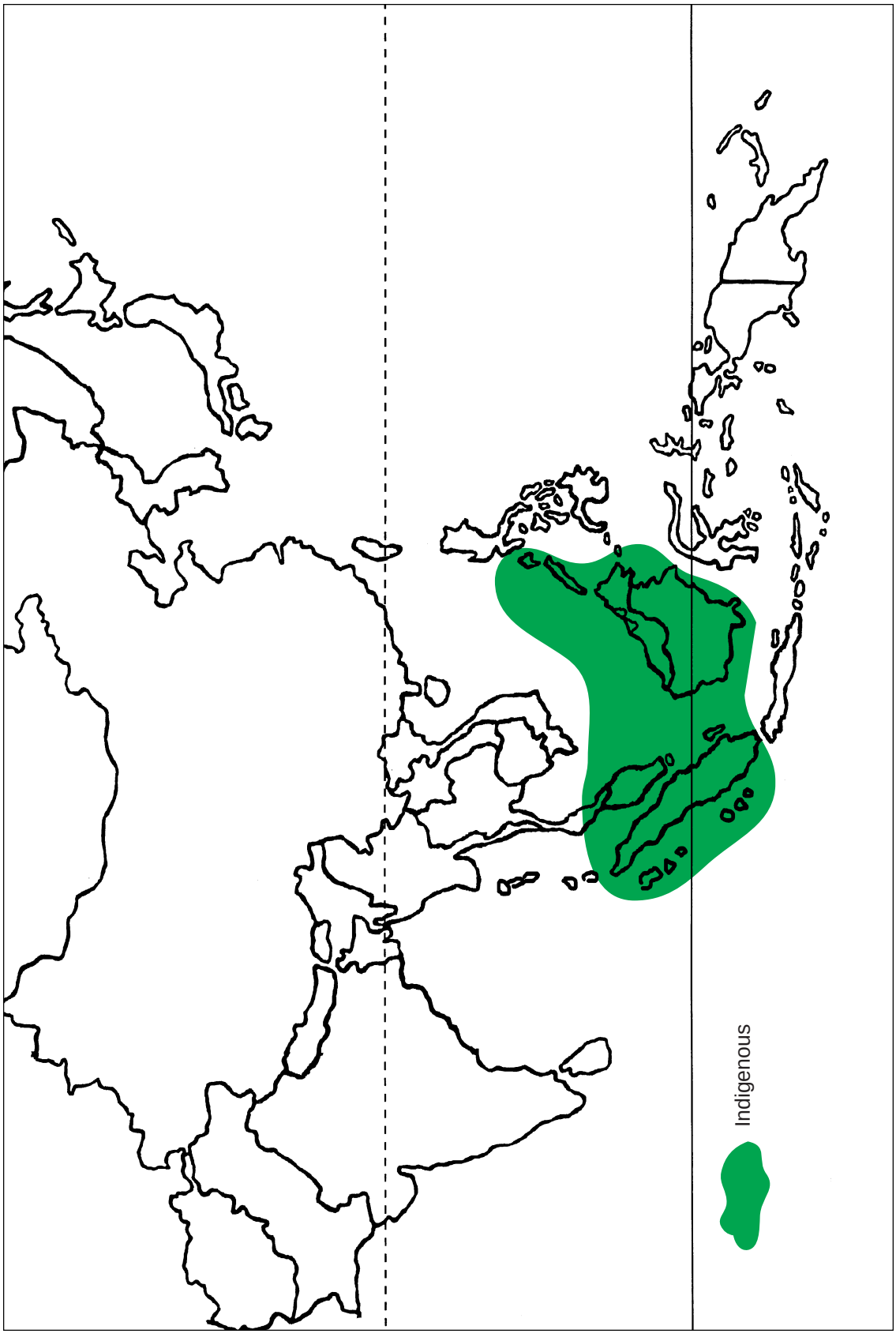

Fig. 23 *Calamus caesius*

RESEARCH NEEDS: The major research need is the collection of provenances to sample the known wide variation in size, quality and apparent ecological requirements. In particular, there is great variation in Borneo, some provenances appearing to be especially vigorous in plantations. *Calamus optimus* Becc., closely related but larger in diameter, should be included in such sampling of provenances. Although much has been achieved in understanding cultivation requirements, much remains unknown, especially at the level of basic biology and maximum growth requirements, further survey and establishment and management of *ex situ* stands need urgent attention.

Calamus trachycoleus

C. trachycoleus is a vigorous rapidly-growing, small diameter rattan that produces one of the best canes of 7–12 mm diameter. The canes are resilient and durable, of a quality only slightly poorer than very best species, *C. caesius*. The outer surface of the cane is glossy and siliceous; this surface silica layer is often removed before the cane is utilized. The species is unusual in its clumping behaviour; clumps develop by the production of long (to 3 m or more) stolons that metamorphose into aerial stems, while at the same time producing more stolons. Growth rates of aerial stems can be very rapid (up to 7 m a year). This growth form and rapid growth rate allow this species to colonize areas rapidly where it is cultivated, but also makes it rather difficult to control in plantations.

GEOGRAPHICAL DISTRIBUTION: The species is confined to the Barito Selatan area of central Kalimantan, Indonesia (Fig. 24). However, it has now been introduced into several parts of Indonesia and Malaysia.

CULTIVATION: *C. trachycoleus* has been cultivated for over 100 years on a large scale by villagers in Barito Selatan, as their main source of income. This clearly successful cultivation system has been used as a model for the setting up of smallholder and commercial plantations elsewhere and there are now new commercial estates of this species in Indonesia and Malaysia.

CLIMATE AND SOILS: The species has performed best in perhumid tropical areas at low elevations. A remarkable feature is its ability to withstand severe and prolonged seasonal flooding (1–1.5 m for up to 2 months) with little damage. In its original area of cultivation it occurs on seasonally flooded alluvial flats on soil overlying highly acidic clay, soils that are not suitable for permanent agriculture. *C. trachycoleus* cannot, however, grow well in waterlogged soils.

CURRENT RESEARCH: Very little research is being conducted at present on this species. Growth studies in plantation in Sabah and trials on different soil types in Malaysia are being performed. The species gives the impression of being remarkably invariable but this needs to be explored further.

UNTAPPED POTENTIAL: At present, expanded cultivation of this species is on a commercial scale. There is great potential for the promotion of cultivation of this species on a smallholder basis, outside the present area of smallholder cultivation.

CONSERVATION STATUS: At present, there appears to be no serious conservation problem.

USES: The primary use of this species is as split cane for weaving into matting, chair cane and handicrafts. For some weaving purposes it may even be preferred over *C. caesius* because the stem is softer and more supple.

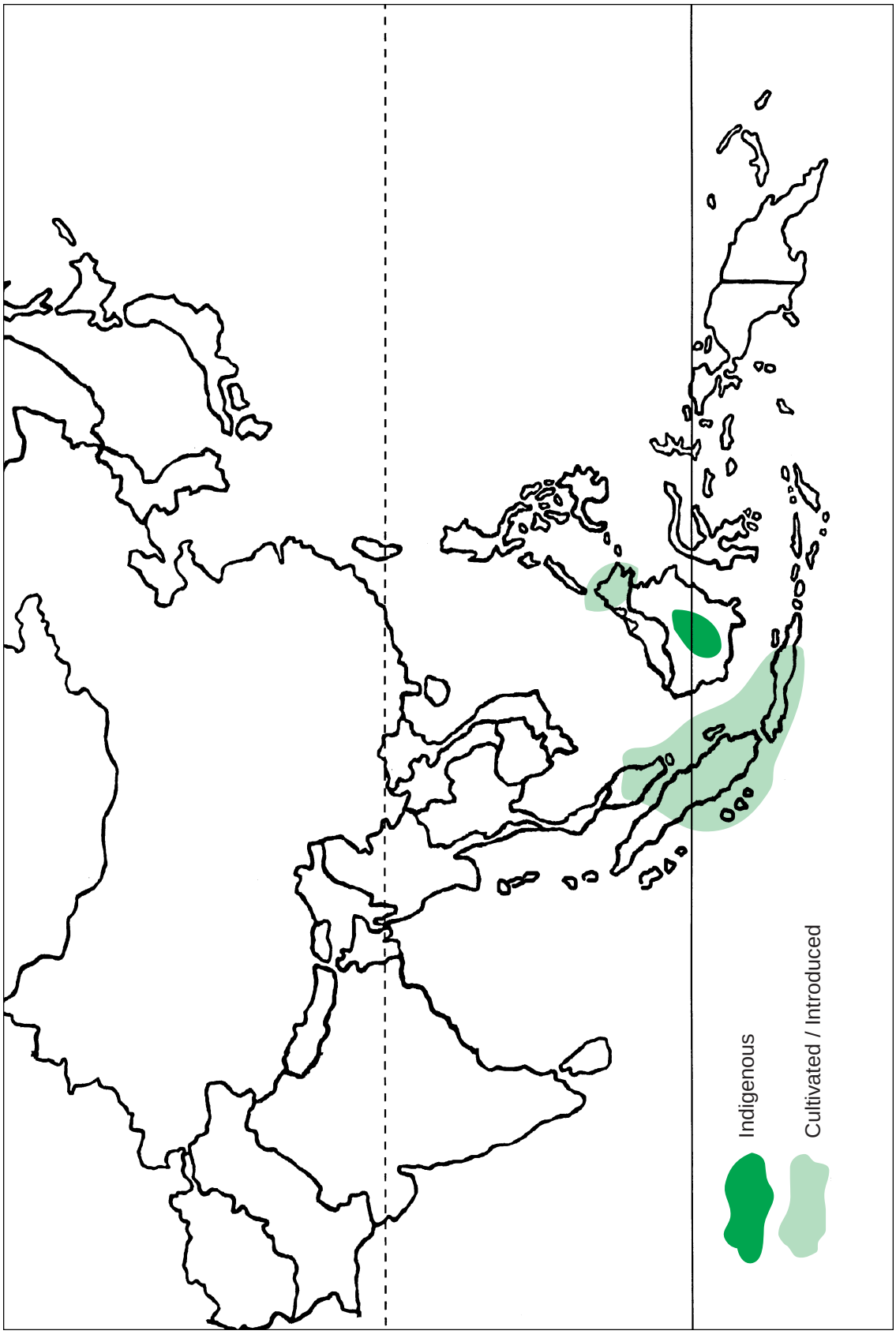

Fig. 24 *Calamus trachycoleus*

RESEARCH NEEDS: Because of the very invasive behaviour of the species, cultivation in neat rows is impossible to maintain and this presents problems for harvesting and commercial estate management. Research is required to develop efficient management and harvesting methods. In view of the close relationship with *C. caesius*, there may be prospects for interbreeding to allow selection of forms combining the growth form and flood tolerance of *C. trachycoleus* with the larger internode length and higher quality of *C. caesius*. Further assessment is needed to understand the variations in populations. Both survey and genetic diversity studies are required to establish provenances.

Calamus Sect. *Podocephalus*

This is a well defined group of very closely related species of medium to large rattans that occurs from the Indian subcontinent to New Guinea (Fig. 25). The group includes about 11 named species and several that have been recognized as being undescribed and have been assigned manuscript names by Fernando who is preparing a monograph on this group.

GEOGRAPHICAL DISTRIBUTION: Taxa recognized so far in this complex and their distribution is given below (Fig. 25):

Calamus "ahliduri" Fernando (in ed.) – Indonesia (Sulawesi)

C. andamanicus Kurz – Andaman, Nicobar Islands

C. burckianus Becc. – Java and Bali

C. erinaceus (Becc.) J. Dransf. – Thailand, Sumatra, Malay Peninsula, Borneo, Palawan

C. erinaceus (Becc.) J. Dransf. var. "declivium" Fernando (in ed.) – Palawan

C. foxworthyi Becc. – Palawan, Philippines

C. merrillii Becc. – Philippines (widespread)

C. nagbettai Fernandez & Dey – Karnataka, W. Ghats, India

C. ovoideus Thw. Ex Trimen – Sri Lanka

C. "parutan" Fernando (in ed.) – Bali

C. polystachys Becc. – Sumatra, Java, Malay Peninsula

C. warburgii Becc. – Irian Jaya, Papua New Guinea

C. zeylanicus Becc. – Sri Lanka

C. "zieckii" Fernando – New Guinea

C. zollingeri Becc. – Sulawesi

More derails about various species listed above are as follows : (see Dransfield and Manokaran 1993).

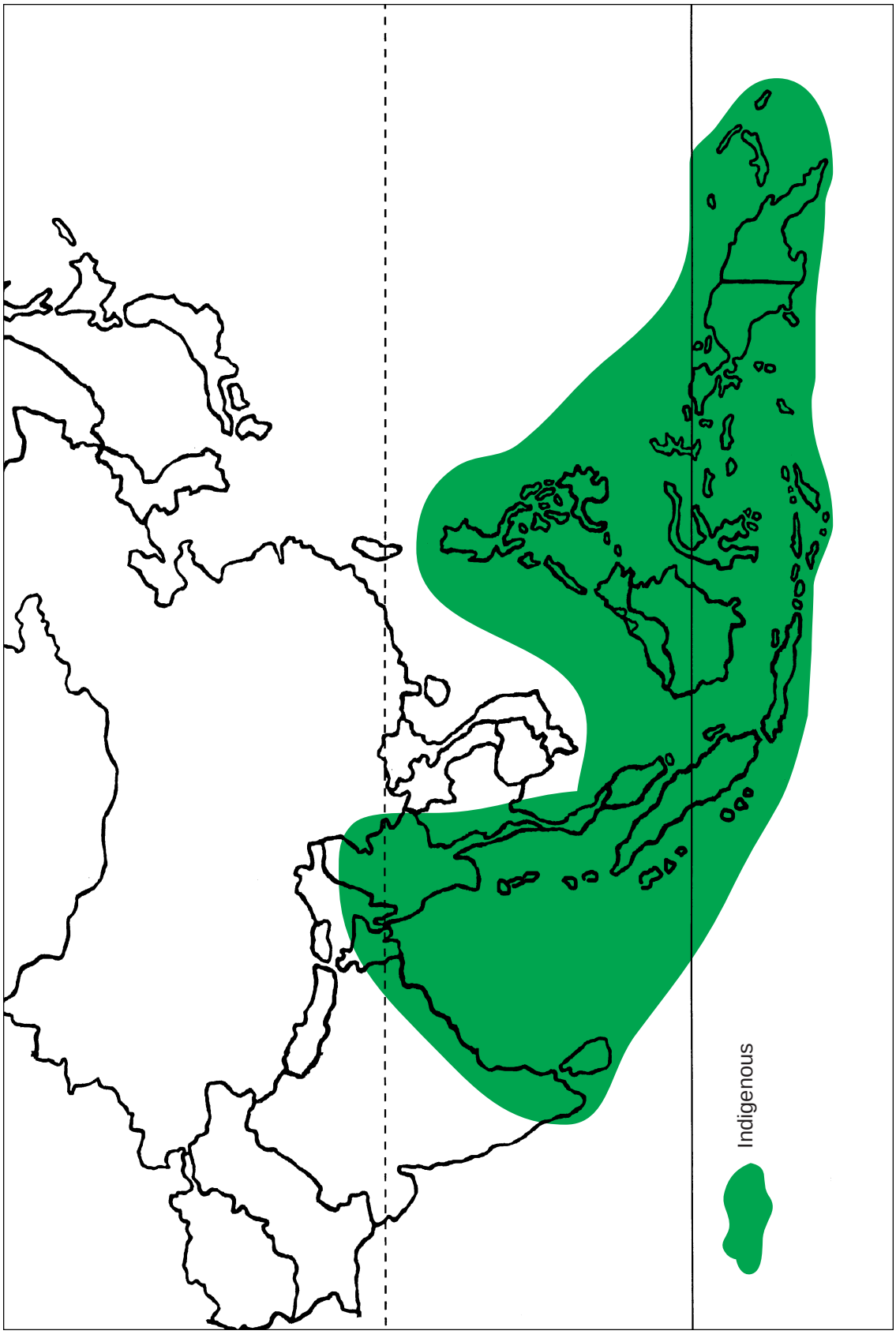

Fig. 25 *Calamus* Sect. *Podocephalus*

Calamus andamanicus

Solitary or clustered rattan, stem 24 m long or more, stem diameter with sheath 8 cm, without 5 cm, pale yellow colour; leaf cirrate, 4 m long, leaflets ± 40 x 3 cm, male inflorescence 1.3 m long, female 1.0 m long, with many flowers on each, mostly present in Andaman, Nicobar islands, flowering in November – December, fruiting in April-May. Fruits ovoid 1.4 x 0.9 cm with 17 rows of scales vertically arranged. Well-used in furniture industry, leaves used for thatching (Renuka 1995). (Table 4).

Calamus burckianus

Clustering rattan, stem upto 25 m tall, diameter 4 cm without leaf sheath, collected from Java and Bali, lowland forests and on hill slopes upto 600 m (Dransfield and Manokaran 1993).

Calamus erinaceus

Clustering rattan near mangrove swamps and coastal margins, stems upto 20m, diameter without sheath ± 3 cm, internodes 25–30 cm, leaf cirrate 4–5 m long; inflorescence 1–1.5 m long, male more compact than female, fruits 1 cm diameter, covered with 12 rows of scales, light yellow in colour; considered as medium to low quality coarse cane; recorded in Thailand, Malaysia and Indonesia. (Dransfield 1992).

Calamus foxworthyi

Endemic to Palawan Island, Philippines, not one of the economically important species (Lapis 1998).

Calamus merrillii

Present in different provinces of the Philippines including Palawan Island; cultivated species, also introduced to Sabah, East Malaysia for growing in plantations; commercially important species (Lapis 1998). Some work also has been done on chemical control of black leaf spot disease.

Calamus nagbettai

Endemic species in Western Ghats of Karnataka state, India; clustering or solitary rattan, stems 25–40 m, upper leaves with long cirrus 3–4 m long, leaflets 40 x 2.5 cm; male and female inflorescences distinct, 30 and 70 cm long respectively; fruits ovoid oblong 2 x 1 cm with 17–18 rows of scales with white margins, flowering Dec–Jan, fruiting from May–June; very useful species for making furniture and other articles, limited cultivation, the species has cultural and religious significance (Lakshmana 1993). (Table 4).

Calamus ovoideus

Endemic to Sri Lanka, clustering rattan, up to 100 m in length, diameter 3–4 cm without sheath; leaf up to 4m long with cirrus 2 m long, leaflets 50 x 2 cm; male and female inflorescences 2.5 m and 1 m long, male flowers bigger than female; fruit ovoid 1.2 x 0.8 cm, scales orange brown, flowering in April, fruiting in October; canes of excellent quality used in furniture industry and handicrafts (Zoysa and Vivekanandan 1994).

Table 4. Information on certain other species that are economically important

Taxa	Value			Domestication	Climate & Ecology		Genetic resources		Distribution
	CS	C	RI		C1	H	GE	Survey	
Calamus thwaitesii Becc.	L	++	++	D	h	Evergreen & Semiever green	H	L	India, Sri Lanka
C. hookerianus Becc.	M	++	++	D	h	Semiever green forests	H	L	Tamil Nadu, Kerala, India, Endemic
C. travancoricus Bedd.	S	++	++	SD	h	Evergreen	H	L	Tamil Nadu, Kerala, India, Endemic
C. brandisii Becc.	S	++	++	W	h	Montane forests	H	L	Tamil Nadu, Kerala, India, Endemic
C. nagbettai Fernandez and Dey	L	++	++	D	h	Evergreen	H	L	Karnataka, India, Endemic
C. nambariensis Becc.	M	++	++	W	h	Evergreen	H	M	Assam, India, Endemic
C. tenuis Roxb.	S	++	++	D	h	Plains & Marshy lands			India, Bangladesh, Burma, S. Vietnam
C. acanthospathus Griff.	M	++	++	W	h	Evergreen	H	M	N.E. India, Bhutan
C. viminalis Willd.	S	++	++	D	h	Plains & Semiever green	H	L	Cambodia, Thailand, Bangladesh, India, Myanmar, P. Malaysia, Indonesia
C. andamanicus Kurz.	L	++	++	SD	h	Evergreen	H	L	Andaman, Nicobar Is., Endemic
C. pseudorivalis Becc.	M	++	++	W	h	Evergreen	H	L	Andaman, Nicobar Is., Endemic
C. guruba Buch-Ham	S	++	++	W	h	Evergreen	H	M	India, Bangladesh, Myanmar, Thailand

For details see Renuka 1992, 1995, 1998, Basu, 1992 and Zoysa and Vivekanandan 1994, Dransfield and Manokaran, 1993).

KEY *Value*

CS = cane size: Large (L), medium (M), and small (S).
C = commercialization potential: High (++), medium (+), and not fully known [(+)].
RI = rural industries: High (++), medium (+).

Domestication
Wild = W, semi-domesticated = SD, domesticated = D.

Climate and ecology
Cl = climate: humid tropics = h, subtropics = s.
H = habitat: dryland = d, wet = w, seasonally flooded = seas. F.

Genetic resources
GE = genetic erosion: High (H), low (L).
IV = need for research on *in vitro*: Low (L).
E = need for exchange: High (H), medium (M), low (L).
Survey = need for further field survey: High (H), medium (M), low (L)

Calamus polystachys

Clustering rattan, common in lowland swampy forests, Indonesia and Peninsula Malaysia, stem 1–2 cm without sheath, internodes 15–20 cm, leaves 2.5 m long with cirrus, leaflets 35 x 1 cm; male and female inflorescence about 50 cm long, fruits ovulate about 8 mm diameter, covered with 18 rows of ivory coloured scales, leaf sheath ant infested, under exploited cane, mostly used by the local people (Dransfield 1979; Dransfield and Manokaran 1993).

Calamus warburgii

Solitary rattan, stem 15 m tall, diameter 3.8 cm without sheath, leaves 4.3 m long, has strong resemblences to *C. zollingeri;* distribution in low land forest of Irian Jaya, Indonesia and Papua New Guinea; used by the local people for making baskets and other articles. (Dransfield and Manokaran 1993; Maturbongs 1997).

Calamus zeylanicus

Endemic to Sri Lanka, occurs along with *C. ovoideus*, mostly in wet lowland forests; clustering rattan, up to 50 m high, diameter 3 cm, internodes 35 cm long, leaf 3 m long with cirrus, leaflets 50 x 3 cm; male and female inflorescences 1.5 and 0.5 m long respectively, fruits almost round 2 cm long, 1.5 cm broad, fruit covered with copper coloured scales with white margin; excellent cane used in furniture industry and handicraft industries, natural resources overexploited and species endangered (Zoysa and Vivekanandan 1994)

Calamus zollingeri

Distribution Sulawesi and Moluccas of Indonesia, clustering; stem 40 m long, diameter about 4 cm without leaf sheath, internodes 35–40 cm long, leaf 6–7 m long, cirrate, leaflets 40 x 3 cm; male and female inflorencences similar 1.1 m long; fruits small 5 mm diameter; good cane for furniture industry, used by the local people for various purposes, earlier exported to Hongkong, grown in plantations on a limited scale. (Dransfield and Manokaran 1993).

The group includes medium diameter species such as *C. erinaceus* to very large diameter species (*C. andamanicus*). Cane quality ranges from mediocre (*C. erinaceus*) to excellent and highly prized (*C. merrillii*). All species appear to be multi-stemmed and can grow to great lengths. *C. merrillii, C. zollingeri* and *C. ovoideus* are among the most highly prized commercial rattans, that produce canes of even, large diameter, good internal structure and appearance, used widely in the furniture industry. Both *C. merrillii* and *C.zollingeri* are grossly over-exploited at present. Although of a quality not as fine as that of *C. manan*, aspects of the growth form of all members of the group suggest they may be more amenable to sustainable cultivation than *C. manan*. Furthermore, the very close relatedness of the recognized species and their very wide geographical and ecological range suggest that there may be considerable scope for selection and breeding for precise cultivation conditions.

CLIMATE AND SOILS: The climate range of the group covers monsoonal to perhumid climates, from the lowlands to ca 1800 m in the mountains, but individual species tend to have a rather narrow range. Soils range from mangrove soils, freshwater swamps (but not peat-swamp), coral limestone and occasionally ultramafic soils.

CURRENT RESEARCH: Current research is focused on *C. merrillii* and a few other species of this group. This species has been the subject of silvicultural trials since about 1979, with promising results. It has been introduced into Malaysia from the Philippines on a trial basis. *C. zollingeri* has also been introduced recently. Other large species in the group are prime targets for silvicultural research. Some *in vitro* research has been carried out on *C. merrillii*.

UNTAPPED POTENTIAL: This group of rattans has very great potential for agroforestry, especially in view of the multi-stemmed habit and wide climatic and ecological range of the group.

CONSERVATION STATUS: Species in the group are subjected to different degrees of threat, ranging from the severe threats from over-exploitation to *C. merrillii* and *C. andamanicus,* and habitat destruction to *C. ovoideus* and *C. zeylanicus* to much less threat to *C. erinaceus.*

USES: Primary use of this group is as a source of large diameter canes for furniture manufacture. Small diameter canes may be used for making rough furniture, coarse baskets and household utensils.

RESEARCH NEEDS: Taxonomic research required to provide a basic framework for further work within this complex of species has yet to be completed, and must be regarded as a high priority. There is a great need to assemble provenances both within the individual species and within the whole group. This complex group offers exciting possibilities for the selection and breeding of high quality, medium to large diameter canes, for permanent rattan plantation in a wide range of climates and soil types. Very little is known of the basic biology of these rattans.

Calamus subinermis

Calamus subinermis is a medium to large diameter rattan of excellent quality, that is the preferred source of cane for furniture frames in Sabah, Palawan and, possibly, parts of Sulawesi. Although the species is clump-forming and thus potentially can produce a sustained harvest, generally the clumps often consist of no more than two or three aerial stems. There is considerable variability in clumping behaviour and armature of the leaf sheaths that suggest considerable genetic variability and the possibility of genetic improvement.

GEOGRAPHICAL DISTRIBUTION: In the narrow sense, *C. subinermis* is confined to Sabah and closely adjacent parts of Sarawak and Kalimantan, and Palawan and offshore islands in the Philippines. A closely related or conspecific rattan occurs in North Sulawesi where it is one of the sources of "tohiti" canes, the preferred large cane for furniture frames in Sulawesi. A similar species also occurs in West Java (Fig. 26).

CULTIVATION: This species has been introduced into cultivation trials in Sabah.

CLIMATE AND SOILS: In the wild, this species is confined to well drained soils on rather dry coastal hills. Although usually found on mildly acidic rocks, the species has been observed on soils derived from coral limestone and on soils overlying ultramafic rock. The geographical distribution of the species and its putative relatives suggests that it may be adapted to survival outside the perhumid areas of southeast Asia.

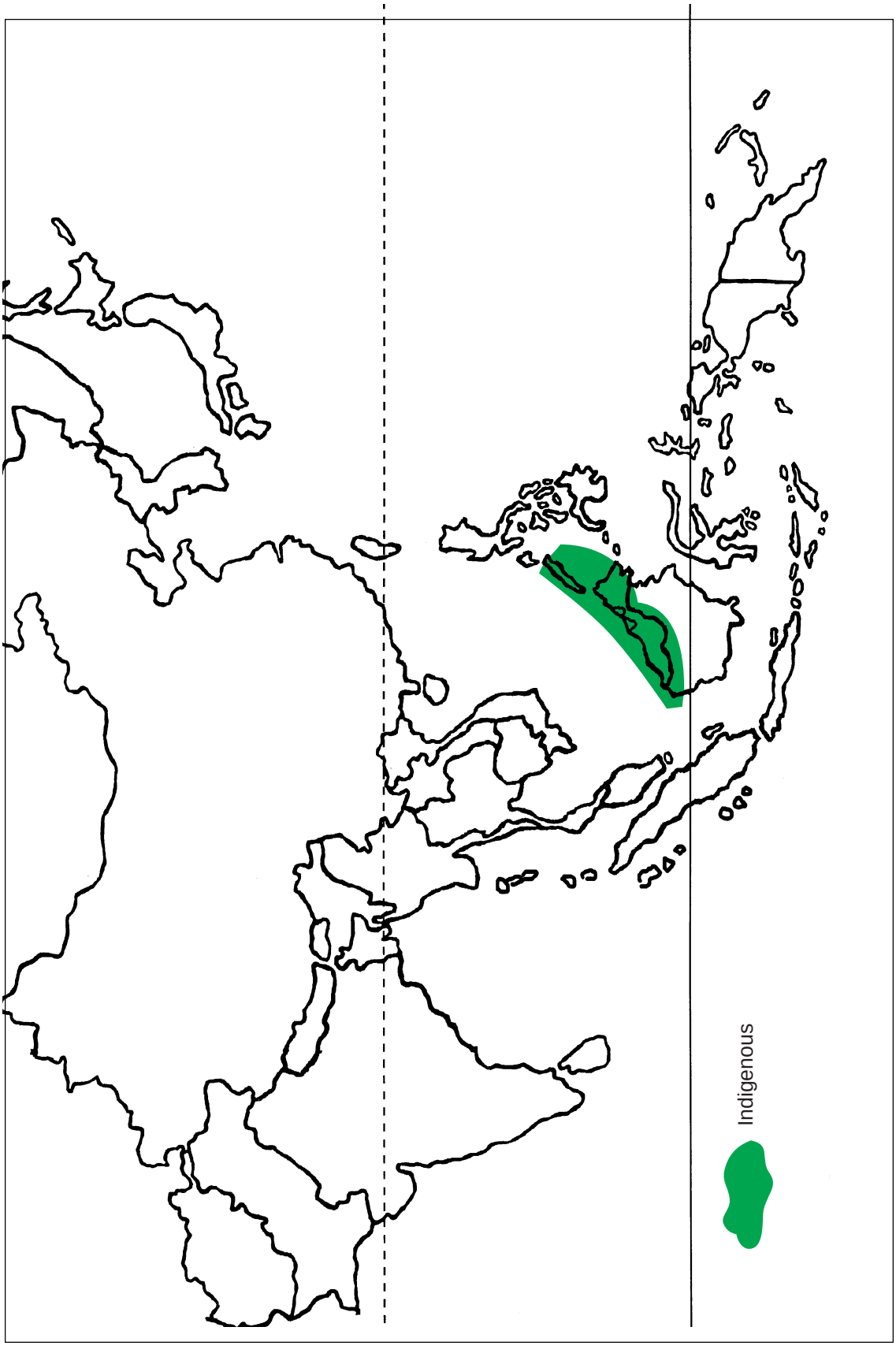

Fig. 26 *Calamus subinermis*

CURRENT RESEARCH: The species is actively being investigated by Lee Ying Fah and his coworkers at the Forest Research Centre, Sipilok, Sabah, Malaysia, who are examining basic aspects of its biology, growth and performance under trials. Some small scale provenance trials have been initiated. Details on flower, pollen longevity and pollination in *C. subinermis* and *C. caesius* have been published (Lee *et al*. 1995 a,b).

The species of *Calamus* are dioecious with regular male and female inflorescence. The male flowers arranged with female flowers are usually sterile. In *Calamus subinermis* both male and hermaphodite flowers were found together for the first time and pollen tested was viable and germinated. Andromonoecy may have a genetical bearing that needs to be analysed (Lee 1998).

UNTAPPED POTENTIAL: Preliminary growth trials suggest that this species has great potential as a plantation crop for drier areas adjacent to perhumid areas. The apparent wide range of soil tolerance in the wild suggests that the species may have potential for cultivation on an equally wide variety of substrates.

CONSERVATION STATUS: Since the revitalization of the rattan industry in Sabah in the late 1970s, *Calamus subinermis* has been subjected to severe overexploitation. Nowhere is it legally protected, except in the Tungku Abdul Rahman National Park near Kota Kinabalu.

USES: Primary use is for furniture frames.

RESEARCH NEEDS: A major requirement is to investigate clumping behaviour, whether it is genetically or environmentally controlled. Seed germination in this species seems often to be staggered and would require further study.

Calamus palustris and relatives

This is a complex of closely related, taxonomically poorly understood rattans that include named species that are known to show great silvicultural potential. These rattans produce canes of medium to large diameter (15–20 mm or more), of an excellent glossy yellowish appearance and with good strength properties. Larger forms from Peninsular Malaysia have been traded as "manau", the trade name of the best large diameter cane, *C. manan*. The taxonomy of the group is confused and is in urgent need of reassessment.

GEOGRAPHICAL DISTRIBUTION: The geographical distribution of this species complex is given in Fig. 27 and the following taxa are tentatively included in this complex:

Calamus palustris Griff and varieties – China, India (Andaman, Nicobar), Myanmar, Thailand, Malay Peninsula, Vietnam.

Calamus inermis T. Anders. – India, Bangladesh.

Calamus nambariensis Becc. and varieties – China, India

Calamus platyacanthus Warb. ex Becc. and varieties – China, Vietnam and possibly a few other places.

CULTIVATION: *C. palustris* var. *malaccensis* is cultivated in north Peninsular Malaysia by smallholders in old rubber plantations. *C. nambariensis* is cultivated within the shifting cultivation cycle by Dai people in southern Yunnan.

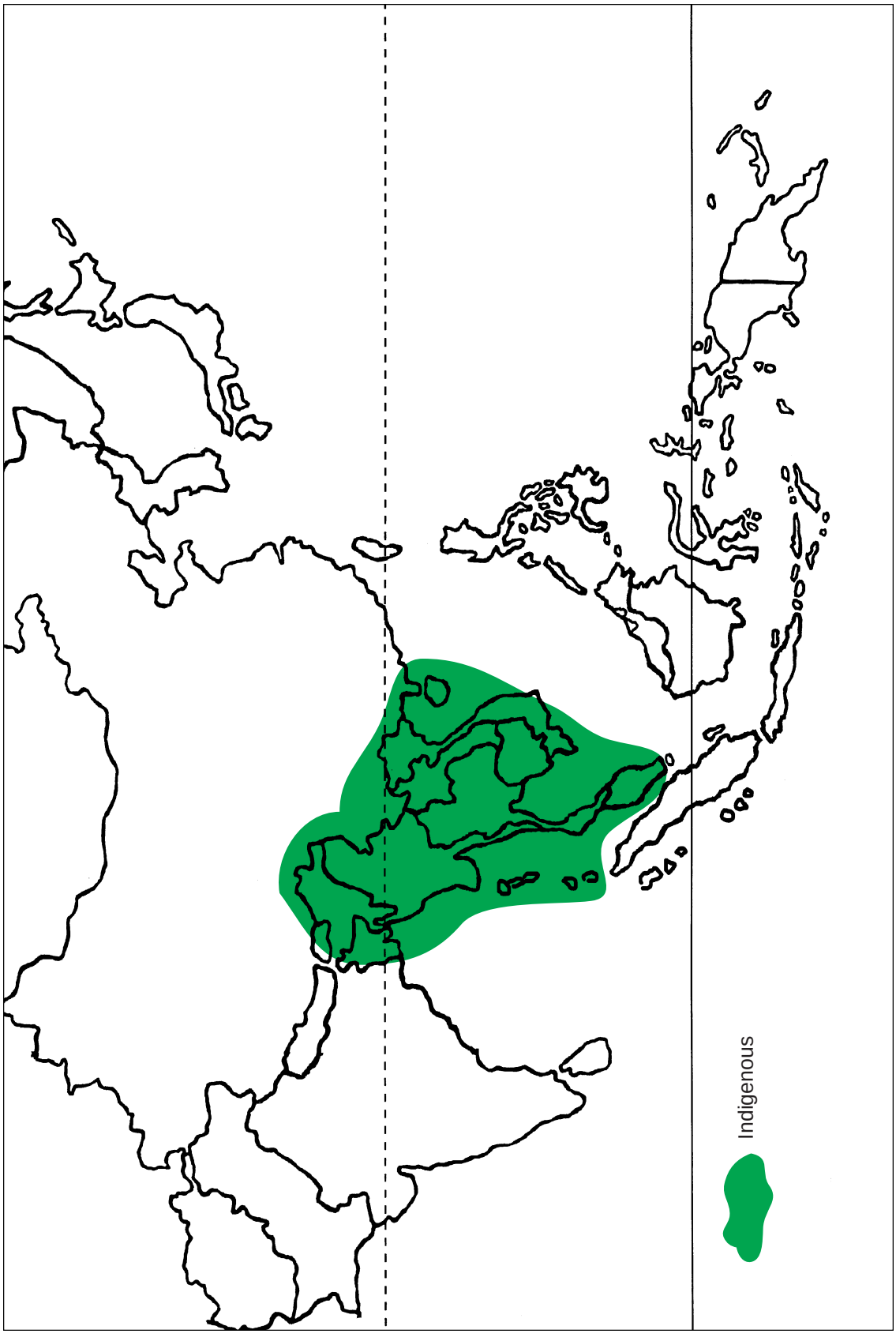

Fig. 27 *Calamus palustris* and relatives

CLIMATE AND SOILS: In the broad sense, the complex is found over a wide geographical and climatic range from northern Peninsular Malaysia to northern India and southern China, from the edge of the perhumid zone to strongly seasonal climates, and from near sea level to about 700 m or more altitudes in southern Yunnan. It appers to perform best on relatively fertile soils but very little is known of its soil requirements.

CURRENT RESEARCH: Research on growth and yields of *C. palustris* is progressing at Forest Research Institute, Malaysia. Research on *C. nambariensis* in the shifting cultivation cycle in southern Yunnan has been carried out by Pei Shengji and associates. Some work on genetic diversity and its distribution has been done in Malaysia and Thailand (Changtragoon *et al*. 1998).

Ms modified basal medium was used to germinate the embryos of *C. tumidus* and *C. palustris* which responded well under in vitro. Detailed reports are prepared on "The role of embryo culture in the seed conservation of palms and other species" and "Biodiversity and Conservation of Rattan Seeds" (Pritchard 1998).

Evaluating the status of genetic resources of rattan (*Calamus palustris*) by isoenzyme gene markers: In collaboration with the Royal Forest Department (RFD) Bangkok, Thailand, the status of genetic resources of *Calamus palustris* in Thailand was evaluated using isoenzyme gene markers. The distribution of *Calamus palustris* which is one of the important rattan species in Thailand was surveyed in disturbed and undisturbed areas. A total of 13 populations from 7 provinces in the South Thailand were studied. *C. palustris* could not be found in four areas where it was known to be distributed from earlier explorations indicating some genetic erosion. Eighteen isoenzyme gene loci were identified and about 80% of the isoenzyme loci studied were found to be polymorphic. The genetic structure, differentiation and diversity of *C. palustris* were studied/measured. The results showed that approximately 18% of the total diversity was due to differences among populations. The conservation of genetic resources of this species is discussed. This work was presented at the last IUFRO Congress (Changtrogoon *et al*. 1998), evaluating the stauts of genetic resources of rattan (*Calamus palustris*) in Thailand by isoenzyme gene markers. (IUFRO Conference on Forest Genetics and Tree Improvement. Contribution of genetics to the sustained management of global forest resources, Beijing, China 22–28 August, 1998).

UNTAPPED POTENTIAL: Growth of *C. palustris* in the northern part of Peninsular Malaysia suggests that this is a very promising species for the drier and more monsoonal areas of the region. The observation that it tolerates rather open conditions suggests that it may be relatively easy to grow. Within the range of variability of *C. palustris* and its relatives, there is potential for the selection of strains for growing in different climatic regions and soil types.

CONSERVATION STATUS: Little known. The genetic diversity study in Thailand indicates significant genetic erosion is occurring.

USES: Primary use is for framework for furniture.

RESEARCH NEEDS: The most important gaps in our knowledge of this complex group are the relationships within the complex. There is a need for an extensive survey to provide the material for a proper classification of the group, a taxonomic study that is required as a framework for future development. Still very little is understood about the basic biology and growth in plantation of different members of this complex. There is clearly a need to establish a major provenance trial.

More details are summarised about the various species.

Calamus palustris

Clustering, 25–30 m tall, diameter without leaf sheath 2 cm, internodes 25–30 cm; leaf cirrate, 1m long, leaflets 35 x 4 cm; inflorescences female shorter than male, 1–1.5 m long, fruit globular, 0.9 cm diameter with 12 rows of light yellow scales. Very useful cane used for furniture, internationally traded (Dransfield and Manokaran 1993).

Calamus platyacanthus (=*C.wailong*)

Yunnan province of China on hill slopes upto 900 m, some cultivated, clustering robust rattan, stem without sheath 20 mm in diameter, internode 50cm or more, leaves 2–6 m long, leaflets 55 x 7 cm, no regular arrangement, rachis ends up with cirrus upto 3 m long, male and female inflorescences similar, fruits ovoid 17 x 11 mm covered with 20 rows of light yellow scales, seed slightly flat, extensively used in weaving, for furniture, and house construction (Dransfield and Manokaran 1993).

Calamus inermis

Endemic species in N E India, Sikkim, up to 800 m, clustering rattan, 20–25 m tall, diameter 2–3 cm without leaf sheath; inflorescence 1 m long, fruits ellipsoid 3 x 1.5 cm, with 18 rows of scales, groove in the middle; used in furniture industry. More details required on all other aspects (Basu 1992).

Calamus nambariensis

Distribution N E India, Yunnan, China and most likely in Myanmar – China border areas; clustering, robust cane, 20–30 m tall, 2 cm diameter, leaves 3 m long, leaflets 40 x 3 cm, 5 nerved; fruits globose 2.5 cm diameter, covered with 21 rows of scales; mostly used in furniture; more details are required on all aspects (Basu 1992).

Calamus tetradactylus

Calamus tetradactylus is a densely clustering small diameter rattan, with good quality canes of 5–8 mm diameter. It can also grow to lengths of up to 30 m. It is closely related to *C. tetradactyloides, C. cambojensis* and to some species in *Calamus* Sect. *Calamus* (Sect. *Coleospathus* Furtado).

GEOGRAPHICAL DISTRIBUTION: *C. tetradactylus* occurs in China on Hainan Island, in southern Guangdong, Guangxi, Fujian, Morinees, Hong Kong and in Viernam (Fig. 28). CULTIVATION: *C. tetradactylus* has been cultivated on a trial and small commercial scale in southern China.

CLIMATE AND SOILS: Ecophysiological requirements are cited as being air temperature 20–30°C (–2°C may kill seedlings), more than 1300 mm rainfall annually and relative humidity over 78%. This species is the most northerly of all cultivated rattans, occurring in areas where rare frosts can occur.

CURRENT RESEARCH: The species has been the subject of intense research in south China over the last 15 years. Successful trials have been established.

UNTAPPED POTENTIAL: The major untapped potential of this species is for wider cultivation in areas with climate similar to that of southern China, as a small holder crop for handicrafts.

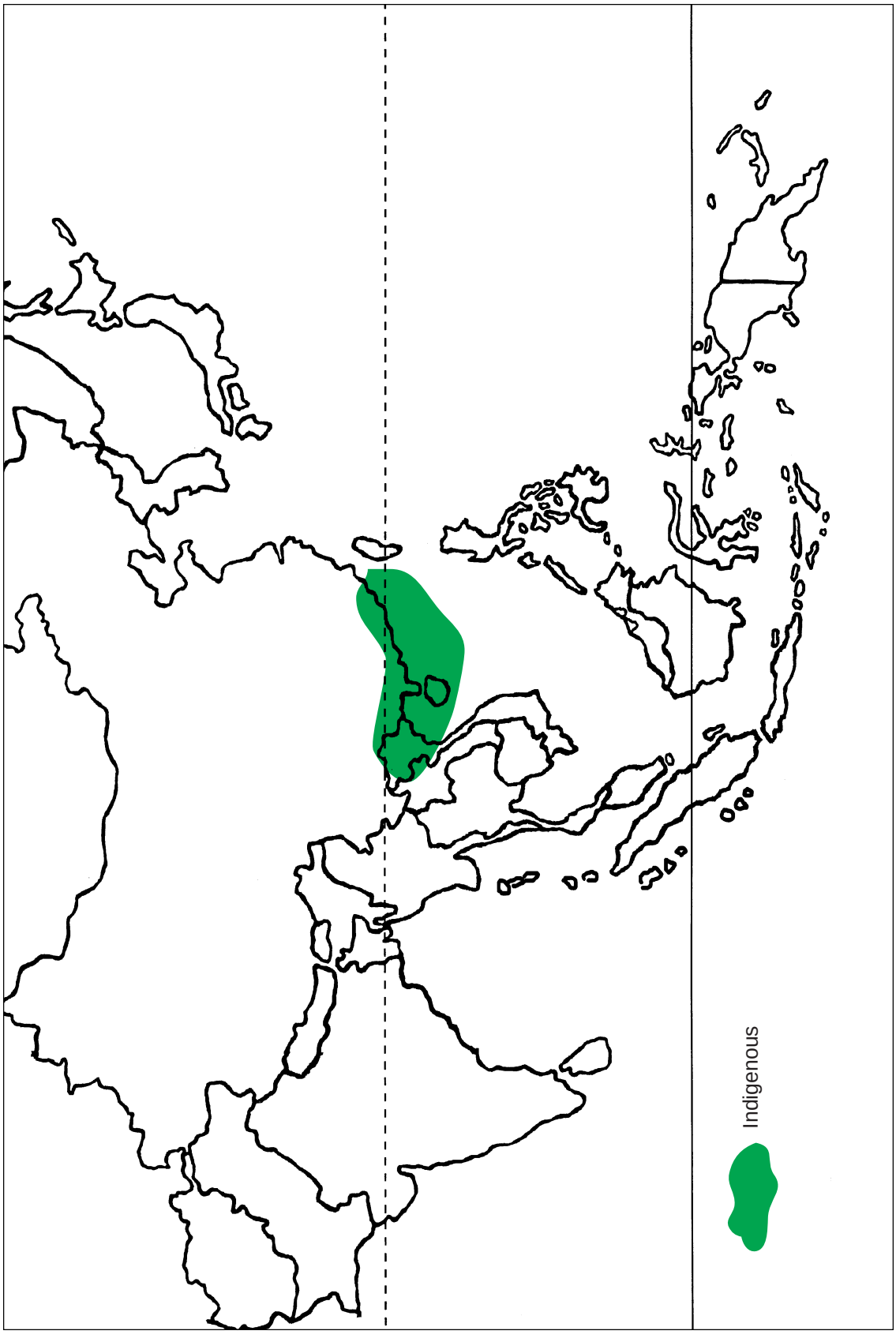

Fig. 28 *Calamus tetradactylus*

CONSERVATION STATUS: Severely threatened in the wild by overexploitation and habitat destruction.

USES: The primary use is as a first class small diameter cane in handicrafts, binding in furniture and cordage.

RESEARCH NEEDS: Studies are needed to understand intraspecific variability and its relationships with other taxa occurring outside China.

Calamus deeratus

C. deeratus is a highly polymorphic small to medium diameter clustering rattan, that produces a cane of moderate quality, up to ca 18 mm diameter. In the past several other species have been described that are now considered to be synonymous. They include:

Calamus akimensis Bess.
C. barteri Drude
C. falabensis Becc.
C. heudelotii Drude
C. laurentii DeWild
C. leprieurii Becc.
C. perrotetii Becc. and
C. schweinfurthii Becc.

GEOGRAPHICAL DISTRIBUTION: This is the only species of *Calamus* to be found in Africa. It occurs in the humid parts of west tropical Africa, the Congo Basin and with outliers in western Uganda and northern Zambia (Fig. 29).

CLIMATE AND SOILS: It appears to be confined to freshwater swamps and alluvial forests in the humid tropical rain forest belt.

CURRENT RESEARCH: There has been very little research conducted on this species.

UNTAPPED POTENTIAL: The potential of this species is unknown. As the best quality species in Africa, it clearly plays an important role in local economies, but whether it has potential for further development requires a detailed pan African survey.

CONSERVATION STATUS: Unknown.

USES: Its main use is in local handicrafts and binding in furniture for local consumption.

RESEARCH NEEDS: Since very little is known about this species, research work in all fields will be needed.

Calamus hollrungii and relatives

Calamus hollrungii is a medium to large diameter rattan that produces a high quality cane ca 9–20 mm or more in diameter. It is usually single-stemmed. Very closely related are several other recognized species that share the same excellent cane quality and size.

GEOGRAPHICAL DISTRIBUTION: The following species are tentatively included under the genepool of *Calamus hollrungii* and distribution of this group is presented in Fig. 30.

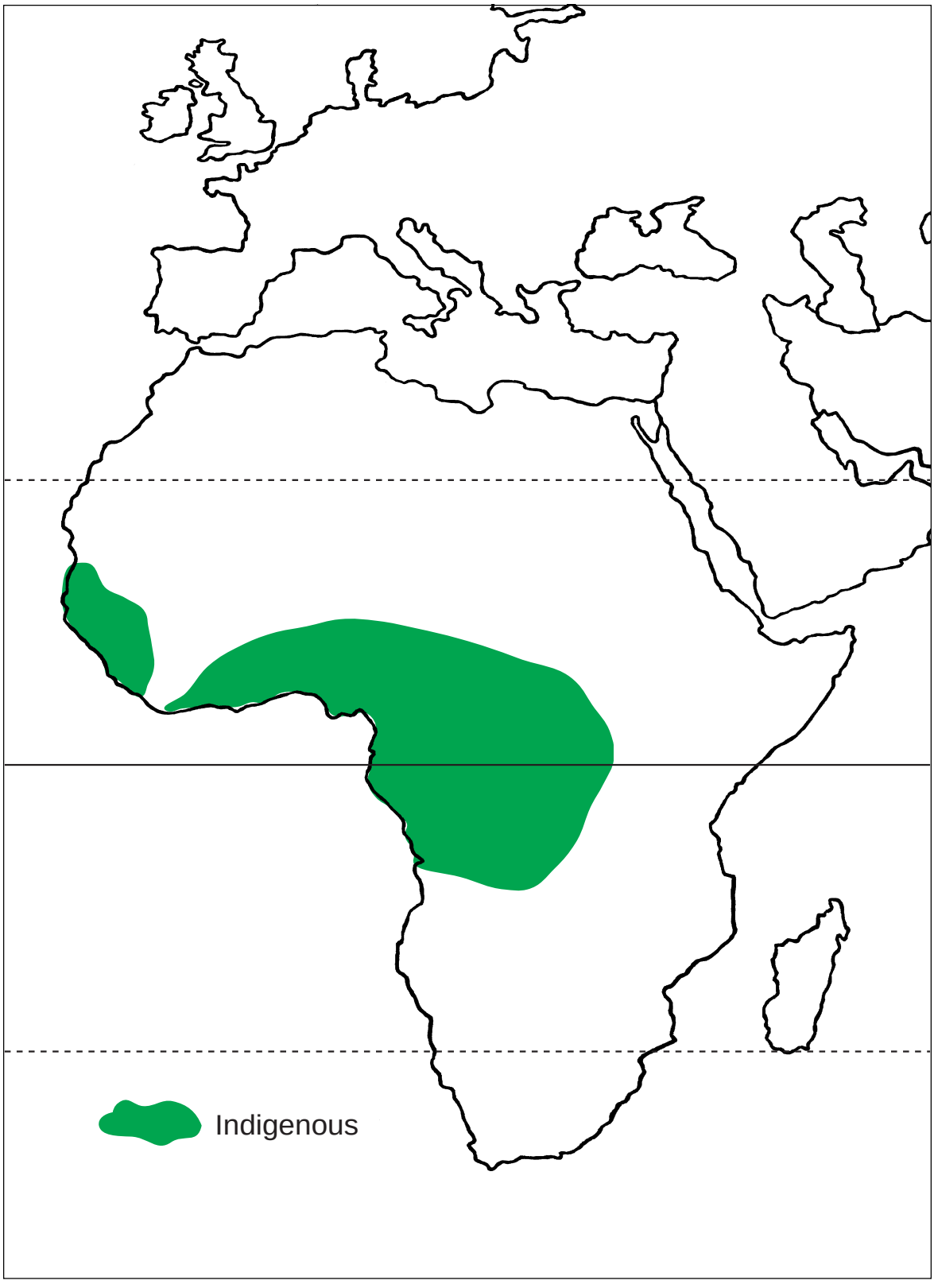

Fig. 29 *Calamus deeratus*

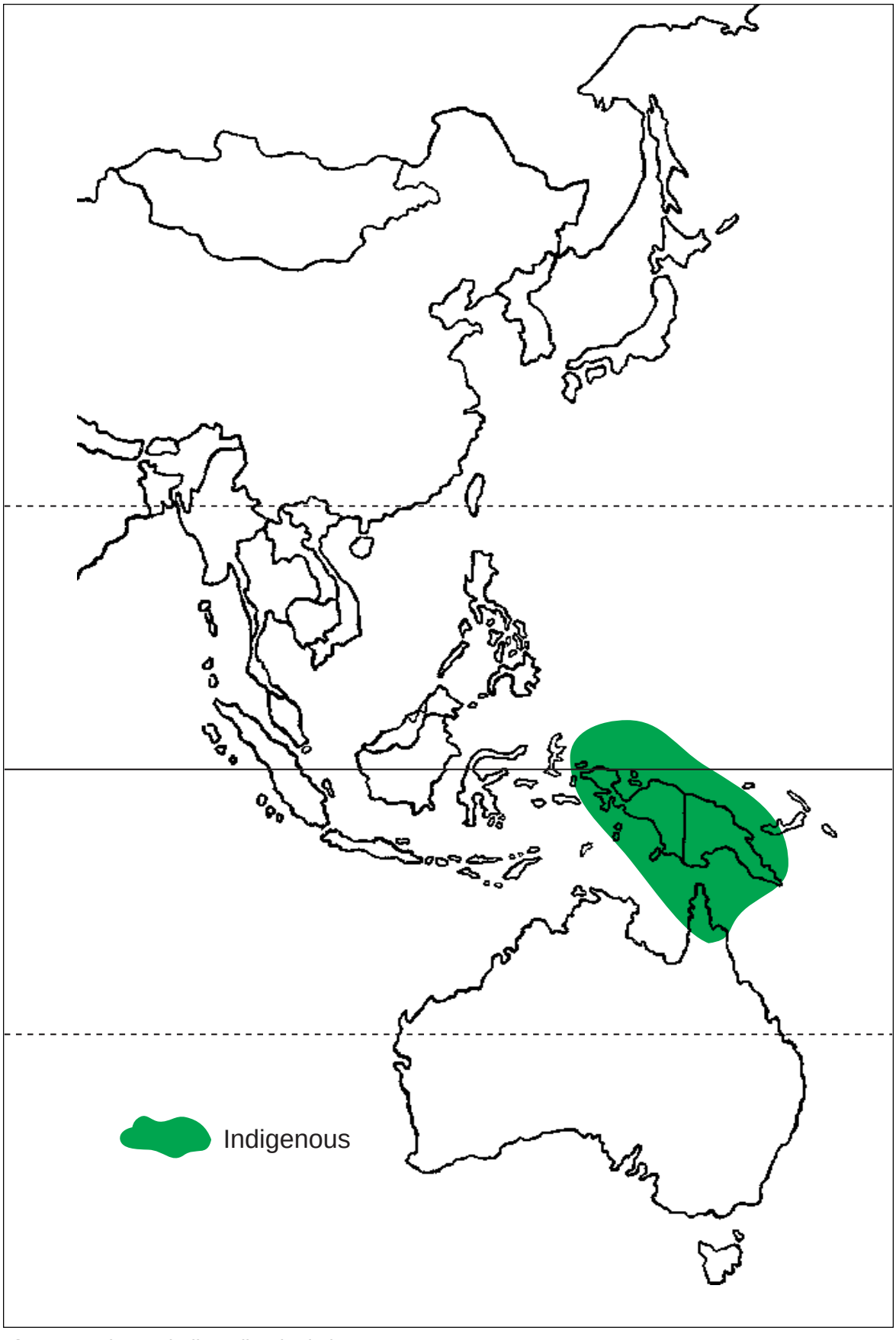

Fig. 30 *Calamus hollrungii* and relatives

C. hollrungii Becc. – throughout New Guinea, Queensland; its distribution in Solomon Islands is to be confirmed.
C. aruensis Becc. – Aru Islands, New Guinea, Queensland.
C. subinermis Becc – Sabah, Sarawak, East Kalimantan (also see separate section on this species and Fig. 15).
C. vitiensis Warb. ex Becc. – Fiji
C. vanuatuensis Dowe – Vanuatu

CULTIVATION: There is no record of systematic cultivation of these species.

CLIMATE AND SOILS: These are all rattans of low elevations on relatively rich soils in perhumid climates. Beyond this, very little is known of their ecological requirements.

CURRENT RESEARCH: Apart from basic floristic survey work, there has been no research on this species complex, except *C. subinermis.*

During the recent botanical expiditions to New Guinea about 60 identified and eight unidentified rattans were collected and a check list has been published including *Calamus hollrungii* and *C. aruensis*. This group provides good planting materials suitable for plantation establishment (Dransfield 1998).

UNTAPPED POTENTIAL: The perceived great potential of this species complex is a plantation subject for the west Pacific region.

CONSERVATION STATUS: Little is known of its conservtion status.

USES: Throughout their range, the canes of this species complex are much sought after for export for manufacturing furniture frames.

RESEARCH NEEDS: Almost all aspects of these rattans as they pertain to cultivation and conservation are in need of research. In particular, trials need to be established.

Endemic species

Many species of rattan are endemic reported by various authors. In the evolutionary scale the endemic species are considered either as young or old species. The relative areas of distribution may increase over time in case of younger species and be reduced in older species depending on the fecundity and genetics of species. The data available at present do not discuss the extent of distribution area of such species but only mention the place or country of occurrence. (Basu 1992; Renuka 1992, 1995; Zoysa and Vivekanandan 1994). (Fig. 31). Further studies would be interesting and details obtained may help to assess the taxonomic relationship of various species and their age and area connections as well as the ecological conditions that govern such species. Conservation measures adopted should take the above details into consideration, as they refer to priority species, their close relatives and superior plant populations.

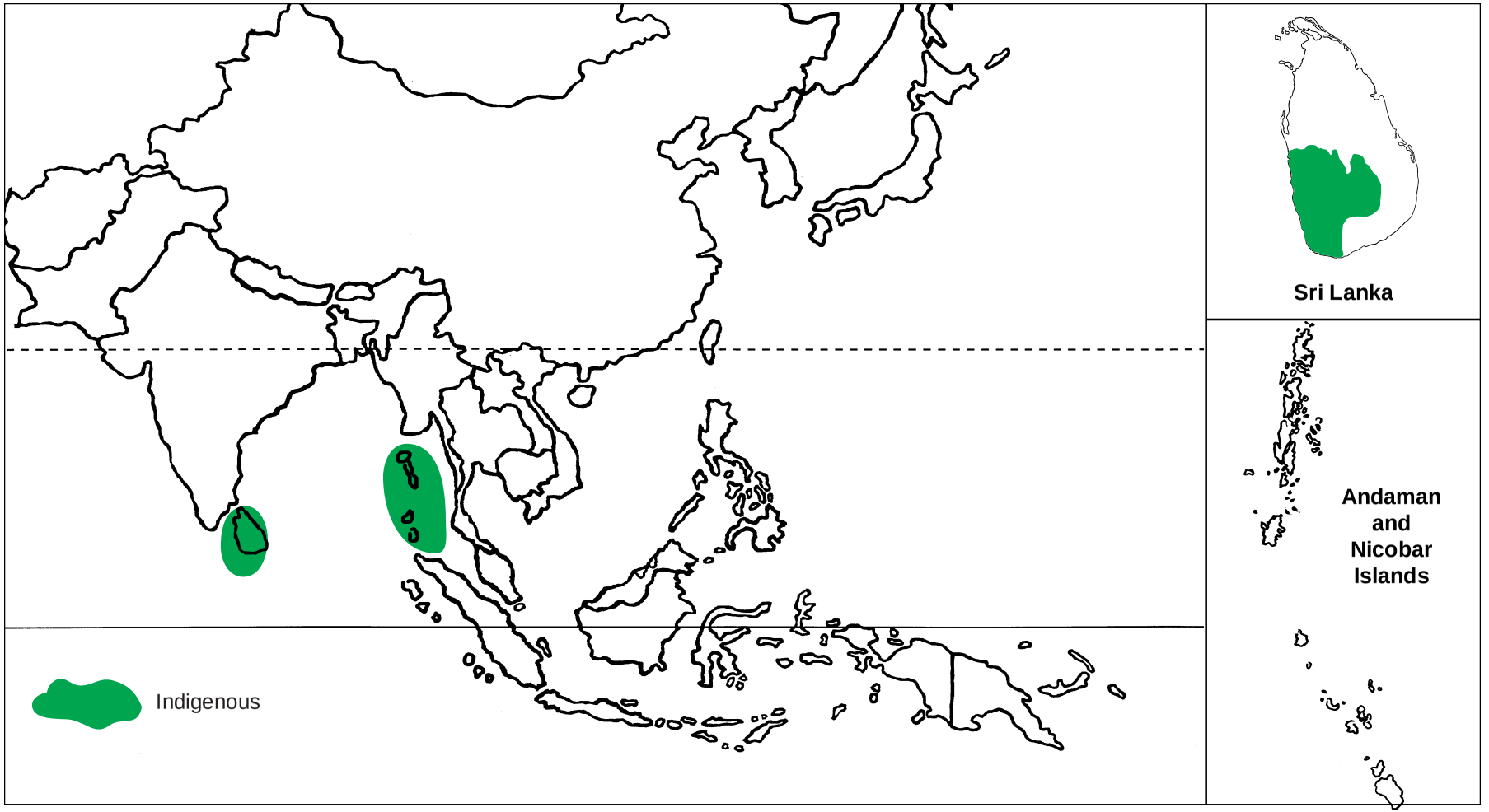

Fig. 31 Endemism of Rattans

Andaman Nicobar islands – Total 3 genera and 18 species of rattans of which eleven species of three genera are endemic. Four species of Calamus ie. C. longisetus, C. palustris, C. unifarius, C. viminalis and Korthalsia laciniosa are spread in S. East Asia as far as Bali, C. palustris extends North to S. China.

Sri Lanka – 19 species of Calamus, 7 are endemic, three species common with India in rattan growing region. (See Table 4).

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Application of the priorities

Bamboos

Participants of the 1994 workshop made the following recommendations in relation to bamboos.

1. In order to enhance production there is an urgent need to survey the priority species across their distributional ranges and sample populations in different areas to assess gross morphological differences and to modify existing biochemical and molecular methods to measure patterns of genetic variation. IBPGR (now IPGRI) is urged to develop an appropriate descriptor system for the priority species of bamboos.

   Present status: Since 1994, survey work has been conducted in China, India, Bangladesh, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and other countries identifying the distribution patterns of some of the priority species (Vivekanandan *et al* 1998). Relative DNA content of certain species is estimated to compare with the ploidy level.

2. Regional provenance trials of selected accessions could be initiated through FORTIP, which has agreed on ten forest species or groups of species for project action and bamboo is a high priority species among these ten.

   Participants suggested that provenance trials should be targeted to agroforestry and small plantation systems for production of culms and/or shoots especially on marginal and degraded lands. Two early interventions are recommended.

   Present status: Agroforestry and socioforestry work is in progress in certain countries like China, India, Thailand and others. All the data available need to be well consolidated and published.

   a. INBAR is asked to obtain from national programmes lists of selected provenance of the priority species characterized by short descriptions of morphology, other attributes and provenance data.

   b. INBAR and FORTIP are asked as a matter of urgency to arrange for the compilation of standard methodology for the design, field lay-out, data collection and analyses for provenance trials. This compilation should have appended known soil preferences of particular species. Furthermore, INBAR is initiating synthesis of all known pests and diseases and thereafter, IBPGR and FAO are asked to develop guidelines for the safe movement of materials.

   Present status: Some initial work and planning was started. A document was published outlining some of the procedures for the provenance trials. (INBAR technical report, 4 (Anon 1994). Initial discussions have started to prepare the guidelines for the safe movement of germplasm materials.

3. For conservation and sustained yield of genetic resources the assessment of patterns of genetic diversity through survey and experimentation is of the utmost urgency in view of genetic erosion. However, IBPGR is requested to develop appropriate conservation methodology in parallel with this work. At this stage it is suggested that since tissue culture protocols are available for many species, that modification of tissue culture methods to promote slow growth for conservation of clones is

quite feasible. Despite the difficulties encountered with flowering cycles, some species (e.g. *Dendrocalamus asper*) may flower but not produce seeds, others may produce seeds in very small quantities (e.g. *D. asper* or *Gigantochloa apus*), or seeds produced may have high inviability. So research on testing seed, viability and storability of seed for long-term conservation is recommended. Innovative research on physiology to induce flowering could be most valuable.

Present status: Tissue culture methods for mass propagation of most of the bamboo priority species are well outlined and further support was given by IPGRI for more studies. Various methods are followed for producing plantlets and by using young plants, bamboo plantations have been established.

In vitro induction of flowering and fruiting offered much hope in the beginning but the degree of success was relative only in certain cases or clones. The methods are not successful in many other cases (INBAR technical report, 5).

Some good work has been recently conducted on bamboo seed harvest, handling, storability and seed viability, with IPGRI's support, and these data are being put together to develop some giudelines towards conservation strategy.

One of the commercial companies in Belgium has gained much experience in invitro culture of bamboos and they solicit orders from clients offering to produce and supply bamboo plantlets of the desired varieties. The presentation made by this company at the recent International Bamboo congress in Costa Rica received many responses.

4. With reference to *in situ* conservation it is pointed out that the agreed priority species do not occur in primary forests but are associated with anthropogenic forest vegetation. Such areas lend themselves to buffer zone areas but conservation areas in ecotones and other anthropogenic forests should be considered in developing *in situ* conservation systems. The conservation community INTERESTED IN CONSERVATION has given inadequate attention to these areas despite repeated mention in relation to crop relatives and a substantial number of other economic plants.

   Present status: The relative status of *in situ* and *ex situ* conservation work has been summarized for five countries, Bangladesh, India, Indonesia, Philippines and Sri Lanka. Plans for further work are also outlined (Vivekanandan 1998). Similar work to produce reports for other countries will be pursued and supported by IPGRI.

   4A. It is noted that the IBPGR research is targeted solely to Asia. The attention of INBAR and IBPGR is drawn to the need to survey *Guadua* in Latin America.

   Present status: Natural distribution and plantation establishment of *Guadua* in Central and South American countries are discussed in a recently held International Bamboo Conference. This priority species i.e. *Guadua angustifolia* is well conserved, and sustainably used in various Central and South American countries, especially for low cost housing. Many books and research papers on this species are recently published. Building of bamboo houses has a long tradition in these countries.

5. An urgent task necessary to enhance bamboo production is genetic enhancement. INBAR and FORTIP are asked to consider how this can be promoted.

   Present status: An expert consultation meeting was held in Los Baños, Philippines and many important recommendations are made for the genetic enhancement of bamboos and rattans (Banik *et al* 1995; Fu 1995; Gurumurthi 1995; Lawrence 1995; Rao and Ramanatha Rao 1995; Williams 1995).

Rattans

Participants of the 1994 workshop made the following recommendations in relation to rattans.

1. Recognizing that current exchange of planting materials is slow and that this needs to be accelerated and further, that widespread testing has not been carried out, the establishment of regional provenance trials on the priority species is urgently required. FORTIP has also accorded priority to rattan and their collaboration should be sought in this regard. As in the case of bamboos, two urgent interventions are needed:

   Present status: Considerable amount of work has been done on plantation and nursery techniques for rattan including some priority species like *C. manan*, *C. caesius*, and *C. trachycoleus*. Large scale *ex situ* collections and plantations have been established in Sabah using the logged over forest areas (Bacilieri 1998). Work on regional provenance trials are awaited but this is not easy to achieve because of particular growth conditions that rattans require like rainfall, soil moisture, light shade conditions and others. More basic research on ecophysiology needed.

   a. INBAR and FORTIP are asked to develop standard methodology as for bamboos (see above).

   b. IBPGR and FAO are asked to develop guidelines for the safe movement of materials when INBAR has databased all current information on pests and diseases.

   Present status: The data collection on pests and diseases is in progress. The papers published on this topic have to be consolidated. More information is available on bamboos than rattans. Preliminary discussions have started on the safe movement of seed materials. CABI Bioscience of CAB International have joined INBAR-IPGRI working group to establish guidelines for the safe movement of Bamboo and Rattan materials.

2. Micropropagation techniques have been developed for a limited number of the high priority species. However, further research in this area can await the commercialization of selected clones (which has not been done yet).

   Present status: Considerable success has been gained in producing rattan plantlets under invitro, part of the CIRAD-FORET/ICSB efforts in Plant Biotech laboratory, Tawau, Sabah. Using root or young leaf segments of *Calamus manan, C. subinermis* and *C. merrillii* somatic embryos have been produced in large numbers which later on differentiated into plantlets. The plants have been transferred to the field already. This is a major breakthrough in conserving and propagating superior rattan plants. The performances of *in vitro* produced plants will be uniform in terms of growth and yield since the plantlets are developed from vegetative tissues of mother plants. All the three species are important commercially and the canes of these species are very well-used in furniture industry. (Goh, 1997). Earlier research on *in vitro* Culture studies on rattan was summarised. (Rao I.V. *et al* 1990).

3. For genetic conservation, rattan seeds are short-lived and hence research is needed on storability. Tissue culture is not a high priority for genetic conservation because current plantings are from heterogeneous seed collections which vary every time. (Almost all rattans are dioecious and a genetic marker for the sex ratio has not been identified). *In situ* conservation in primary forests is clearly of the highest priority and this must be coupled with survey and identification of patterns of genetic variation.

   Present status: Broad based data on *in situ* conservation of rattan have been obtained for few countries like Philippines, Sri Lanka, China, India, Nepal and others. More intensive work is required to identify the pattern of genetic variation in rattans. Large scale *ex situ* rattan collections have been established in Luasang Sabah, involving five commercially important species (Aloysius , 1998). Similar exercises can be practiced in other countries also. As said before it is feasible to obtain large number of (genetically uniform) plants by using *invitro* methods. Since vegetative tissues are used as explants, uniform performance of plants produced in the laboratory is expected with few modifications. The *invitro* methods can also be tried for genetic conservation of species. Identifying genetic markers and sex ratio studies should progress since they help to firmly establish the scientific methods, needed to carry out conservation programmes.

   a. Development of extractive reserves and models for sustainable management of natural stands should be vigorously pursued, but development of clear scientific standards is essential.

   Present status: Some efforts are under way, supported by IPGRI, to understand the impact of extraction. More socio-economic, ethnobotanical research needs to be done.

   b. A great deal of data exist on rattan distribution in protected areas and these should be collated. However, these should be checked by reference to herbarium materials and by on-ground surveys.

   Present status: Some valuable data are collected on the distribution of rattan in protected areas and natural forests of certain countries including Bangladesh, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand and Vietnam. The accuracy of data varies since very little work is done in certain countries due to shortage of manpower and lack of expertise. Available data has been brought upto date (Vivekanandan *et al* 1997).

Other topics related to furthering research

1. Participants discussed the need for relevant information systems and noted that a number of databases either exist or are planned by international organizations. It was felt that it would be precipitous to discuss these further until descriptor systems were available and widely used.

2. Attention was drawn to the need to use the existing bamboo and rattan information centres in China, India & Malaysia.

   Present status: The information sent by the various centres is well-used. The future of these centres need to be reassessed.

3. The value of the palm database at the Royal Botanic Garden, Kew, UK was noted and that this covers not only taxonomy but distribution, ecology, uses and other topics. INBAR is asked to explore the possiblity of the subset dealing with rattans being made available to cross reference with bibliographic data in the Rattan Information Centre.

   Present status: Alice Nomenclature database and collection database on rattan are available at Kew, Richmond, England.

4. A similar database for bamboos is not yet available and this would be the first task to be explored.

   Present status: Plans are being made to establish bamboo database.

Other decisions

1. Participants wished to state that of the numerous species not listed as the priority in this report there are many which need to be protected in reserve areas and inventories maintained. This is due to the over-riding importance of the use of these species by local peoples. This would require appropriate sustainable management of these species within the forests.

   Present status: Attention has been drawn of the concerned people to the above problems at various meetings recently conducted. The country reports presented at the training courses and workshops throw some light on the subject illustrating the progress made. (See the list of references). Additional number of species have been added and discussed in the present volume also.

2. It is recognized that there are major gaps in our knowledge on the biodiversity of many species of priority bamboos and rattans. As research proceeds it will become clear that the priorities identified in this report will require revision.

   Present status: Very little work has been done on the biodiversity of rattan and bamboo so far. Some varieties are identified for certain species. The deficiency is largely due to the lack of well trained manpower and intensive field survey in the region.

Epilogue

A.N. Rao

Epilogue (1994 edition): Agreement on priority species of bamboo and rattan represents a landmark achievement. Obviously the next question posed is what should be next in the areas of biodiversity and understanding and exploiting genetic diversity.

Recommendations made in the report relate to immediate follow-up action so that research networking applies the priorities and develops a degree of standardization in methodology. However, in relation to diversity scientists will be pondering over many unknowns for bamboo and rattan. Conservation is of particular interest in this respect, and advances in conservation will rely on understanding patterns of diversity in relation to ecology, physiology, genetics, reproductive biology and molecular biology. Since the knowledge base is extremely small in relation to these subjects, by necessity we need to follow a multidisciplinary approach. Advances will be made when groups of researchers working in the various disciplines can be brought together to work on common problems. Such groups will include universities as well as research institutes and silviculturists in various countries.

The stimulation of this type of research presents a great challenge to organizations such as IBPGR and other international and regional efforts on conservation and utilization of plant genetic resources. In any event, it needs careful preparation: topics need to be well defined and programming implemented against a background of continual assessment and rolling priorities. With some dedicated work, good results can be achieved in about 2–3 years time. Lastly, this approach for bamboo and rattan will be needed for many other non-timber forest products.

Epilogue (1998): The meetings at Dehradun and the subsequent ones organized by INBAR, FORTIP and IPGRI-APO provided excellent opportunities for many researchers to discuss the various issues raised above during the last four years. Although all the problems have not been fully solved or the various questions answered, a good beginning has been made in several countries and directions outlined to promote research on Bamboo and Rattan. The series of publications that have come out in the last 3 years bear evidence to such facts giving out various details on several important points including conservation and sustainable utilization. (See list of references 1996–1998). Methodologies outlined whether they are for field trials, nursery techniques, plantation development, vegetative propagation, biochemical methods including tissue culture work are very closely followed in many laboratories and institutions. Much progress has been made. Population analysis studies are in progress in certain countries paving the way for genetic analysis and conservation of various species.

The publication of final scientific report on the EEC project is an important document showing the valuable research carried out on conservation, genetic improvement and silviculture of various rattan species. In many ways the document outlines the new methods followed to solve the various problems on rattan and sets up models for further research. The results obtained during the four year period by the joint work of researchers from five institutions in France, UK and Malaysia have helped to open many frontiers, unexplored before. Limited or complete answers are made available to many questions raised earlier at various meetings and conferences. (Bacilieri 1998). The joint efforts of these organizations along with IPGRI-APO, INBAR and FORTIP also helped to improve the manpower development in the region.

The relative status of *ex situ* and *in situ* conservation of Bamboo and Rattan has been evaluated for more than six Asian countries. Details on *Guadua angustifolia* are

being published by various researchers in Central and South America. Attempts are made to understand and analyse the patterns of diversity in certain priority species.

Identification and selection of Bamboo Rattan species for plantation establishment and to increase production have been discussed in earlier pages. As explained the nativity or indigenous nature of certain species is well known or easily identifiable, for others the indigenous status is unknown but certain species are widely distributed in large areas either as camp followers or due to their inherent success and ecological adaptability to various edaphic and climatic conditions. Few of them are endemic representing either the primitive or the advanced stages of evolution. Altogether the distribution of about 30–40 species are included in this revised text with distribution maps.

Analysis and understanding the range of species distribution is basic to plan and promote conservation measures. Selection and promotion of superior clones or varieties of the various species would enhance their economic value. The rarity or scarcity of species prompted the various International organizations to prepare the lists of plants – generic names proposed for conservation in 1948. Since then many directories or Red books have been published for various countries indicating the endangered or threatened status of various plant species. Present day conditions endangering the vegetation in tropical and subtropical forests are such that we need to prepare a list of Bamboo Rattan species that need to be conserved in various countries either immediately or over a period of time in the near future. To carry out such an exercise in different countries distribution maps given for various species in this publication will be helpful.

Plant species distribution is the major topic or the core subject of Phytogeography or Plantgeography, the main principles of which are discussed in various publications over the last 140 years (1807–1944) under different headings including: zonation of plants, geography of plants, botanical geography and localities, life zones, floristic provinces, age and area and others. The basic principles were enumerated in a concise form about 50 years ago by Cain including principles concerning environment, plant responses, migration of flora and climaxes, plant evolution etc. Most of these details are yet to be covered or analysed in case of Bamboo and Rattan by conducting further research. Fossil evidence for both the groups is absent since they are monocots. Bamboos are present both in old and new worlds whereas rattans are mostly South East Asian in distribution.

Majority of the woody bamboos investigated so far are polyploids and polyploid species often show a wider range of distribution. Almost all the priority species considered in the present text are polyploid species and the limited distribution of majority of priority species confirm the above statement. The chromosome numbers in the related woody genera of bamboos, including the priority species considered presently, are not variable, making it difficult to establish genetic relationship between economically important genera and the species. Nevertheless genetic enhancement and hybridization research has progressed (Tewari 1994, Williams, *et al* 1995).

Very few rattans, not more than 4–5 species have been investigated cytologically to determine the chromosome numbers, diploid numbers vary between 22–24. Most of the rattans when 2–3 years old are very slow growers, and majority of them are dioecious. The nature and role of X and Y chromosome analysis in rattans, if any, causing diocy are yet to be determined analysing the segregation of sexuality in rattan populations. Most probably the pattern of sexuality in dioecious rattan follows the same archetype as species of *Borassus* and *Phoenix* where male plants have XY pair of chromosomes, X larger than Y, and female plants with XX pair, with no size difference between the two chromosomes. Andromonoecious condition has been reported in *Calamus subinermis,* an endemic species from Sabah (Lee 1998), suggesting an important advice to researchers to re-examine the flower arrangements and structure of many other species more closely.

Population analysis of rattans is very important not only to understand the phenology and ecology of plants but also to maintain the proper balance between male and female plants in a population so that good seed production is ensured to propogate and conserve the genetic resources which form the baseline for sustainable utilization. Except for suckers there is no vegetative propagation method in rattans. Not all rattans would produce suckers. Methods outlined to obtain somatic embryos through tissue culture work of 2–3 species may prove very helpful in the near future for other species.

Dioecious condition is said to be a very advanced evolutionary tendency in reproduction of flowering plants (Renner and Ricklefs 1995). Correlations between dioecious rattan plants, their ecophysiological, morphological and genetical characteristics are yet to be well correlated. Physiological and morphological amplitudes of a species are governed by the genetical characters of a species. Therefore proper understanding and analysis of rattan reproduction for conservation should involve a good measure of both ecophysiological and genetical studies.

Researchers in developing countries are pursuing a multidisciplinary approach using the manpower that are available. Experts are brought from various countries to improve or augment the situation wherever needed. More efforts will be made to solve the problems in different Asian countries that grow Bamboo and Rattan. With the continued support provided by INBAR and IPGRI-APO many of the researchers in developing countries are forging ahead to solve the various national and regional problems. The networks already established are functioning well in Asian countries and more coordinated efforts will help to conserve and sustainably use Bamboo and Rattan resources in the near future, using various biotechnological methods (Ratnam *et al*, 1994, Salwana *et al*, 1996).

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