

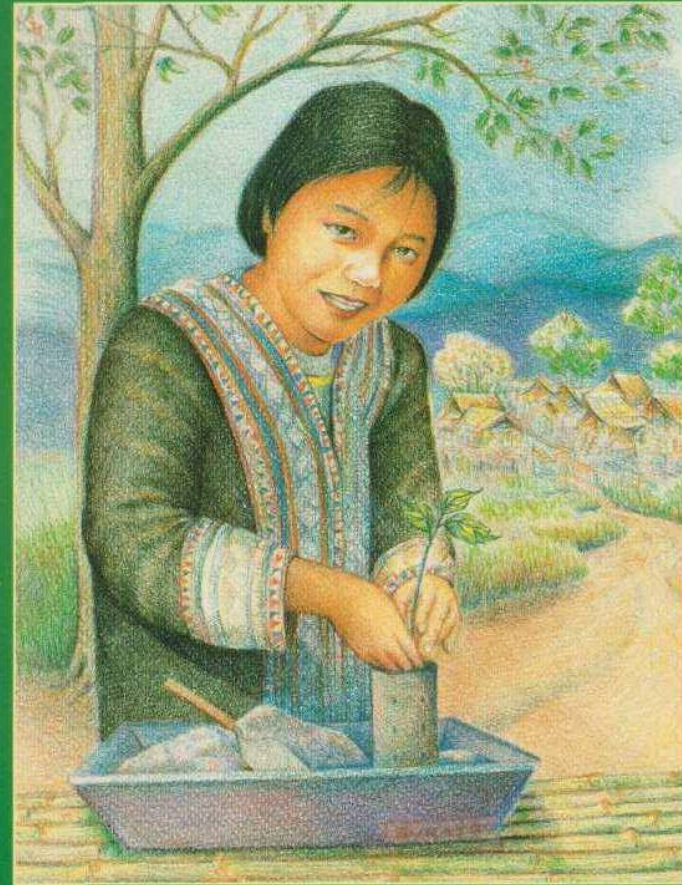


The forests of northern Thailand are fast disappearing along with their wildlife and the many products and ecological services they provide for local communities and the national economy. In recent years, public awareness of the problem has greatly increased and impressive efforts are now underway to restore degraded forestland, by planting a wide range of native forest trees. An essential part of any tree-planting project is recognition of the tree species being planted. However, identifying tree seedlings is difficult, because they have different characteristics to those of adult trees. Based on a research programme, carried out by the Forest Restoration Research Unit (a joint initiative between Chiang Mai University and Doi Suthep-Pui National Park), this book provides essential information about 45 native forest tree species, known to be useful in forest restoration projects. Detailed descriptions of fruits, seeds and seedlings, a key to aid seedling identification and tips on propagation and planting are presented in this handy book for use in tree nurseries or in the field. Line drawings, full colour illustrations and an extensive glossary of technical terms complement the text.

TREE SEEDS AND SEEDLINGS

FORRU

# TREE SEEDS AND SEEDLINGS FOR RESTORING FORESTS IN NORTHERN THAILAND



BY  
THE FOREST RESTORATION RESEARCH UNIT







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It is impossible to ascribe this book to a single author or even a small group. The information presented has been contributed by the many staff and volunteers who have worked at FORRU since 1994, including...

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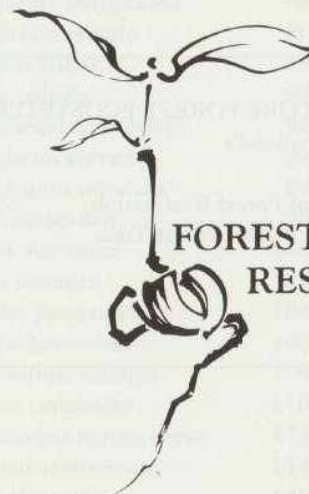
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# TREE SEEDS AND SEEDLINGS

## FOR RESTORING FORESTS IN NORTHERN THAILAND



### FOREST RESTORATION RESEARCH UNIT

EDITED BY

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SPONSORED BY

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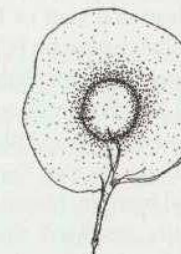
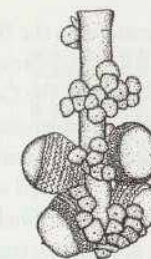
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The text of this book was compiled by Janice Kerby, Dr. Stephen Elliott and Dr. David Blakesley and translated into Thai by Dr. Vilaiwan Anusarnsunthorn. J. F. Maxwell identified the tree species and provided expert botanical and taxonomic input. The cover picture and drawings are by Mr. Surat Plukam. Photos are by FORRU staff and by Simon Gardner and Pindar Sidsunthorn. M.R. Smansnid Svasti provided helpful comments on the text and designed FORRU's logo.

All opinions expressed in this book are those of the editors and not necessarily those of the sponsors or reviewers. The editors thank anyone, not already mentioned above, who has contributed in any way towards FORRU'S work or production of this book.



## A MESSAGE FROM THE BRITISH COUNCIL, THAILAND

**Dr. John Richards**  
Director  
The British Council, Thailand



Thailand's forests are one of the country's richest natural resources, supporting a huge diversity of plant and animal species, and providing forest products to support local livelihoods. The oxygen and water produced in Thailand's forests are crucial to the whole country, supporting lowland as well as mountain eco-systems. In recent years, forest cover has decreased dramatically. Currently, only 17% of Thailand remains forested, but the government now aims to reverse the trend and to restore forest cover to 40%, with a focus on natural, conservation forests.

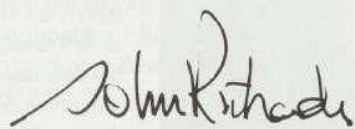
Reforestation is a complex, multi-faceted process, requiring active intervention over many years. It requires an understanding of forest eco-systems as well as the trees themselves. It also requires dedication and involvement from local communities and NGO's, to participate in initial reforestation activities and engage in long-term sustainable management of forest resources. The Forest Restoration Research Unit (FORRU) at Chiang Mai University, and Doi Suthep-Pui National Park under the Royal Thai Forest Department, are making a significant contribution to reforestation in Northern Thailand. Through FORRU's education programme, the practical techniques developed from FORRU's research are made available to communities and organisations, to assist reforestation projects nation-wide.

The work of FORRU has excited interest and support from scientists in other countries, including Britain. The British Council is pleased to have supported FORRU since it began in 1994, especially in enabling Dr. David Blakesley of Horticulture Research International and Dr. Kate Hardwick of the University of Wales to visit Thailand and



contribute actively to FORRU's work. In January 2000, the British Council was pleased to join other sponsors in supporting the regional workshop organised by FORRU, 'Forest Restoration for Wildlife Conservation', which developed a research agenda for forest restoration in South-East Asia and established a regional network of experts in this field.

The key to successful reforestation is a practical understanding of the tree species planted. This book, FORRU's second major publication, offers practical guidance on seedling culture, it covers key forest tree species, indigenous to northern Thailand, which have already been used successfully in reforestation projects. The publication of this book will make the results of FORRU's work available to all organisations engaged in reforestation in Thailand. I am sure that they will find its practical advice invaluable and am confident that this book will make a significant contribution to successful reforestation in Thailand. I am delighted that The British Council has been able to play a part in its publication.



*Dr. David Blakesley and Dr. Kate Hardwick attending the Regional Workshop on Forest Restoration for Wildlife Conservation, sponsored by the British Council.*



## A MESSAGE FROM VSO THAILAND

**David Young**  
Programme Officer  
VSO Thailand



VSO is a UK-based development organisation, which works through placing skilled volunteers where they are requested by government and non-government institutions. As such, we are able to take a longer-term view, and concentrate on the development of individual human potential. With over thirty years experience in Thailand, we have been increasingly involved in supporting the efforts by Thai people to sustainably manage their remaining natural resources. Thus we have closely followed, and continuously been impressed by FORRU's projects. Since the formation of FORRU in 1994, the staff have collected a huge quantity of information on indigenous species identification, nursery techniques for seedlings, and forest restoration.

In 1998, we were pleased to receive a request for a volunteer to work with FORRU on the dissemination of this information. Furthermore, we were in a position to respond to FORRU's request for financial support for the dissemination of its work through our Central Project Fund, which in turn is supported by the European Union. The Thai edition of this book is one product of this collaboration, providing an accessible guide to one of the most important stages in the restoration of indigenous forest ecosystems.

In many countries, including Thailand, there is little tradition in the nurturing of native forest trees, as people have been able to rely on nature. As inappropriate land-use systems have been adopted in the interests of short-term economic development, forest loss has increased at an alarming rate, whilst the techniques for its reconstitution have been inadequately studied. In northern Thailand,



FORRU has made great strides to rectify this, and this book provides people with the tools to identify and nurture seedlings in order to protect them and encourage their re-establishment on degraded forestland. The availability of this book will assist Royal Forest Department staff and local communities alike to reverse the decline in forest cover, whilst retaining high levels of biodiversity in Thailand's hill areas. VSO is proud to have facilitated a small part of the production of the book and the ongoing dissemination of FORRU's work.

*David Young*

David Young  
Programme Officer  
VSO Thailand  
September 1999



*Janice Kerby, VSO volunteer, prepares to plant trees with the villagers of Ban Mae Sa Mai*

# PART 1



## USING NATIVE TREES TO RESTORE FOREST ECOSYSTEMS

RESEARCH TO RESTORE NORTHERN THAILAND'S  
DEGRADED FOREST ECOSYSTEMS

THE FRAMEWORK SPECIES METHOD OF FOREST RESTORATION  
GROWING, PLANTING AND CARING FOR NATIVE FOREST TREES



*Cherdak Kuarak monitors the growth of tree seedlings in FORRU's research nursery.*





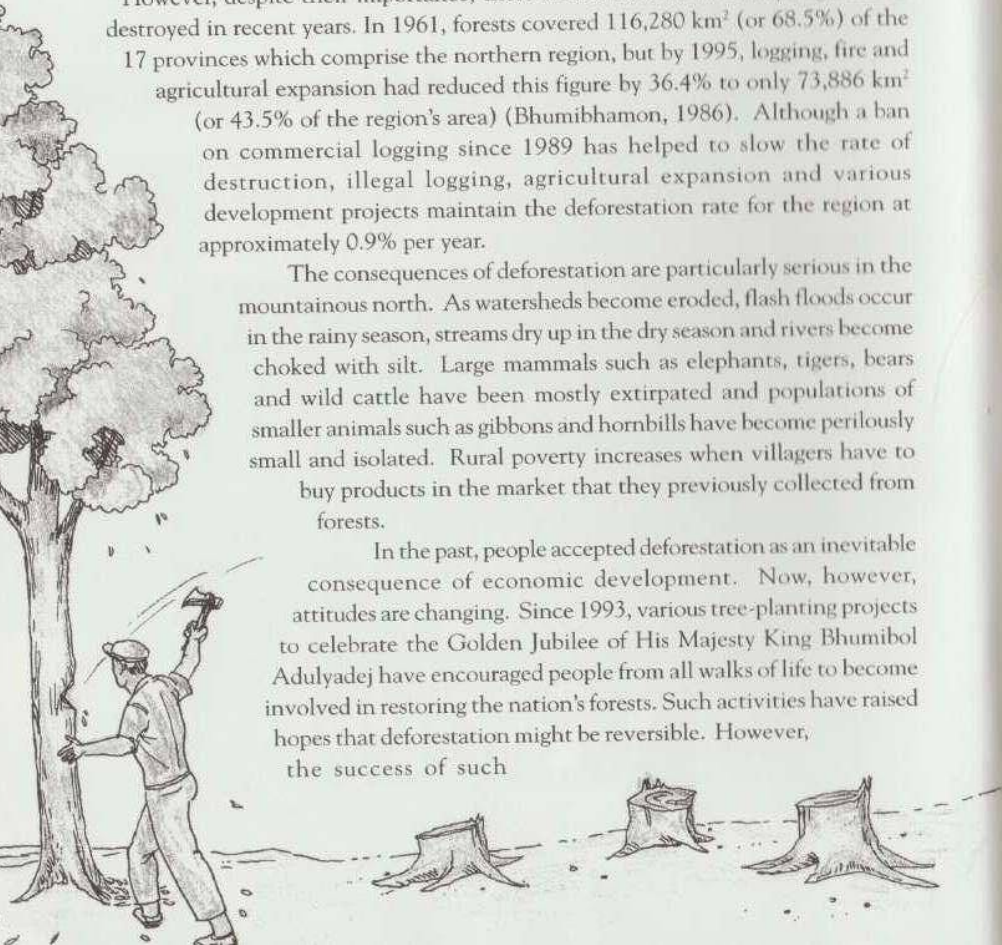
## RESEARCH TO RESTORE NORTHERN THAILAND'S DEGRADED FOREST ECOSYSTEMS

The forests of northern Thailand are one of the Kingdom's most important natural resources. They are habitat for numerous wildlife species, including 150 mammal species (Lekagul & McNeely, 1988), 383 birds (Round, 1988) and at least 3,450 vascular plants, of which 1,116 are trees (CMU Herbarium Database, 1999). Northern villagers still rely on forest products such as firewood, bamboo, edible fruits, mushrooms, medicinal plants, honey etc. to meet some of their basic needs. Furthermore, the northern forests protect extensive mountainous watersheds that feed the Chao Phraya River, irrigate the rice fields of the central plains and supply water to the nation's capital.

However, despite their importance, these forests have been widely degraded or destroyed in recent years. In 1961, forests covered 116,280 km<sup>2</sup> (or 68.5%) of the 17 provinces which comprise the northern region, but by 1995, logging, fire and agricultural expansion had reduced this figure by 36.4% to only 73,886 km<sup>2</sup> (or 43.5% of the region's area) (Bhumibhamon, 1986). Although a ban on commercial logging since 1989 has helped to slow the rate of destruction, illegal logging, agricultural expansion and various development projects maintain the deforestation rate for the region at approximately 0.9% per year.

The consequences of deforestation are particularly serious in the mountainous north. As watersheds become eroded, flash floods occur in the rainy season, streams dry up in the dry season and rivers become choked with silt. Large mammals such as elephants, tigers, bears and wild cattle have been mostly extirpated and populations of smaller animals such as gibbons and hornbills have become perilously small and isolated. Rural poverty increases when villagers have to buy products in the market that they previously collected from forests.

In the past, people accepted deforestation as an inevitable consequence of economic development. Now, however, attitudes are changing. Since 1993, various tree-planting projects to celebrate the Golden Jubilee of His Majesty King Bhumibol Adulyadej have encouraged people from all walks of life to become involved in restoring the nation's forests. Such activities have raised hopes that deforestation might be reversible. However, the success of such



tree-planting projects is often limited by lack of skills and knowledge about how to grow, plant and take care of native forest trees, which have never before been planted on a large scale in Thailand. Forest ecosystems contain a very great diversity of tree species, many of which have never been studied in detail. Often, the tree species grown for planting projects are unsuited to the sites being planted. Methods of growing and planting native forest trees need to be improved and appropriate methods to care for the trees after planting (e.g. fertiliser application, weeding etc.) need to be developed.

### The Forest Restoration Research Unit (FORRU)

It was to address some of these technical aspects of tree planting that the Forest Restoration Research Unit (FORRU) was established in 1994 (Elliott et al., 1995). FORRU is a joint initiative between Chiang Mai University (CMU) and Doi Suthep-Pui National Park Headquarters (under the Royal Thai Forest Department (RFD)). The main unit comprises a research tree nursery and office at Doi Suthep-Pui National Park Headquarters. In addition, the unit has established a community tree nursery and demonstration plots at Ban Mae Sa Mai, an Hmong hill tribe village in the north of the national park.

The aim of the unit is to develop effective methods to complement and accelerate natural forest regeneration on deforested sites within conservation areas, to increase biodiversity and protect watersheds. Specific objectives include:

- i) development of tools for studying and implementing restoration of natural forest ecosystems (such as this book);
- ii) research to investigate the ecological processes of natural forest regeneration, to determine how these processes might be accelerated;
- iii) identification of tree species suitable for planting to complement natural tree establishment;
- iv) development of appropriate methods to propagate such tree species and test their performance after planting out;
- v) development of appropriate silvicultural techniques to maximise the performance of planted trees and
- vi) training of interested groups in the new forest restoration techniques developed by the unit.

FORRU's initial priority was to gather basic ecological data about the very large number of tree species which grow in northern Thailand, to determine which ones might be useful for restoring damaged forest ecosystems. With more than 600 tree species growing on Doi Suthep (Elliott and Maxwell, 1995), there were plenty to choose from. Apart from a few commercially valuable tree species, very little was known about seed production, germination and seedling growth of the vast majority



of wild forest trees. Without such information, it was impossible to make sensible choices as to which tree species to use in forest restoration projects. Therefore, FORRU collected and germinated the seeds of as many species as possible and developed criteria to assess their potential to restore damaged forest ecosystems (Elliott et al., 1997a).



## Seed production and collection

To determine when ripe seeds can be collected, FORRU's researchers recorded the abundance of flowers and fruits of 94 native tree species in the forests of Doi Suthep, every 3 weeks, for 4 years. The data, summarised in each species description in Part 2, can help nursery managers plan seed collection programmes.

Data on the characteristics of fruits and seeds (e.g. colour, size, shape, weight etc.) have been entered into a computer database that can be used to help identify species and provide clues as to their seed dispersal mechanisms (Pakkad, 1997). Different fruit or seed types vary in their potential to be naturally dispersed into deforested areas. Some are more likely to attract wildlife into planted sites than others, so it is important that fruit and seed characteristics are considered among the criteria used to select tree species for planting.

Research currently underway is determining how to identify superior parent trees for seed collection. Maintaining genetic diversity is an essential element of any tree-planting programme with conservation objectives. Therefore, in collaboration with Horticulture Research International in the U.K., genetic variation within selected tree species is being assessed to ensure that genetic diversity is maintained among the seedlings grown for planting.

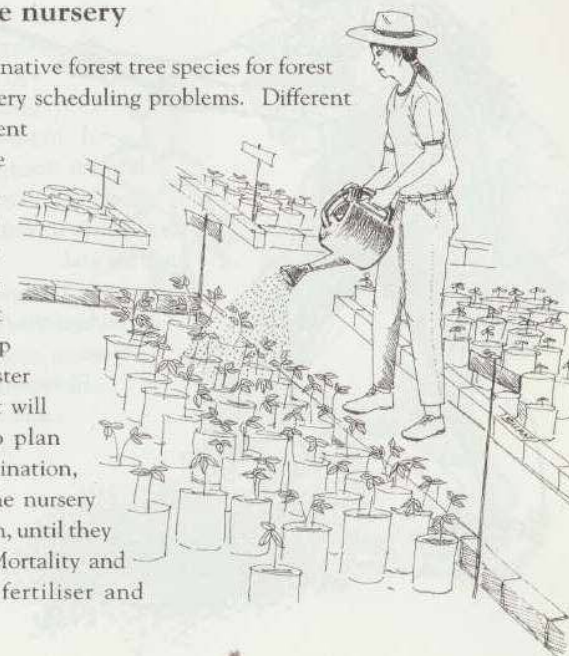
## Seed germination

Seed germination trials have been carried out on nearly 400 tree species to provide basic data on germination rates and dormancy. The results enable nursery managers to estimate how many seeds to sow and the time required to produce a required number of seedlings. Initially, experiments compared seed germination in partial shade (similar to that in deforested gaps) and deep shade (similar to that beneath a forest canopy), to eliminate shade dependent species that are unsuitable for planting in sunny deforested sites. The results showed that many so-called primary or climax forest tree species could germinate and grow well in the sunny conditions of deforested sites. Therefore, including such species in tree-planting programmes can greatly accelerate forest regeneration.

Using both trial and error and controlled experiments, FORRU researchers and CMU students have determined the best methods to clean seeds and treat them to accelerate germination and increase the final germination percentage. Treatments have included soaking the seeds in water, scarification and various heat treatments (Kopachon, 1995). Recommendations, based on the results of this research are included in the notes on propagation of each tree species in Part 2. Further research is currently underway on seed storage, improving the seed germination medium and preventing fungal diseases that cause damping-off during germination.

## Seedling growth in the nursery

Producing a wide range of native forest tree species for forest restoration is beset with nursery scheduling problems. Different species produce seeds at different times of the year and they have different seedling growth rates. Yet, all the trees must reach a suitable size by the planting season i.e. June. Research on the growth of seedlings at FORRU is helping to develop production schedules (see poster accompanying this book) that will enable nursery managers to plan nursery operations. After germination, seedlings are monitored in the nursery through all stages of production, until they are ready for planting out. Mortality and growth rates, responses to fertiliser and





pruning, and any signs of pests or diseases are routinely recorded.

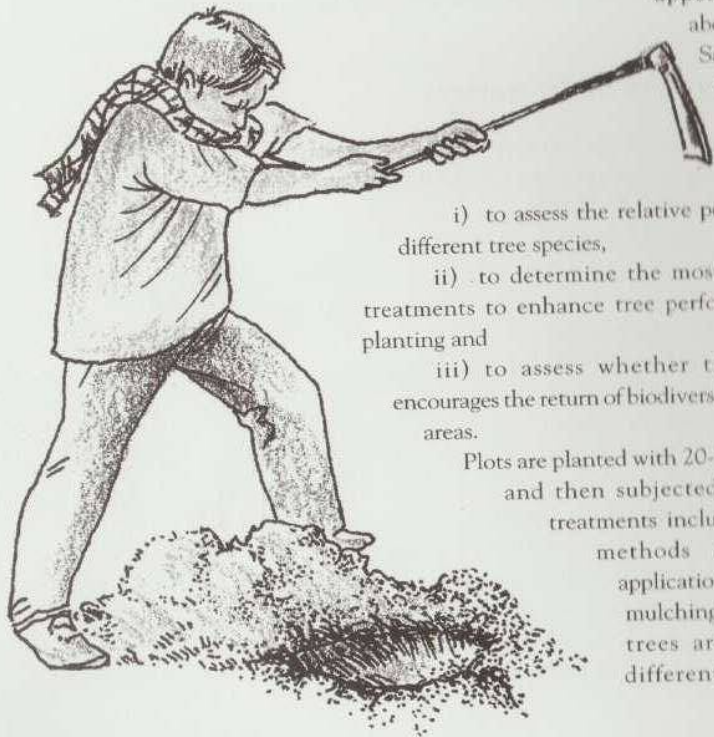
Experiments to test different container types have shown that root trainers: rigid plastic pots, with vertical grooves to prevent root spiralling, are ideal (Zanglum, 1988). However, if such containers are not available, excellent results may also be obtained with 9" x 2 1/2" plastic bags, provided that roots are prevented from growing out of the bottom of the bags by frequent pruning. Recently, experiments have begun to test the effectiveness of air pruning. Seedling containers are raised off the ground on a wire grid. As the roots grow out of the bottom of the containers, they are killed when exposed to air. This stimulates the formation of a compact root-mass that increases survival of the trees after planting. Other experiments, currently underway, are examining the effects of container size on seedling growth in the nursery and testing different types of fertiliser and methods of application.

### Tree-planting experiments

In collaboration with Doi Suthep-Pui National Park authority and with sponsorship from the Biodiversity Research and Training Programme, FORRU has established experimental field trials in the degraded upper watershed above Ban Mae Sa Mai. These trials have three main objectives:

- i) to assess the relative performance of different tree species,
- ii) to determine the most appropriate treatments to enhance tree performance after planting and
- iii) to assess whether tree planting encourages the return of biodiversity to degraded areas.

Plots are planted with 20-30 tree species and then subjected to different treatments including different methods of fertiliser application, weeding and mulching. In addition, trees are planted at different densities.



Saplings propagated using different nursery methods are compared with those transplanted directly from forest. The performance of the planted trees is monitored 3 times per year. In addition, the attractiveness of the planted trees to seed-dispersing birds is monitored, as well as the species diversity of the ground flora and recruitment and subsequent performance of naturally-establishing tree seedlings. Planted plots are compared with non-planted control plots.

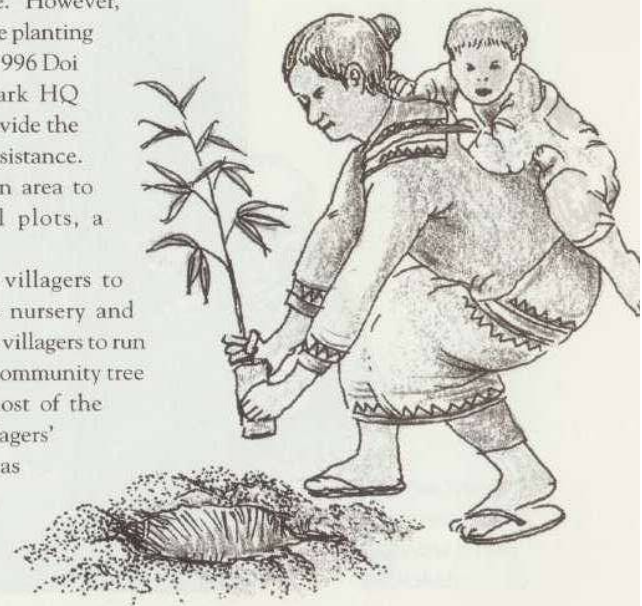
These experiments have identified several top-performing tree species including, *Melia toosendan*, *Erythrina subumbrans*, *Sapindus rarak*, *Spondias axillaris*, *Hovenia dulcis*, *Gmelina arborea*, *Prunus cerasoides*, *Ficus subulata*, *Ficus micro-carpa* and *Ficus altissima*. Optimum methods of weeding, fertiliser application and mulching, determined from this research are described in the section on "Growing, Planting and Caring For Native Forest Trees".

### Working with a local community

FORRU is not a social development project. Its aim is not to persuade individuals or communities to plant trees, but to provide technical advice to those who decide for themselves that they would like to become involved in restoring the nation's disappearing forests. One such community is Ban Mae Sa Mai on the northern slopes of Doi Suthep-Pui.

The villagers wanted to restore forest to abandoned agricultural land above their village to protect the watershed and celebrate the King's Golden Jubilee. However, their initial attempts at tree planting were disappointing, so in 1996 Doi Suthep-Pui National Park HQ asked FORRU staff to provide the villagers with technical assistance. Since FORRU needed an area to establish experimental plots, a partnership was formed.

FORRU helped the villagers to build a community tree nursery and trained and employed two villagers to run it. The Ban Mae Sa Mai community tree nursery now produces most of the trees needed for the villagers' tree-planting activities as well as some planted in FORRU's experimental plots. It is also used to test the feasibility of

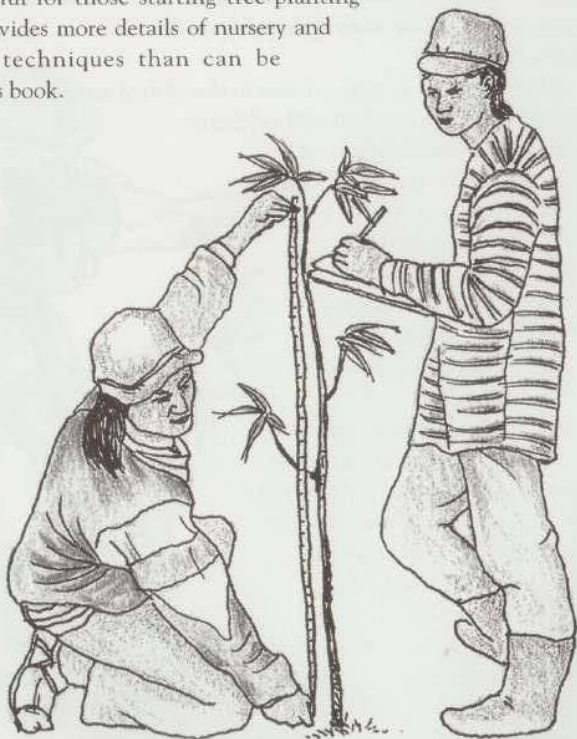




new techniques developed at FORRU's research nursery within a local community. The nursery also has an education and training function. School children in the village visit the nursery during their classes and many workshops and training sessions have been located there. It has also become a focal point for the village's conservation group, the "Mae Sa Mai Resources Conservation Volunteer Group". This group organises tree planting, the cutting of firebreaks and fire lookouts to protect the planted areas.

### Sharing results

All results of FORRU's research are freely available to any individuals or groups interested in restoring forests. In addition to hosting many visits from a wide range of different organisations throughout the year, FORRU organises workshops to share information generated by the project. Furthermore, the unit has produced several publications, details of which are provided in the list of references at the end of this book. FORRU's first training manual "Forests for the Future: Growing and Planting Native Trees for Restoring Forest Ecosystems" is particularly useful for those starting tree-planting projects. It provides more details of nursery and tree-planting techniques than can be described in this book.



## THE AIM OF FORRU...



*...is to develop ecologically effective and socially acceptable techniques to turn degraded areas like this.....*



*...back into forest like this, to restore habitat for wildlife and protect watersheds.*



## SHARING RESULTS



*The results of FORRU's research programme are made available to a wide range of organisations at frequent workshops.*



*New techniques developed by FORRU's research are tested at a community tree nursery run by the villagers of Ban Mae Sa'Mai.*



## THE FRAMEWORK SPECIES METHOD OF FOREST RESTORATION

With more than 1,100 tree species growing naturally in northern Thailand, it would be impossible to grow and plant them all. Forest restoration projects cannot replant all the tree species that might once have grown on any particular site. Replicating the exact species composition of the original tree community is impossible, since for most sites, the identity of all tree species originally present is unknown. Neither can forest restoration recreate entire forest ecosystems in a single step. Rather, the aim of forest restoration is to enhance and accelerate the natural processes of forest regeneration, in order to restore ecosystem structure and function and original levels of biodiversity. This can be achieved by planting a mixture of 20-30 native forest tree species that rapidly shade out weeds and attract seed-dispersing animals. This is the framework species method of forest restoration, developed in the late 1980's in Australia to restore forests to degraded sites within Queensland's Wet Tropics World Heritage Area (Goosem and Tucker, 1995; Lamb et al., 1997; Tucker and Murphy, 1997). Since 1997, FORRU has been adapting this approach to forest restoration in northern Thailand, using forest tree species indigenous to the region (Elliott et al., 1997).

### Selecting framework tree species

Framework tree species must rapidly "capture" degraded sites, by growing fast and developing dense, spreading canopies that shade out herbaceous weeds. Competition with weeds is one of the most important factors preventing forest regeneration in degraded areas. Weeds also provide fuel for fires; control of weeds is therefore an essential part of any forest restoration programme and it is very expensive. So, selecting tree species that rapidly shade out weeds will reduce weeding costs and help prevent fire. However, structural diversity is also important in creating wildlife habitat. Therefore, a few trees with tall narrow crowns can also be included in the species mix.

Framework tree species should provide resources for wildlife, such as edible fruits or seeds, nectar, roosting or nesting sites. Planted framework trees will then attract seed-dispersing animals that might have fed on fruits and seeds in remaining nearby areas of forest. These animals will help disperse the seeds of non-planted tree species into the planted sites, thus accelerating the return of biodiversity. In the past, large mammals such as elephants, rhinos and wild cattle would have dispersed seeds from forest into deforested areas, but now these animals have mostly disappeared from the forests of northern Thailand. The most important seed-dispersers today are birds,



fruit bats and civets. These are the animals that must be attracted into planted sites. However, since they are unable to disperse very large seeds, it is beneficial to include some large-seeded tree species amongst the framework tree species planted.

Fire is an annual hazard during the dry season and can destroy years of hard work in an instant. If fire prevention measures fail, it helps if some of the planted tree species have been selected for their natural resilience to fire damage. Such species readily resprout from their rootstock or stem after fire has burnt their above-ground parts (i.e. coppicing).

From a practical point of view, selected tree species should be easy to propagate in nurseries. They should fruit prolifically and have high rates of seed germination and seedling growth.

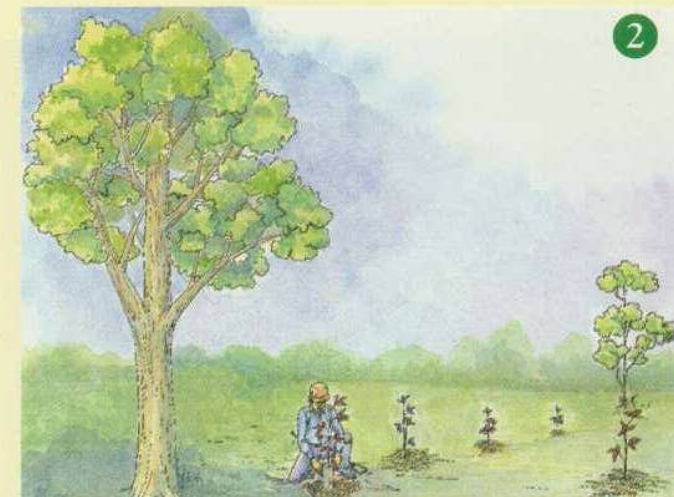
The mixture of framework tree species selected should include of both pioneer species (fast-growing trees, which colonise open areas) and slower-growing climax species (those normally growing in mature forest). By planting both types of tree species at the same time, forest succession can be short-circuited. Many climax forest tree species can perform well in the open, sunny conditions found in deforested areas. The main reason why they do not usually colonise such areas is lack of seed dispersal. By including some climax forest tree species amongst those planted, it is possible to overcome this limitation and accelerate the return of climax forest. Fast-growing pioneer trees quickly close canopy and shade out weeds. Climax forest trees, which grow more slowly, form a rising understorey beneath the canopy of the pioneer trees. The new forest canopy attracts seed-dispersing birds, bats and civets into the planted site. Seeds dropped by these animals germinate to form a layer of young, naturally established trees. Pioneer trees tend to be short-lived and many begin to die naturally 10-20 years after planting. By this time, the understorey of slower-growing climax forest trees is ready to replace them, along with a dense layer of naturally established trees.

The tree species covered in Part 2 of this book include those most likely to act as framework species in northern Thailand, as well as those that naturally colonise deforested sites. They are not the *only* species that should be planted, but most have a track record of good performance after planting out in deforested sites. We encourage tree planters to experiment with as many species as is practical, bearing in mind the framework criteria outlined above. Currently FORRU is concentrating on upper watershed areas, so many of the species detailed in Part 2 are suitable for planting on sites above 1,000 m elevation, but readers will note, from the elevation ranges provided, that many species can also be planted at lower elevations.

## THE FRAMEWORK SPECIES METHOD OF FOREST RESTORATION



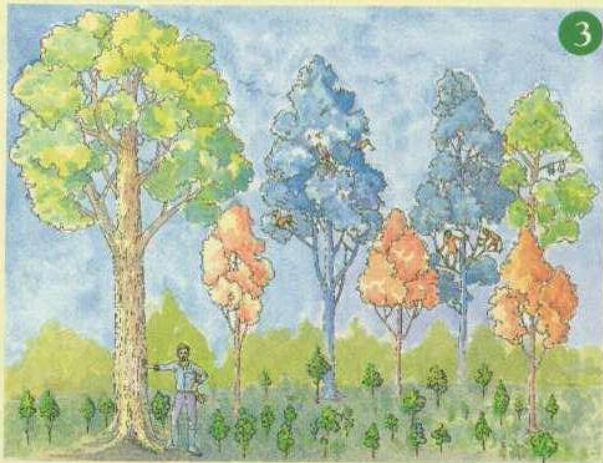
*The site is cleared of weeds, taking care to preserve any existing tree seedlings or saplings.*



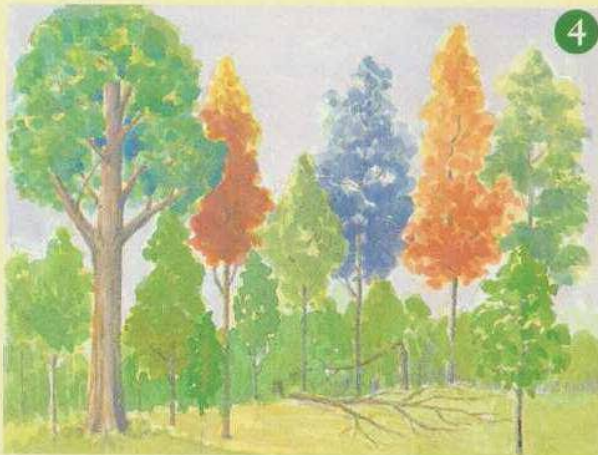
*A mixture of 20-30 native tree species, including both pioneer (indicated by blue saplings) and climax (indicated by red saplings) species, is planted, spaced 1.6-1.8 m apart.*



## THE FRAMEWORK SPECIES METHOD OF FOREST RESTORATION



The pioneer trees (blue) grow rapidly, forming an upper canopy, which attracts seed-dispersing wildlife. Slower-growing climax trees form an understorey (red). Seeds brought in by wildlife, germinate to form a layer of naturally-established trees (green).

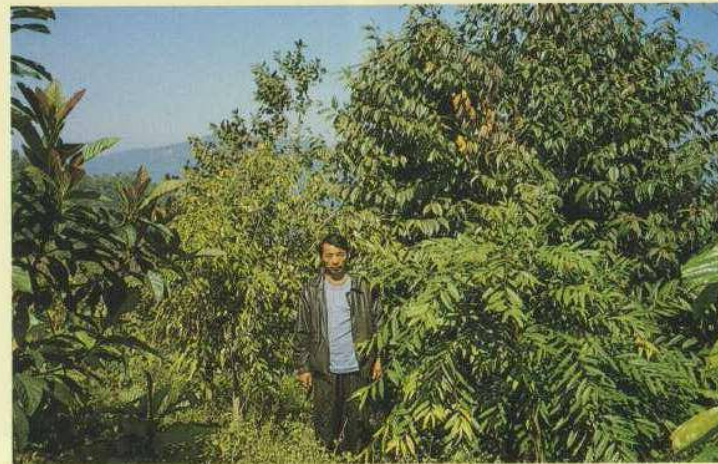


After 10-20 years the pioneer trees begin to die, recycling nutrients and providing rotten wood for invertebrates. The planted climax trees (red) form the main canopy. Underneath, naturally-established trees (green) form an understorey, ready to return the forest to its former diversity.

## FRAMEWORK SPECIES TRIALS ON DOI SUTHEP



Twenty years ago, this area near Ban Mae Sa Mai was covered in lush evergreen forest. Degraded by excessive cultivation, invaded by weeds and ravaged by frequent fires....could it be restored?



The same site 2 1/2 years after planting with 29 framework tree species. The canopy is beginning to close. Fig trees in the foreground are already producing fruits, which attract seed-dispersing birds into the plot.





*Macaranga denticulata* - 6 months after planting, its large leaves rapidly shade out weeds



*Balakata baccata* - 6 months after planting; its dense canopy and attractive fruits make it an ideal framework species



*Ficus altissima* - 1 year 2 months after planting. Figs are a key food resource for wildlife.



*Prunus cerasoides* - 2 years 2 months after planting. This species can begin to flower 2 years after planting, producing fruits relished by birds.



## GROWING, PLANTING AND CARING FOR NATIVE FOREST TREES

The following notes provide a brief summary of how to establish mixed-species plantations of the tree species described in Part 2 (for more complete information please see "Forests for the Future", FORRU 1998). The main effects of such plantations are to accelerate natural forest regeneration, attract wildlife into planted areas, prevent soil erosion and conserve water resources.

Once a community or organisation has decided to carry out a tree-planting programme, one of the first questions is how to obtain young trees of the species required, of a suitable size and at the right time of the year for planting? Saplings can sometimes be obtained from local commercial nurseries or from the Forest Department. However, most nurseries tend to concentrate on the production of economically important species, such as Eucalypts or Pines. One of the reasons why FORRU was established was to generate information to enable organisations and communities to grow a wide range of the tree species indigenous to northern Thailand.

There are many advantages to communities growing their own trees. The community can select the species grown and collect high quality seed from a nearby source. The community can also control the quality of the trees grown and the time at which saplings will be ready for planting.

### Collecting seeds

Seeds should be collected locally, from trees close to the site to be planted, and at similar elevation, soil type, bedrock etc. Trees that grow well in environments similar to the planting site are likely to grow well at the planting site itself. Seeds should be collected from 10-20 different, widely spaced trees, to maintain genetic diversity among the saplings planted. Do not be tempted to collect seed from a single tree or a very small number of vigorous or high-yielding trees, as the maintenance of genetic diversity is important in the restoration of forests for conservation purposes. Try to ensure that seed is collected from the whole tree, not just from a convenient lower branch. This is particularly important if the tree species is very rare.

The time of seed collection is also important, as seed that is immature or too old, may not germinate. Seed collectors can judge the optimum collection time from the fruit colour or, in the case of dehiscent fruit, when they begin to split open. The number of seeds collected will depend on how many trees are required for planting, the likely germination percentage and the survival rate. Typical germination rates are indicated under each species description in Part 2.



Seed collection trips require planning and liaison with the people responsible for treating and sowing the seeds, because the seeds are vulnerable to desiccation and/or fungal attack, if they are not handled carefully. Avoid leaving seeds in the sun, where they could dry out. Many species cannot tolerate desiccation and will quickly die. Also, do not keep seeds in damp places for any length of time, as some species will germinate prematurely, or succumb to fungal attack.

If no information is available about seed storage, sow the seeds immediately. Storage is an important issue, but for the seeds of many native tree species, much more research is required. The length of time seeds remain viable after collection differs among species. The most common treatment for storing seed is to dry them to a low moisture content and to store them in a dry, cool environment. Species with seeds that will tolerate drying are termed 'orthodox'. However, many species produce 'recalcitrant' seeds that die when dried. The seeds of such species should be sown as quickly as possible after collection.

Some seeds require cleaning or pre-treatment before sowing (or storage). Seeds in fleshy fruits should be removed and cleaned, otherwise the fruit flesh will attract insects and fungi, which may attack the seed. Seeds within a tough, woody pyrene should be removed by cracking open the pyrene with a vice or hammer. Dehiscent fruits (capsules and pods) should be allowed to dry naturally until they split open and the seeds can be removed.

The seed itself may require pre-treatment to overcome dormancy. If large seeds have a thick seed coat, then cutting away a small piece of the seed coat with a sharp knife can accelerate germination. For smaller seeds, rubbing them with sandpaper or placing them in hot water or acid for a few minutes can have the same effect. All of these treatments enable the seeds to absorb water, which triggers germination. The required treatment for each species is indicated in Part 2.

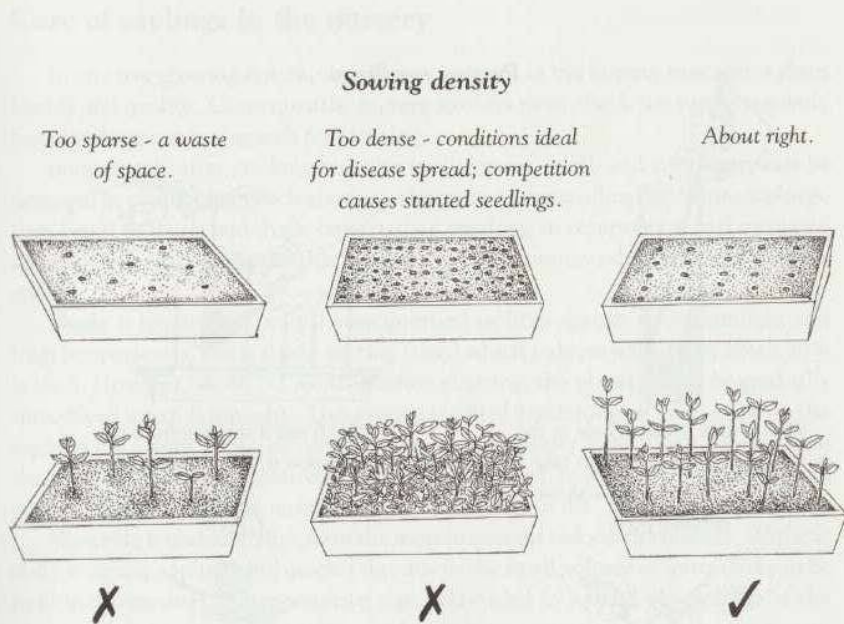
## Seed germination

After any necessary pre-treatments, seed should be sown in a germination mix in plastic trays. The mix used at FORRU contains 67% forest soil and 33% coconut husk. Other materials can be used, but any germination mix must provide adequate aeration and drainage to bring about germination.

Sowing density (the number of seeds sown in each tray) is important. Whilst too few seedlings per tray is wasteful in terms of space and materials, too many will create ideal conditions for the spread of diseases, particularly the fungal diseases collectively termed 'damping-off'. It is important to monitor the seedlings for disease, since they are particularly vulnerable just after germination and infection can spread rapidly. Infected seedlings should be removed or fungicide applied (e.g. Captan).

The results of FORRU's germination trials show that for most species, seed germination is better in partial shade (about 40% of full sunlight) than in deep shade.

Shade requirements for germination of each species are outlined in Part 2. Some species with large seeds and high germination rates (e.g. *Quercus semiserrata*) may be sown directly into containers.



## Pricking out

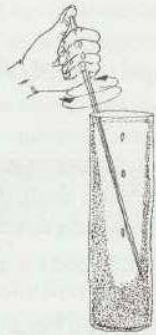
After germination, seedlings must be transplanted into individual containers filled with a potting mix; a process termed pricking out. Only vigorous healthy seedlings should be transplanted. Weak or diseased seedlings should be burnt or thrown away.

Rigid plastic pots, with vertical grooves to prevent root spiralling (REX tray root-trainers, available from Mahasarakham Nursery Centre, P.O. Box 81, Muang, Khon Kaen) or black plastic bags 9" x 2 1/2" are suitable containers. The potting mix must provide physical support for seedlings as they grow into saplings large enough for planting, over 6-18 months, depending on species. The mix must provide everything required for growth of a vigorous and healthy root system including aeration, drainage, water and nutrients. Simply filling a container with forest soil will not achieve this, as the container wall will impede drainage and reduce oxygen supply, resulting in weak, sparse roots. Consequently, forest soil must be mixed with other ingredients to make a potting mix with a more open texture within the confines of the container.

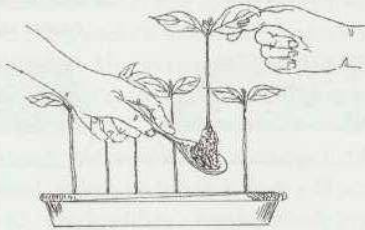


An example of a successful mix used at FORRU is 50% forest soil, 25% peanut husk and 25% coconut husk. However, any locally available materials can be used to make a good potting mix, provided the mix has all the properties mentioned above.

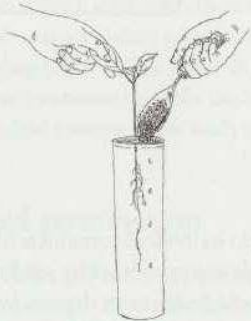
### Potting seedlings



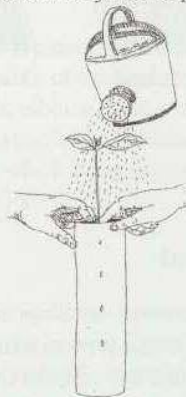
With a stick, make a hole in the potting mix, deep enough to take the roots of the seedling without bending them.



Gently lift out a seedling from the germination tray with a spoon.



Place seedling in a container and fill with potting mix.



Firm down the potting mix and water.

Seedlings should be pricked out when the first or second leaf pair is fully developed. Pricking out requires utmost care, as seedlings are very delicate at this stage of their development. Seedlings should be gently lifted out of the germination tray with a spoon, holding the seedling by the leaf, rather than the stem. A seedling may tolerate

slight leaf damage, but damage to the stem provides an entry point for diseases and the plant is unlikely to survive.

### Care of saplings in the nursery

In any tree growing system, the primary concern of the nursery manager is plant health and quality. Consequently, nursery workers must check the plants regularly from pricking out to dispatch for planting.

Immediately after pricking out, the seedlings are small, and containers can be arranged in contact with each another. However, as the seedlings grow into saplings, they begin to touch and shade one another, resulting in competition and increased risk of pests and diseases. As this begins to occur, containers should be more widely spaced.

**Shade** is required to protect containerised saplings against strong sunlight and high temperatures. Black shade-netting (slan) which reduces sunlight by about 50% is ideal. However, about 1-2 months before planting, the plants should be gradually introduced into full sunlight. This process is called 'hardening off'; and prepares the saplings for planting into an environment which is likely to be much harsher than the nursery. Saplings transferred directly from a shaded, humid environment into an exposed planting site will most likely perform poorly or die.

**Watering** is undoubtedly one of the most important tasks in the nursery. Without daily watering, saplings will quickly die, due to the small volume of water that can be held in a container. Over-watering can be avoided by careful observation of the plants and the wetness of the soil immediately before watering. Growth of mosses in the containers is a clear indication of over-watering.

**Fertiliser** application depends on the species involved and on the growth rate required. Weak saplings with yellow leaves require fertiliser. However, it is possible to accelerate seedling growth too much, particularly with fast-growing species such as *Prunus cerasoides*. This results in saplings out-growing their containers before the planting season. Consequently, some experimentation may be required to arrive at the appropriate rates of fertiliser application for each species. At FORRU, good results have been obtained with slow release fertiliser, such as 3-month Osmocote, NPK 14:14:14. About 10 granules per container are placed on the surface of the potting mix at 3-monthly intervals.

**Pruning** is often necessary, particularly for species which grow quickly in the container, or which are retained in the nursery for a long period, due to the time of sowing and planting. Roots that grow through the holes at the base of the containers can be easily removed with pruning-shears. This task should be carried out at a cool time of the day, to minimise stress to the saplings. If the saplings are neglected, fibrous roots important for water uptake will grow into the soil below the pots. When the pots are finally moved, the damage to these roots will cause severe stress to the



saplings. This can be avoided by regular checking. Fast-growing species with soft weak stems should have their shoots pruned about 1 month before planting. This reduces damage during transportation and allows enough time for the development of new leaf buds before planting.

**Control of weeds, pests and diseases.** It is easy to overlook pests and disease, which may have serious consequences if the outbreak spreads quickly through the saplings. The risks however can be minimised by simple procedures;

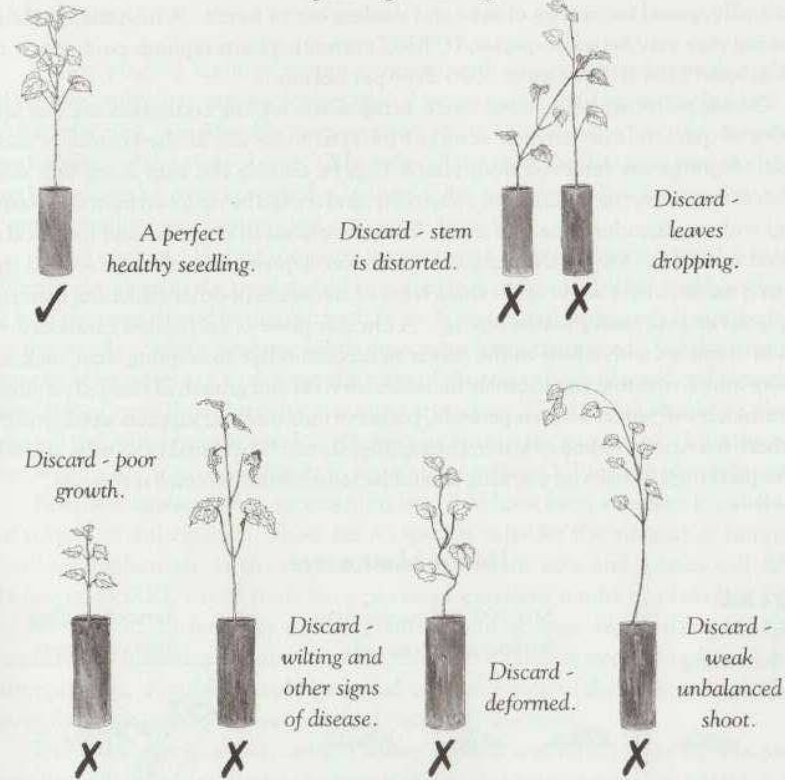
- i. regular checking, looking for health and hygiene problems amongst the plants,
- ii. immediate response to problems, for example by applying pesticides, or removal of affected plants if the problem is severe,
- iii. removal of weeds, which can compete with saplings as well as harbour pests and disease,
- iv. provision of adequate ventilation amongst the saplings, by spacing the pots out as the saplings develop.

It is necessary to walk around the nursery at least once a week, carefully inspecting saplings for early signs of pests, diseases or other problems. Serious losses can be averted if the nursery manager becomes familiar with the plants and invests a relatively small amount of time each week to monitor their growth.

The plants should be graded before they are dispatched for planting. Routine checking should prevent poor quality saplings being maintained for many months, only to be discarded at the time of hardening off and dispatch. Quality control at this stage is very important, because it is a false economy to plant a weak sapling, which will not survive, only to require replanting the following year.

Depending on the species, plants may have to be maintained in the nursery for up to 18 months. The actual period will depend on both the growth rate and the dates of seed sowing and planting. Both these dates are outside the control of the nursery manager, unless seed can be stored. Otherwise, seed must be sown soon after collection. By the time of the planting season (May-June), saplings must have grown to a suitable planting size (usually 50-60 cm tall, or 30 cm for the fastest-growing species). This means that it may be necessary to accelerate the growth of certain species to ensure that they reach a suitable size in time for planting. Other species might need to be retained in the nursery for many months after they have reached a plantable size. Compilation of a 'production schedule' helps nursery managers to plan all activities in the nursery, from seed collection through to hardening off and dispatch. It ensures that seed is collected at the right time and that labour is available at busy times of the year. The poster accompanying this book provides a preliminary production schedule based on the best information currently available. Nursery managers are encouraged to monitor their own nursery production processes and modify the poster accordingly.

### Grading seedlings



### Planting

At the planting stage, the care taken to produce high quality saplings pays off, in terms of establishment, survival and subsequent performance. In northern Thailand, mixtures of 20-30 framework tree species should be planted in May-June, after the monsoonal rains have become reliable. This gives the planted trees maximum time to establish and develop a deep root system that should enable them to withstand the dry conditions of the first hot season after planting (from February to April).

During transportation from the nursery to the planting site, the trees are vulnerable to damage and stress, although those grown in containers, if handled properly, are more resistant to dehydration than bare-rooted saplings. Nevertheless, they must not be allowed to dry out and the containers should not be squashed together or piled on top of one another.

One of the primary aims of forest restoration is to achieve a closed canopy as

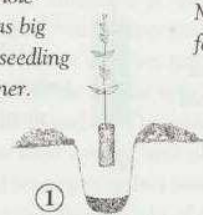


soon as possible. Hence, planted saplings must become established quickly and be optimally spaced for canopy closure and shading out of weeds. Whilst the optimum spacing may vary between species, FORRU currently plants saplings randomly, 1.6-1.8 m apart (494-625 per rai or 3086-3906 per hectare).

During planting, holes about twice as big as the sapling containers are dug and 100 g of quick-release fertiliser is mixed into the loose soil at the bottom of each hole. Saplings are removed from plastic bags by cutting the bags along one side. Even at this stage, the saplings are vulnerable, and should be removed from the plastic bags without disturbing the root mass. They are placed in the holes and loose soil is added until they are firmly anchored. A saucer depression in the soil around the stem is made to save water and a thick layer of cut weeds or other mulching material is placed around each planted sapling. A circular piece of corrugated cardboard 40 cm in diameter, with a hole in the center to accommodate the sapling stem, makes a cheap mulch mat that significantly increases survival and growth of planted saplings. The mulch will reduce soil temperature, conserve moisture and suppress weed growth. If there is a nearby source of water, the saplings should be watered as soon as possible after planting. Otherwise planting should be scheduled when rain is forecast.

### How to plant a tree

Dig a hole twice as big as the seedling container.



①

Mix 100 g of quick-release fertiliser into loose soil.

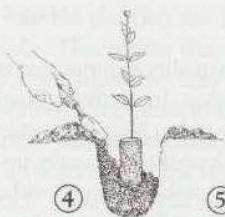


②

Remove seedling from container.



③



④

Place seedling in hole and fill in with soil.



⑤

Firm soil around the seedling and make a shallow depression to collect water.



⑥

Place mulch (cut vegetation) around the seedling and water it or plant when raining.

## Aftercare

Newly planted saplings cannot compete with vigorous weed growth and are therefore unlikely to survive longer than 2 years, unless they are properly cared for. After planting, considerable management effort is essential to ensure maximum performance of the planted trees. Otherwise, all the work that has gone into producing and planting the trees is wasted. Caring for the trees after planting involves weed control, fertiliser application and protection from fire.

**Weed control.** During the rainy season, weeding is necessary every 4-6 weeks. Weeds very close to the trees should be pulled by hand and all other weeds within 1-2 m of the trees should be dug out with hoes. It is essential to dig or pull out the roots of the weeds. Simply slashing weeds does more harm than good. Whilst weeding, care must be taken not to damage the roots of the trees. Both planted and naturally-established trees should receive the same attention. Dead weeds should be placed around the young trees as a mulch. Herbicides are not recommended whilst the trees are small, since it is very difficult to apply them without killing the planted trees.

**Fertiliser application** is necessary on sites that have been extensively cultivated or subject to soil erosion. There are no specific rules for the amount or timing of fertiliser application, as the requirements of different sites and species will differ. However, FORRU's field trials have produced excellent results by providing 100 g of NPK 15-15-15 fertiliser during planting and at least two further 50-100 g applications immediately after weeding, during the rainy season, for at least 2 years after planting. Fertiliser should be spread in a circle around the trees, at least 30 cm away from the base of the tree to avoid "burning" the stem.

**Fire** is the most common cause of failure of forest restoration projects. Thorough weeding will help to minimise the impact of fires, but in most areas fire-breaks, 6-8 m wide, should be cut to prevent the spread of fire into planted areas. Constant vigilance by patrols is necessary during the dry season to spot any fires moving towards the planted areas. Fire-fighting tools should be stored close to the planting sites and teams of fire fighters organised to extinguish any fires that threaten the planted trees. Public education to persuade people not to start fires might help to alleviate the problem in the long-term, but meanwhile, the above precautions will remain the best defence against fire.

If these simple recommendations are followed, the canopy of the forest should close in less than 3 years after planting. Beneath the canopy of planted trees, a layer of young, naturally established trees should develop, eventually returning the forest to its original condition.



### Recommended Weeding Method



Weeds growing around a tree deprive it of light, moisture and nutrients.



Close to the tree, pull out weeds by hand. Avoid damaging the tree roots.



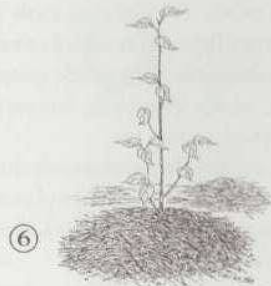
Dig out the roots of all weeds within 1-2 m of the tree.



Form a shallow circular channel around the tree.



Apply fertiliser at least 30 cm from the base of the tree.



Pile dead weeds around the tree as mulch.

## PART 2



### SELECTED TREE SPECIES

.....  
HOW TO USE PART 2  
KEY TO YOUNG SEEDLINGS  
SELECTED TREE SPECIES FOR  
RESTORING FORESTS



Saplings of just a few of the many framework tree species grown at FORRU.





## HOW TO USE PART 2

This part of the book contains descriptions of 45 tree species recommended for forest restoration. All of them fulfil at least some of the framework species criteria described in Part 1. Part 2 provides sufficient information to enable readers to identify these species, collect seeds and grow seedlings. All descriptions are based on specimens, stored at the Chiang Mai University (CMU) Herbarium in the Department of Biology. Given the large number of tree species in northern Thailand and the similar appearance of many species, this book cannot guarantee identification to species level. However, if all the information on appearance, phenology, habitat and elevation range is carefully considered, correct identification will be achieved in most cases. For young seedlings, the key on pages 31-34 provides an additional identification aid.

All descriptions are based on features that can be seen with a 10x-magnification hand lens, and are thus suitable for use in the field. Species are arranged in alphabetical order by **botanical name**, shown on the top of each page, followed by the **family**, **English name or accepted trade name** where known, and the **Thai name**. The glossary, starting on page 137 and Figures 1-11 will help readers interpret the descriptions. Information listed in each description includes the following:

The **abundance** of the species in northern Thailand, based on the extensive records of the Chiang Mai University Herbarium and the **general size** of the mature tree (where small is up to 15 m tall, medium is 15-25 m and large is 25 m or taller) are provided. Next, the description states whether the species is **deciduous** i.e. shedding its leaves annually, usually in the dry season, or **evergreen** i.e. retaining leaves all year round. Some species can exhibit both characteristics, depending on elevation and exposure to drought (this is termed tropophylly). **Height** of the mature tree, in metres, and **trunk diameter at breast height**, (dbh measured 1.3 m above the ground), in centimetres, are listed.

This is followed by a brief description of the adult tree (e.g. **bark**, **leaves and flowers**), based on specimens from northern Thailand. Leaf blade dimensions are highly variable, so the most representative examples have been chosen from the specimens available. Given the space limitations of this book, only gross flower characteristics such as colours and type of inflorescence are provided. The descriptions complement the line drawings of adult leaves and fruit.

**Fruits and seeds** are then described; giving sizes and colour changes. The data are based on research undertaken at the CMU Herbarium since 1995 (Pakkad, 1997). Colour plates presented in Part 3 complement this section.

The **habitats** in which each species usually grows are listed, using the habitat categories of the CMU Herbarium database (Maxwell et al., 1995 and 1997):

- 1) **Bamboo + deciduous forest** from lowlands and foothills in northern Thailand, up to about 900 m elevation has replaced the original teak forest. Teak is absent or reduced to a minor component of the forest. Tree species richness is, approximately 150, of which 77% are deciduous. The main canopy trees are up to 30 m tall and no single tree species dominates. Bamboo thickets indicate disturbance, where tree felling or fires reduce canopy cover. Bamboo can persist even if over-topped by trees, and can inhibit tree seedling establishment.
- 2) **Deciduous dipterocarp-oak forest** replaces bamboo + deciduous forest in dry or degraded areas, in the lowlands and along dry ridges with little or no top soil, up to 900 m elevation. Most (about 86%) of the 88 tree species in this forest type are deciduous. It is a secondary, fire climax forest. Where fires occur frequently, oaks (Fagaceae) may be rare or absent. If such areas are protected from fire, oaks slowly re-establish themselves, if seed-producing trees survive nearby. The trees rarely grow more than 20 m tall and the canopy is open, allowing a ground layer to develop, dominated by grasses and sedges. In some areas, pine also occurs in this forest type.
- 3) **Mixed evergreen + deciduous forest**, with a mixture of deciduous and evergreen trees, is found from about 800 m elevation (600 m near permanent streams) up to 950-1000 m. This forest type is transitional between evergreen and deciduous forest, but it supports many species that do not occur in the other forest types. Such forest has high tree species richness (about 200 tree species) of which only 42% are deciduous. Canopy height varies from 20 to 30 m, but emergent trees exceeding 30 m are fairly common. Canopy cover is usually complete, though less dense than in evergreen forest.
- 4) **Evergreen forest** merges with upper mixed evergreen + deciduous forest from c. 900-950 m elevation. Primary evergreen forest has the highest tree species richness of all the forest types; c. 250 species (of which only 28% are deciduous). The main canopy is higher and denser than that of the other forest types, often exceeding 30 m in height. Emergent trees occur. Beneath the main canopy is a lower storey, of smaller trees, treelets, and shrubs. Woody climbers are common and epiphytes are abundant. Seedlings and saplings of the adult trees, and numerous herbs dominate the ground flora. Grasses are mostly absent.
- 5) **Evergreen forest with pine** occurs on fire-prone, exposed ridges at elevations of about 950-1800 m. *Pinus kesiya* Roy. ex Gord. (Pinaceae, three-leaved pine) grows with other evergreen forest tree species and in some places, it dominates the forest. Evergreen forest with pine has fewer tree species (95, of which 25% are deciduous) than evergreen forest without pine. The canopy tends to be more open than that of evergreen forest without pine, fires and eroded soils are common.



If a species is often found in degraded habitats this is noted in the text, as it can be an important criterion for selecting species that will survive in sites requiring restoration. This is followed by the known **elevation** range of the species in northern Thailand.

Selected **uses** of each species are summarised from several sources, listed in the bibliography, and augmented by information from Thai and Hmong hill tribe villagers living in or near forests. The lists are not exhaustive.

The geographical **distribution** of each species excludes artificial introductions and is based on the CMU Herbarium Database and on references listed in the bibliography.

**Seedling descriptions** for each species are based on fresh specimens grown from seed in FORRU's research nursery. Seedlings were examined, from the cotyledonary or first leaf stage until the seedling had grown sufficiently large for potting. The descriptions cover the variability found among the specimens. The text is complemented by line drawings of the seedlings in both the early growth stages and at 30-50 cm in height.

**Cotyledons and cotyledonary leaves** are described for species with these organs visible above the soil (i.e. those with epigeal germination). For species with hypogeal germination (where cotyledons remain hidden below the soil) morphology of the cotyledons and hypocotyl are not essential for species identification. Sizes given are those of the fully expanded cotyledons or cotyledonary leaves.

The **stem** is described in 3 parts viz. the **hypocotyl** (where it emerges above ground), **epicotyl** and **internodes**. The **leaves** are described, with particular attention to changes in shape and arrangement. The sizes of the first 3 blades to emerge when mature are given, so that the scale of the seedling is clear. The primary and secondary **venation** (where visible) are briefly described. Descriptions and sizes are provided for the **petioles**, **stipules** and **petiolules** where they occur.

Recommended methods of **propagation** are based on the results of FORRU's research. Information is provided on when to collect seeds, how to prepare them before sowing, and whether to sow in partial or deep shade. Partial shade is approximately 40% of full sunlight, similar to conditions in partially regenerating gaps, whilst deep shade is less than 1% of full sunlight, similar to conditions under a forest canopy. Shallow trays are recommended for seed germination unless otherwise stated. Typical germination rates (**GR**) and the period required to achieve such levels of germination are given. Seedlings should be planted out when they are 50-60 cm tall. Sometimes such growth can be achieved by the first planting season (June-July) after seed germination, but for other species, seedlings must be grown for longer periods in the nursery. Broad guidelines as to the growth period required before planting are given.

The information in the following pages should be sufficient to successfully identify and grow trees for forest restoration. Problems in identification should be referred to an experienced taxonomist.



## KEY TO YOUNG SEEDLINGS

This key is an identification aid to young seedlings of the tree species described in this book. It refers to seedlings that retain their cotyledons or cotyledonary scars and for which germination type can be determined. Starting at the first statement, select the phrase that most suits the specimen being identified. Then proceed to the next numbered statement indicated and repeat until a species name is reached. Identifications should then be confirmed by reading the species descriptions in the text.

1. Germination type:	epigeal hypogeal / semi-hypogeal	2 26
2. Epigeal germination; cotyledonary leaf:	distinctly longer than wide approximately wide as long	3 13
3. Cotyledonary leaf apex:	acute or acuminate obtuse retuse/emarginate	4 5 8
4. Cotyledonary leaf attachment:	decurent or sessile petiolate	18 21
5. Cotyledonary leaf base:	truncate, cuneate or attenuate obtuse or acute	6 7
6. 1 <sup>st</sup> leaf blades simple, ovate, venation light green all over, petioles light green 1 <sup>st</sup> leaf blades simple, ovate, venation light green but pink at base, petioles pink 1 <sup>st</sup> leaf blades simple, elliptic to oblong, cotyledonary leaves bifoliate 1 <sup>st</sup> leaves imparipinnate		<i>Ostodes paniculata</i> <i>Balakata baccata</i> <i>Engelhardia spicata</i> var. <i>spicata</i> <i>Sapindus rarak</i>



7. Leaf blade margin:	entire toothed	9 10
8. Leaf blades hairless, elliptic to lanceolate after 2 <sup>nd</sup> node, petioles 1-2 mm Glandular hairs on blades and stem, leaf blades ovate to deltoid, petioles >30 mm		<i>Eurya acuminata</i> <i>Gmelina arborea</i>
9. Base decurrent, leaves simple, with sparse tiny white hairs  Base petiolate, leaves compound, hairless		<i>Pterocarpus macrocarpus</i> <i>Dalbergia cultrata</i> var. <i>cultrata</i>
10. Blade hairs light brown  Blade hairs white		<i>Elaeocarpus braceanus</i> 11
11. Glandular stipules present Stipules absent, or if present not glandular		<i>Prunus cerasoides</i> 12
12. Stipules absent Stipules light green, petioles light green-pink, toothed margin constant		25  <i>Betula alnoides</i>
13. Cotyledonary leaf apex:	obtuse retuse, emarginate or not obtuse	14  16
14. Cotyledonary leaf apex obtuse; base:	obtuse, partially decurrent obtuse, petiolate	  <i>Bischofia javanica</i> 15
15. Cotyledonary leaf margins entire, 1 <sup>st</sup> blades toothed all round Cotyledonary leaf margins entire, 1 <sup>st</sup> blades toothed in apical half		<i>Hovenia dulcis</i>  <i>Ficus subulata</i> var. <i>subulata</i>
16. Cotyledonary leaf apex retuse Cotyledonary leaf apex emarginate, 1 <sup>st</sup> blades elliptic, red hairs on petiole Cotyledonary leaf apex acute, 1 <sup>st</sup> blades ovate, white hairs on petiole		17  <i>Ficus altissima</i>  <i>Macaranga denticulata</i>

17. 1 <sup>st</sup> leaf blades ovate, base obtuse, margin entire		<i>Ficus benjamina</i> var. <i>benjamina</i>
1 <sup>st</sup> leaf blades ovate, base obtuse, 1st pair slightly oblique, margin toothed in apical half		<i>Ficus microcarpa</i> var. <i>microcarpa</i>
1 <sup>st</sup> leaf blades obovate, epidermis with many white glandular hairs		<i>Callicarpa arborea</i> var. <i>arborea</i>
First 2 leaf pairs ovate, base truncate, then elliptic, many non-glandular hairs below		<i>Debregeasia longifolia</i>
18. Cotyledonary leaf attachment decurrent or sessile; primary veins:	parallel not parallel	19 20
19. 5 parallel primary veins, cotyledonary leaves green, first leaves simple 3 parallel primary veins, cotyledonary leaves pinkish, first leaves compound		<i>Diospyros glandulosa</i>  <i>Spondias axillaris</i>
20. Primary veins pinnate, 1 <sup>st</sup> leaf blades elliptic, 41 x 24 mm Primary veins pinnate, 1 <sup>st</sup> leaf blades obovate or oblong, 11 x 6 mm, like leaflets		<i>Manglietia garrettii</i>  <i>Phyllanthus. emblica</i>
21. Cotyledonary leaf attachment petiolate; cotyledonary leaves:	compound simple	22  <i>Morus macrooura</i>
22. Cotyledonary leaves compound;	venation pinnate primary veins	23 24
23. Cotyledonary venation pinnate;	petioles pink petioles light green	<i>Rhus rhesoides</i> <i>Melia toosendan</i>
24. Cotyledonary venation with 3 primary veins;	leaflets < 3mm wide leaflets >3 mm wide	<i>Albizia chinensis</i> <i>Albizia odoratissima</i>
25. Stipules absent, cotyledonary leaf blades;	oblong, petiole light green suborbicular, petiole pinkish	<i>Nyssa javanica</i> <i>Schima wallichii</i>



26. Germination hypogeal/ semi-hypogeal; 1 <sup>st</sup> leaf blade:	elliptic not elliptic	27 30
27. Later blades:	elliptic  lanceolate to oblong	<i>Horsfieldia amygdalina</i> var. <i>amygdalina</i> 28
28. Later leaf blades lanceolate to oblong; venation:	3 basal primary veins pinnate	<i>Cinnamomum iners</i> 29
29. Stipules;	>2 mm, mid-green, new leaf blades maroon above absent, new leaf blades light green	<i>Castanopsis tribuloides</i>  <i>Phoebe lanceolata</i>
30. 1 <sup>st</sup> leaf blades:	bifid/bifoliate/obcordate ovate or deltoid oblong lanceolate	31 32 33 <i>Castanopsis acuminatissima</i>
31. 1 <sup>st</sup> leaf blades bifid/bifoliate/obcordate, later blades simple, margin; toothed with a sharp white-yellow point on each tooth, no stipules slightly toothed in apical half, stipules with many hairs		<i>Helicia nilagirica</i>  <i>Quercus semiserrata</i>
32. 1 <sup>st</sup> leaf blades ovate or deltoid; later blades: deltoid, base truncate, apex acute or acuminate, with very sparse short white hairs ovate, base obtuse, apex acuminate, hairless		<i>Erythrina stricta</i> <i>Erythrina subumbrans</i>
33. 1 <sup>st</sup> leaf blades oblong;	with brown star-shaped hairs with short, white prickles	<i>Horsfieldia thorelii</i>  <i>Heynea trijuga</i>



## SELECTED TREE SPECIES FOR RESTORING FORESTS



## *Albizia chinensis* (Osb.) Merr.

(LEGUMINOSAE, MIMOSOIDEAE) • Silk Tree • กางหลวง

A fairly common, medium-sized, deciduous tree, up to 23 m tall, dbh up to 52 cm.

**Bark:** smooth, light brown when young, becoming dark grey-black, thick and roughly cracked, branchlets finely lenticellate, grey. **Leaves:** spirally arranged, doubly pinnate; 20-35 x 14-16 cm, leaflets opposite, 9-13 pairs, rachis mid-brown with fine, light-brown hairs; secondary leaflets opposite, 17-33 pairs, asymmetrically lanceolate, apex obtuse, base truncate-acute; sessile and

eccentrically attached, margin entire with short, light brown hairs; blades 7 x 3 mm; above mid-green, hairless; below light green with sparse short hairs, particularly on the midrib; slowly sensitive to touch at night; venation oblique, asymmetrically pinnate; petioles 4-5 cm long, with a distinct gland at the base and white hairs; stipules asymmetrically elliptic, thin, 15 x 10 mm. **Flowers:** in a spreading panicle of glomerules, fragrant; central flowers of each group slightly larger than the

others; calyx pale light yellow, 4 mm long; corolla white-cream outside, slightly longer than the calyx; stamens many; anthers minute, pale light-yellow; filaments much longer than the corolla, light green in the lower half and white otherwise.

**FRUIT/SEED:** pods flat, dehiscent along 1 valve, mid-green when unripe, light brown when ripe, up to 135 x 21 x 1.8 mm, each containing 9-13 flattened, ovoid, dark green seeds up to 5.0 x 4.0 mm (see photo on page 129); dispersed by wind.

**HABITAT:** open disturbed areas and secondary growth in mixed evergreen + deciduous forest, degraded areas in evergreen and evergreen + pine forest; elevation 350-1,450 m.

**USES:** wood, light weight, widely used for house and bridge construction, boat building, furniture and cabinet work, interior finish, agricultural implements, musical instruments, turnery, veneer, charcoal and firewood. Leaves are a low quality fodder. Planted as a shade tree for tea and coffee, wind breaks and to improve soil fertility.

## *A. chinensis*

**DISTRIBUTION:** northern and south-western Thailand, tropical and sub-tropical Asia

**SEEDLINGS:** **Cotyledons:** thick, leathery, opposite, oblong, apex obtuse, base sagittate, margin entire, petiolate, hairless; inside light pink-green; outside light pink-green, wrinkled; venation not visible. **Cotyledonary leaves:** compound, opposite; one once-pinnate leaf with 5 pairs of opposite leaflets with terminal cusp; other leaf bifoliate with 8 pairs of secondary

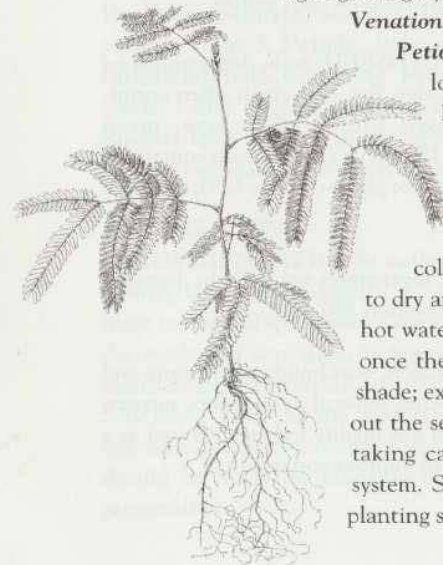
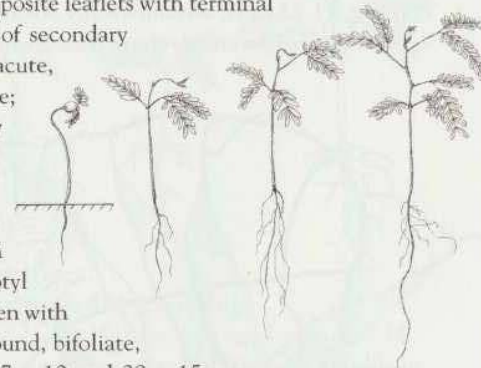
leaflets asymmetrically oblong, apex acute, base cuneate and oblique, margin entire; above bright light green, hairless; below light green-grey with sparse tiny white hairs along the midrib. **Stem:** hypocotyl initially light green to pink-white, then light green, hairless, with fine cream striations and pale cream lenticels; epicotyl light green, hairless; internodes light green with sparse tiny white hairs. **Leaves:** compound, bifoliate, alternate, first three leaves 19 x 14, 17 x 10 and 29 x 15 mm; leaflets asymmetrically oblong, apex acute, base cuneate and oblique, margin entire; 16 or 24 secondary leaflets, 7-8 x 2.5 mm; above bright light green, hairless; below light green-grey with sparse tiny white hairs along the midrib.

**Venation:** midrib eccentric, light green, primary veins 3.

**Petiole:** light green with curled white hairs, 5-15 mm long. **Petiolule:** light green with curled white hairs, 1 mm long. **Rachis:** light green with tiny curled white hairs. **Stipules:** erect, subulate, light green, 2 mm long.

### PROPAGATION RECOMMENDATIONS:

collect brown pods in January-February. Allow them to dry and split open. Remove the seeds, place them in hot water, allow the water to cool and remove the seeds once they begin to swell. Sow seeds in trays in partial shade; expected GR at least 20% over 30-179 days. Prick out the seedlings when they are approximately 5 cm tall, taking care not to damage the rapidly developing root system. Saplings should be ready for planting in the second planting season after collection.

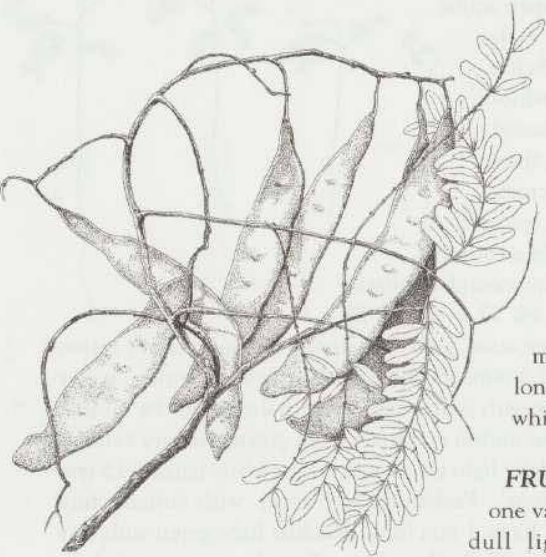




*Albizia odoratissima* (L.f.) Bth. (LEGUMINOSAE, MIMOSOIDEAE) • Ceylon Rosewood • กาน้ำมอด

A fairly common, medium-sized, deciduous tree, up to 16 m tall, dbh up to 50 cm.

**Bark:** thin with irregular vertical and horizontal cracks, dark brown, becoming dark grey with age. **Leaves:** spirally arranged, doubly pinnate; leaflets opposite, 4-6 pairs, up to 44 x 24 cm; rachis mid-brown with tiny sparse cream hairs; secondary leaflets opposite, 11-13 pairs, asymmetrically oblong, apex obtuse, base obtuse-acute; 20-29 x 7-14 mm, margin entire; above dark-green, hairless; below light green, with sparse short, light-brown hairs along the midrib; venation eccentric, asymmetrically pinnate; stipules minute; petioles 4-6 cm long, gland present near the distinct pulvinus. **Flowers:** in a spreading panicle of glomerules, fragrant; central flowers of each group slightly larger; calyx and corollas pale light green, 3-4 mm long; stamens numerous; anthers minute, light green; filaments much longer than the corolla, white; style white; stigma light yellow.



**FRUIT/SEED:** pods, dehiscent along one valve, flat, mid-green when unripe, dull light brown when ripe, mean dimensions 152 x 33 x 2.7 mm, each containing

2-9 flat, ovoid, dark brown seeds 7.9 x 5.8 x 1.9 mm (see photo on page 129); dispersed by wind.

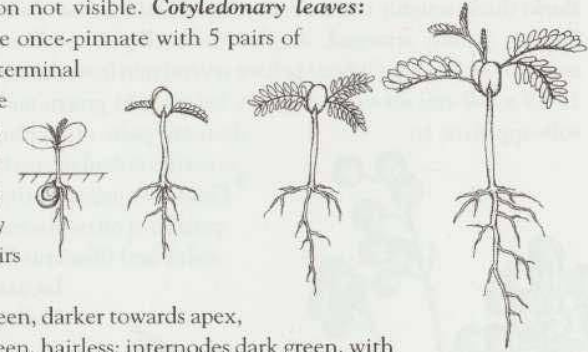
**HABITAT:** mixed evergreen + deciduous forest, regenerates naturally in degraded areas in evergreen and evergreen + pine forest; elevation 350-1,025 m.

**USES:** wood lightweight, widely used for construction, boat building, furniture and cabinet work, interior finish, agricultural implements, musical instruments, turnery, veneer, charcoal and firewood. Leaves provide a low quality fodder. Planted as a shade tree for tea and coffee, for windbreaks and to improve soil fertility.

*A. odoratissima*

**DISTRIBUTION:** northern Thailand, Sri Lanka, India, tropical south-east Asia except for peninsular Malaysia

**SEEDLINGS:** **Cotyledons:** opposite, thick, leathery, oblong, apex obtuse, base sagittate, margin entire, petiolate, hairless; inside mid-green; outside light green, wrinkled; venation not visible. **Cotyledonary leaves:** compound, opposite; one once-pinnate with 5 pairs of opposite leaflets with a terminal cusp; the other bifoliate with 8 pairs of secondary leaflets; above bright light green, hairless; below light green-grey with sparse tiny white hairs along the midrib.

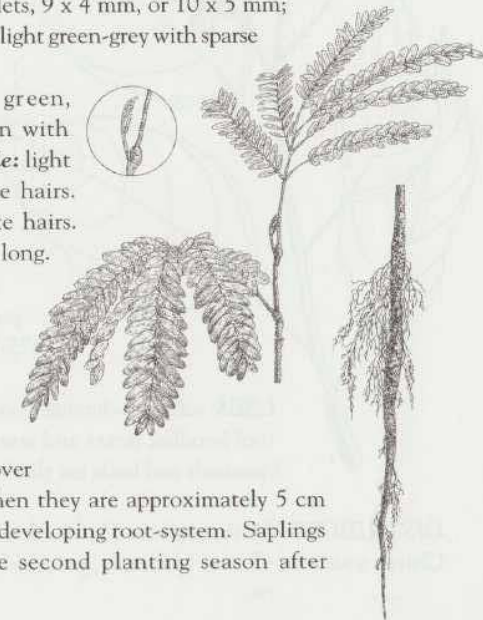


**Stem:** hypocotyl light green, darker towards apex, hairless; epicotyl dark green, hairless; internodes dark green, with tiny white hairs. **Leaves:** compound, bifoliate, alternate; first two leaves 42 x 14 mm, 31 x 16 mm; leaflets asymmetrically oblong, apex acute, base cuneate and oblique, margin entire; 16 or 24 secondary leaflets, 9 x 4 mm, or 10 x 5 mm; above bright light green, hairless; below light green-grey with sparse tiny white hairs along the midrib.

**Venation:** palmate, unequal, light green, primary veins 3. **Petiolo:** light green with curled white hairs, 6 mm long. **Petiolo:** light green, 1 mm long, with curled white hairs. **Rachis:** light green with curled white hairs. **Stipules:** subulate; light green, 1.5 mm long.

**PROPAGATION**

**RECOMMENDATIONS:** collect brown pods in January-March. Allow them to dry and split open. Remove the seeds and sow them in trays in partial shade; expected GR up to 53%, over 7-70 days. Prick out the seedlings when they are approximately 5 cm tall, taking care not to damage rapidly developing root-system. Saplings should be ready for planting in the second planting season after germination.





**Balakata baccata (Roxb.) Ess. (EUPHORBLACEAE)**

• Mousedeer's Rubber Tree • โปบาย (สตีนก)

Synonym: *Sapium baccatum* Roxb.

A common, large, evergreen tree, up to 25 m tall, dbh up to 105 cm.

**Bark:** thick, roughly vertically cracked and sometimes flaking, dark grey to blackish.

**Leaves:** spirally arranged, simple; blades elliptic to oblong, apex acuminate, base acute or obtuse; attachment peltate several mm from the base, margin entire; hairless 13-19 x 6-9 cm; above dark green; below light green; midrib prominent with c.10 sub-opposite to

alternate pairs of arching secondary veins; finer venation reticulate; petioles reddish, 4-9 cm long.

**Flowers:** numerous, tiny, unisexual, in a terminal panicle of often bisexual spikes; axes light green; calyx and filaments light yellow-green; anther locules reddish and turning blackish.

**FRUIT/SEED:** fleshy drupes with white sap, green when unripe, glaucous, dark red-purple to black when ripe, dimensions 14.9 x 14.3 x 12.1 mm, each containing two black seeds, 5.3 x 4.2 x 4.1 mm, (see photo on page 129); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous, and evergreen forests, particularly along streams; elevation 475-1,300 m.

**USES:** soft, non-durable wood, used for temporary construction, small tool handles, boxes and crates and for plywood and particle board. Mammals and birds eat the fruits.

**DISTRIBUTION:** throughout Thailand, east Himalayas and north India to Indo-China, southern China, Myanmar, peninsular Malaysia and Sumatra



**B. baccata**

**SEEDLINGS: Cotyledonary leaves:** opposite, oblong, apex obtuse, base cuneate, margin entire, petiolate, hairless; inside mid-green; outside light green; venation, parallel, tri-veined, light green, red towards base. **Stem:** hypocotyl mainly red, light green at the top; epicotyl and internodes bright mid-green, the latter paler at first, all hairless. **Leaves:** opposite, simple, first blades ovate, apex obtuse to acute, base obtuse, peltate very close to the margin, later ones more truncate, margin entire; first two blades, 34 x 24 and 35 x 24 mm, hairless; above bright mid-green, below light green.

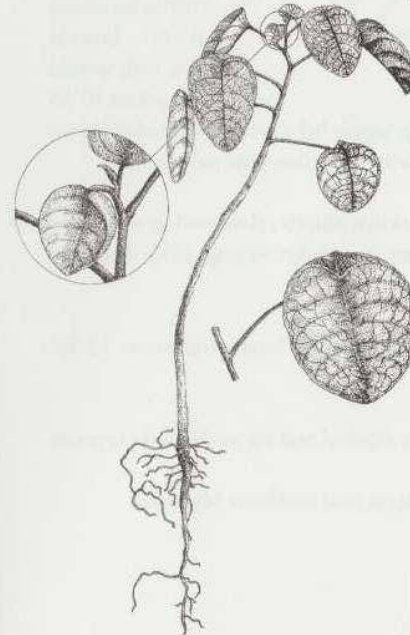
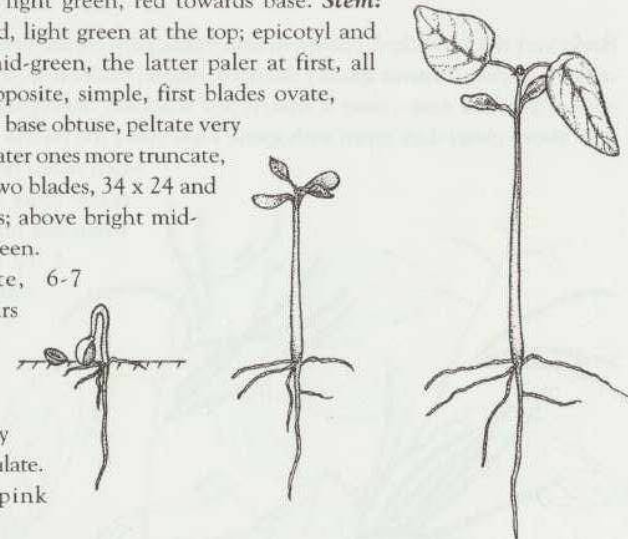
**Venation:** pinnate, 6-7 slightly alternate pairs of veins, light green, becoming pinker with age; secondary venation, thin, reticulate.

**Petiole:** light pink becoming

darker with age, hairless, 11 mm long. **Stipules:** absent.

**PROPAGATION**

**RECOMMENDATIONS:** collect dark red fruits in May-December. Remove the pericarp. Soak the pyrenes in water for 2-3 days or put them in a plastic bag to warm for the same period. Sow the pyrenes in trays in partial shade; expected GR up to 25% over 32-144 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the first planting season after germination.





**Betula alnoides** Ham. ex D. Don  
(BETULACEAE) กำจัดเชื้อโรค

An uncommon, large, briefly deciduous tree, up to 45 m tall, dbh up to 125 cm.

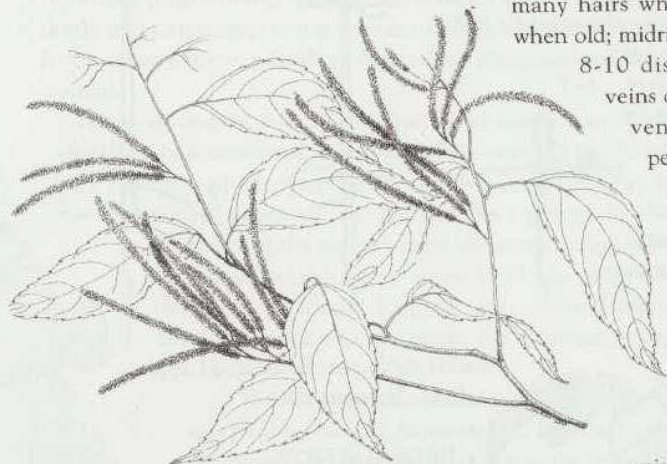
**Bark:** very thick, cracked, peeling in thin flakes, grey-brown, branchlets pale grey with cream lenticels. **Leaves:** spirally arranged, simple; blades thin, ovate to ovate-oblong, apex acute, base acute, margin sharply and shallowly doubly serrate; 26-43 x 63-115 mm; above glossy dark green with sparse hairs along the midrib when young, hairless

when older; below light green with many hairs when young, sparse when old; midrib prominent with 8-10 distinct secondary

veins on each side; finer venation reticulate; petioles initially very hairy, becoming

hairless with age, 2-3 cm long, orange bud scales present on young twigs. **Flowers:**

inflorescences from lateral nodes, with several unisexual catkins 10-15



cm long, with numerous tiny flowers 2 mm long; tepals light green with reddish tips; bracts green, as long as the flowers; anthers pale brown; filaments pale green.

**FRUIT/SEED:** samaras numerous in dense catkins, elliptic, flattened, green when unripe, light brown when ripe, 1.5 x 1.5 x 0.5 mm (see photo on page 129); dispersed by wind.

**HABITAT:** fire-prone evergreen, and evergreen + pine forest; elevation 1,050-1,700 m.

**USES:** in Thailand the bark is used to denature alcohol and for medicinal purposes.

**DISTRIBUTION:** northern Thailand, Himalayas and northern Myanmar

**B. alnoides**

**SEEDLINGS:** **Cotyledonary leaves:** opposite, elliptic, apex and base obtuse, margin entire, petiolate, hairless; inside light yellow-green; outside pale light yellow-green; venation obscure, only midrib visible.

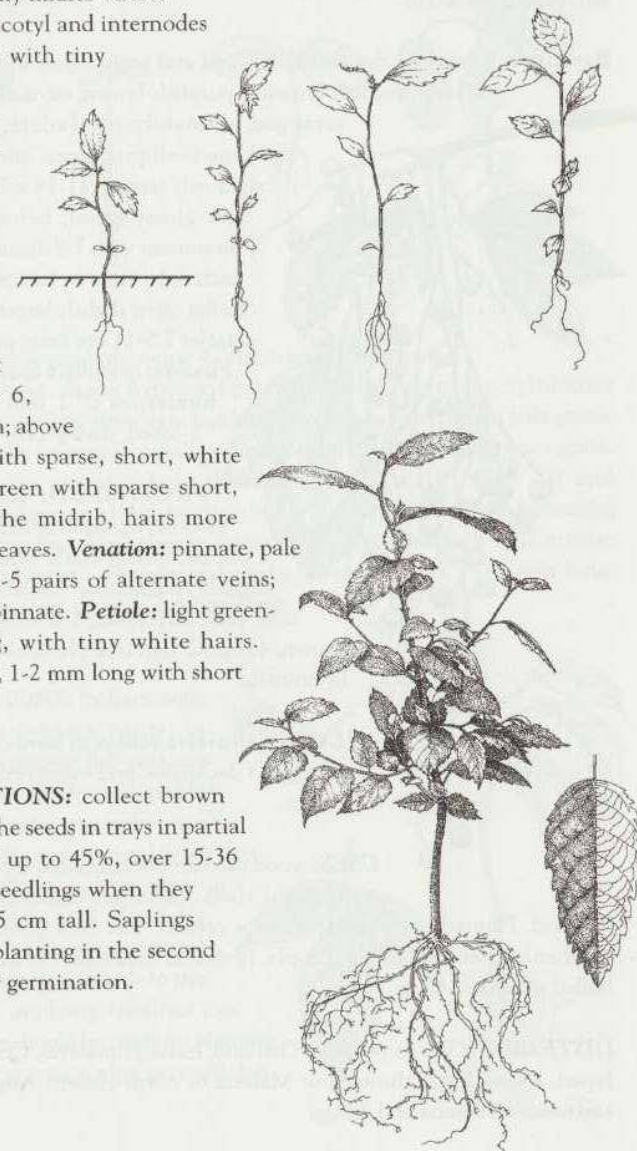
**Stem:** hypocotyl, epicotyl and internodes all light green-pink with tiny white hairs.

**Leaves:** spirally arranged simple; first blade elliptic, apex acute, base cuneate, thereafter elliptic to ovate, apex acute, base obtuse; margin dentate mainly in the apical half; first three blades 10 x 6,

10 x 7 and 12 x 7 mm; above bright mid-green with sparse, short, white hairs; below light green with sparse short, white hairs along the midrib, hairs more abundant on young leaves. **Venation:** pinnate, pale light green-white, 3-5 pairs of alternate veins; secondary venation pinnate. **Petiole:** light green-pink, 2-4 mm long, with tiny white hairs. **Stipules:** light green, 1-2 mm long with short white hairs.

**PROPAGATION**

**RECOMMENDATIONS:** collect brown fruits in April. Sow the seeds in trays in partial shade; expected GR up to 45%, over 15-36 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.





## *Bischofia javanica* Bl. (EUPHORBIACEAE)

### • Bishop Wood, Java Cedar • เต็ม

A common, large, evergreen or deciduous tree, up to 30 m, but exceptionally 35 m tall, dbh up to 80 cm.

**Bark:** thin to slightly thickened, fissured and scaly, often with small, thick shaggy flakes, reddish-brown to purplish-brown, sap dark red. **Leaves:** spirally arranged, pinnately trifoliolate, leaf blades slightly thickened, elliptic, apex and base acute, margin shallowly serrate; 11-14 x 5-8 cm, hairless; above dark glossy green; below mid-green; midrib prominent with 7-9 distinct secondary veins on each side; finer venation reticulate; terminal leaflet often slightly larger than the lateral ones; petioles 7.5-11 cm long; petiolules 1-4 cm long.

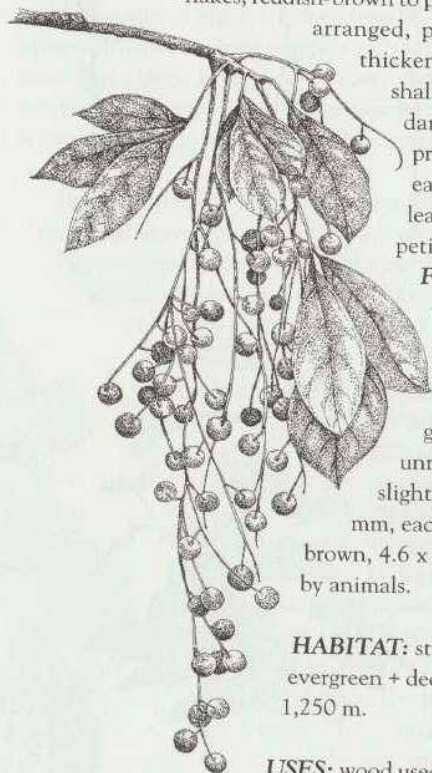
**Flowers:** in axillary unisexual panicles, flowers numerous c. 2 mm long; calyx deeply 5-lobed; dark green; stamens 5; stigmas 3.

**FRUIT/SEED:** slightly fleshy drupes, globose, tip often apiculate, light green when unripe, brown-black when ripe, exocarp thin, slightly roughened, 7.8-10.0 x 7.6-9.6 x 7.5-9.0 mm, each containing 1-2 seeds, oblong-ovoid, light brown, 4.6 x 3.3 mm (see photo on page 129); dispersed by animals.

**HABITAT:** stream valleys in bamboo + deciduous, mixed evergreen + deciduous, and evergreen forest; elevation 525-1,250 m.

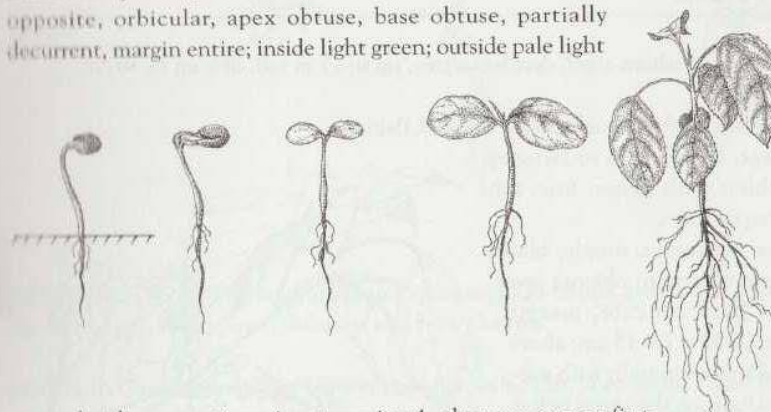
**USES:** wood used for construction, interior finish, furniture, agricultural tools, carvings, charcoal, veneer, paper and plywood. Planted as a shade tree for coffee. The bark contains tannins used for toughening nets and ropes. People, birds and mammals eat the fruit. The roots are boiled to make a soup.

**DISTRIBUTION:** throughout Thailand, India, Himalayas, China, Taiwan, southern Japan, Indo-China, throughout Malesia to north-eastern Australia, Pacific islands eastwards to Samoa and Tonga



## *B. javanica*

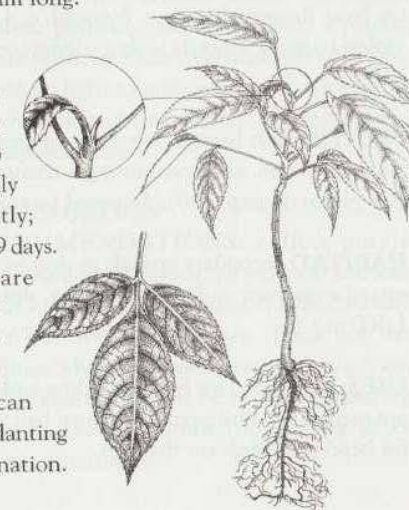
**SEEDLINGS:** **Cotyledons:** thick, curved, falling after 3-4 days. **Cotyledonary leaves:** opposite, orbicular, apex obtuse, base obtuse, partially decurrent, margin entire; inside light green; outside pale light



green, hairless; venation pinnate, veins 4, alternate except first pair; petiole 3-5 mm long. **Stem:** hypocotyl pale green, pink-white at cotyledonary stage, light green with shallow striations, hairless; epicotyl and internodes pale green, hairless. **Leaves:** spirally arranged, initially simple; blades thin lanceolate, apex acute, base cuneate, margin serrate; first three blades 31 x 18, 41 x 20 and 51 x 22 mm; above mid-green, glossy, hairless; below light green, hairless, becoming trifoliolate after 7-9 nodes. **Venation:** pinnate, light green, veins 6-7, alternate; secondary venation obscure. **Petiole:** pale light green, hairless, 8-13 mm long. **Stipules:** subulate, hairless, papery, 1.5 mm long.

### PROPAGATION

**RECOMMENDATIONS:** collect soft, dark brown to bluish-black fruits, in October-February. Remove the pericarp before sowing the seeds shallowly and thinly in trays in partial shade; water frequently; expected GR up to 44%, mostly over 15-169 days. Prick out the seedlings when they are approximately 5 cm tall, (usually approximately 30 days after germination) and water them frequently. Growth in the nursery is slow, but applying fertiliser can accelerate it. Saplings should be ready for planting in the second planting season after germination.





*Callicarpa arborea* Roxb. var. *arborea*  
(VERBENACEAE) • Great Woolly Malayan Lilac •  
ผ้า, ซ้ายเป็น

A common, medium-sized, deciduous tree, up to 17 m tall, dbh up to 36 cm.

**Bark:** thick, slightly roughened or cracked, flaking with age, light brown to tan-grey; branchlets with dense, fine, tan, star-shaped hairs.

**Leaves:** decussate, simple; blades leathery, elliptic to oblong, apex acute, base cuneate, margin entire; 18-32 x 7.5-15 cm; above dull dark green initially with star-shaped hairs on the veins; below light green-grey with dense, persistent, star-shaped hairs; midrib prominent; secondary veins distinct, 11-12 on each side; finer venation scalariform; petioles 3.5-7 cm long with abundant star-shaped hairs.

**Flowers:** inflorescences axillary, cymose, spreading; axes with star-shaped hairs, 9-16 cm long; flowers numerous, bisexual, c. 4 mm long; corolla light violet; anthers tan-violet; stamens 5 mostly violet; stigma cream; ovary green; calyx light green with tan hairs.

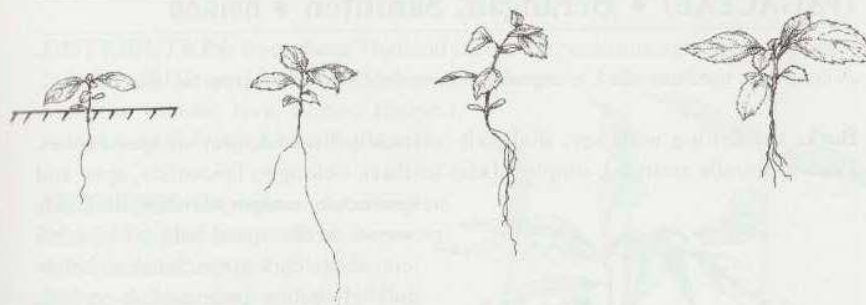
**FRUIT/SEED:** berries globose, light green when unripe, dark purple when ripe, 4.5 x 4.2 x 4.0 mm, each containing 4 triangular, light brown seeds, 2.0 x 1.0 x 1.0 mm (see photo on page 130); dispersed by animals

**HABITAT:** secondary growth in deciduous dipterocarp-oak, bamboo + deciduous, mixed evergreen + deciduous forest, disturbed areas, roadsides etc; elevation 850-1,300 m.

**USES:** wood used for house building and light construction and for fuel. The twigs are used in the Philippines as prawn bait and to stupefy fish. The bark is a substitute for betel nut. Birds eat the fruit.



*C. arborea*



**DISTRIBUTION:** Thailand, India to Myanmar, Indo-China, peninsular Malaysia, Sumatra, Java, Philippines, Sulawesi and New Guinea

**SEEDLINGS:** **Cotyledonary leaves:** opposite, orbicular, apex retuse, base obtuse, margin entire, light green with sparse tiny white hairs; venation very obscure; petioles 1 mm long, hairy. **Stem:** hypocotyl pale light green, with many short white hairs; epicotyl and internodes light green with abundant short white hairs. **Leaves:** opposite, simple; blades obovate, apex acute, base attenuate, margin serrate mainly in apical half; first three leaves 6 x 3, 12 x 6, 18 x 10 mm; above

bright light green with many short white stalked glandular hairs; below pale light green with many short white glandular hairs, especially along the veins; epidermis glandular above and below.

**Venation:** pinnate, pale light green, 3 pairs of alternate veins; secondary venation very obscure.

**Petiole:** light to mid-green with many short white glandular hairs, 1-2 mm long.

**Stipules:** absent.

**PROPAGATION**

**RECOMMENDATIONS:** collect purple berries in August. Remove the pericarp and sow the seeds in trays in partial shade; expected GR up to 67%, over 72-135 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.





*Castanopsis acuminatissima* (Bl.) A. DC.  
(FAGACEAE) • Berangan, Saninten • ก่อเต็อย

A common, medium-sized, evergreen tree, up to 25 m tall, dbh up to 102 cm.

**Bark:** thickening with age, shallowly vertically fissured, grey or grey-brown.

**Leaves:** spirally arranged, simple; blades leathery, oblong to lanceolate, apex and

base acute, margin variable, shallowly serrate in the apical half; 10-15 x 3-5 cm; above dark green, hairless; below dull light yellow-green and silvery with sparse, short, white hairs; midrib distinct; secondary veins thinner, 11-13 on either side; finer venation scalariform; petioles 8-15 mm long.

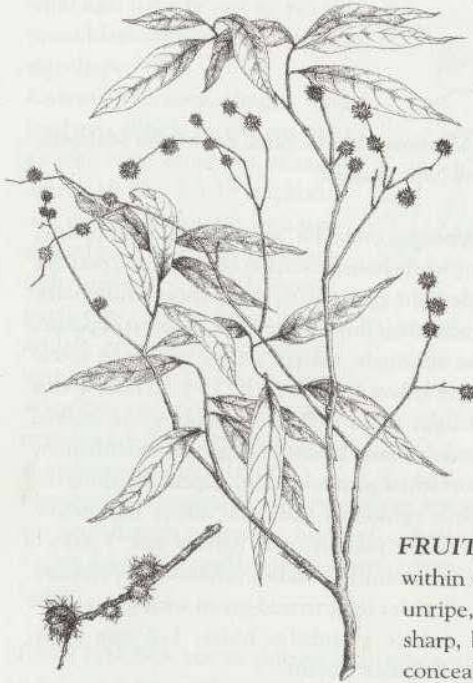
**Flowers:** in dense, axillary and terminal, erect panicles of spikes; unisexual; flowers numerous, fragrant in spaced clusters, c. 5 mm long; male tepals pale light yellow; stamens several, prominent; anthers pale light yellow; filaments white; female flowers inconspicuous, bractate, lacking tepals; styles 3.

**FRUIT/SEED:** nuts, completely contained within a spiny cupule that is light green when unripe, light brown when ripe; spines rigid, sharp, branched, finely hairy, not completely concealing the cupule epidermis; nut 8-10 x 7-8 mm, each containing a single brown seed (see

photo on page 130); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous, evergreen, and evergreen + pine forest; elevation 760-2,100 m.

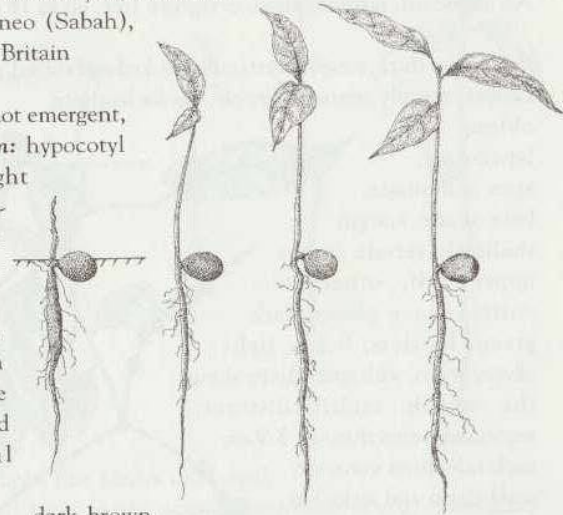
**USES:** wood used for medium to heavy construction, interior fitting, furniture, cabinet-making, plywood, sliced veneer and fire wood. People, birds and mammals eat the nuts. The cut branches are used to culture mushrooms. The leaves are used for fodder. The bark is a laxative and in Thailand is chewed with betel nut.



*C. acuminatissima*

**DISTRIBUTION:** throughout Thailand except the peninsula, north-eastern India, Indo-China, Taiwan, peninsular Malaysia, northern Sumatra, western Java, Borneo (Sabah), Sulawesi, New Guinea, New Britain

**SEEDLINGS:** **Cotyledons:** not emergent, hypogeal germination. **Stem:** hypocotyl not emergent; epicotyl light yellow at base, dark green-brown elsewhere, with sparse short white hairs and faint dark green-brown striations; internodes mid green-brown, with dense, short white-cream hairs; first node with minute stipules and primordial

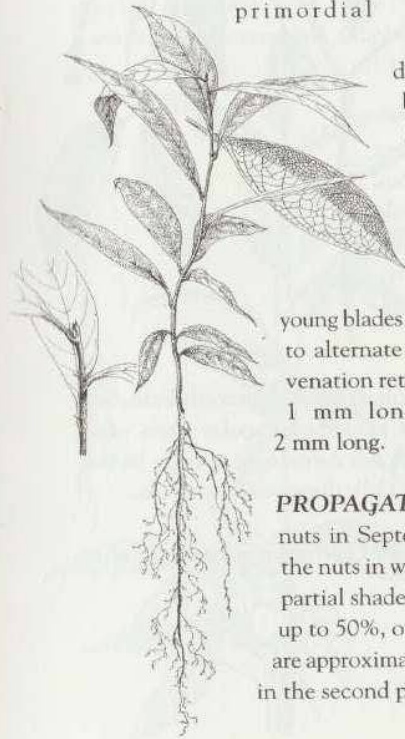


dark brown buds with cream hairs.

**Leaves:** alternate, simple; blades thickened, lanceolate, apex acuminate, base cuneate, margin entire; first three blades 41x18, 46x21 and 52x19 mm; above light to mid-green with pale green margin and sparse, short, white hairs; below light green, with sparse hairs, mostly along the midrib; young blades maroon.

**Venation:** pinnate, veins 4-5 sub-opposite to alternate either side of the midrib, light green; secondary venation reticulate. **Petiole:** mid-green with short white hairs, 1 mm long. **Stipules:** subulate, dark green-brown, 2 mm long.

**PROPAGATION RECOMMENDATIONS:** collect brown nuts in September-November. Remove the cupules and soak the nuts in water for 12-24 hours, before sowing them in trays in partial shade. Protect trays from small mammals; expected GR up to 50%, over 13-62 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.





## *Castanopsis tribuloides* (Sm.) A. DC.

(FAGACEAE) ก่อใบเลื่อม

An abundant, medium-sized, evergreen tree, up to 18 m tall, dbh up to 70 cm.

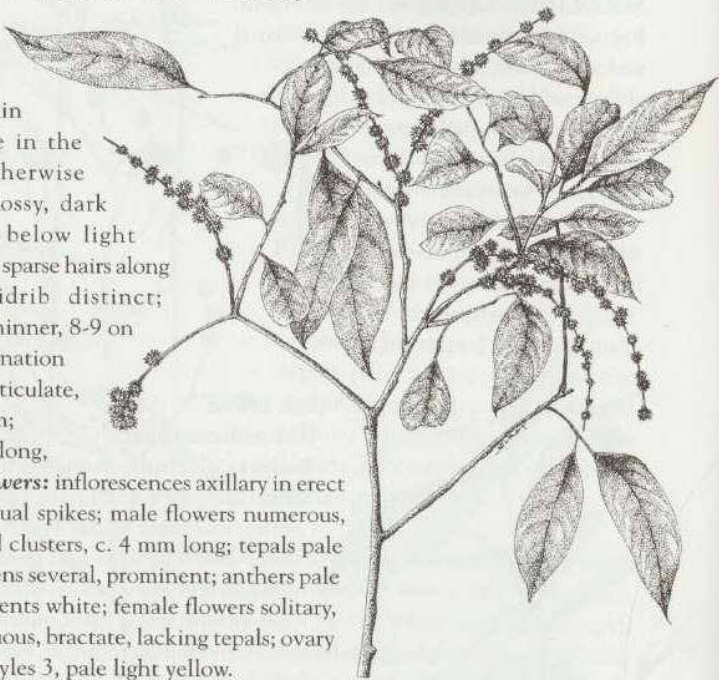
**Bark:** very thick, roughly vertically cracked and ridged, dark grey-black or dark brown.

**Leaves:** spirally arranged, simple; blades leathery,

oblong to lanceolate, apex acuminate, base acute, margin shallowly serrate in the upper half, otherwise entire; above glossy, dark green, hairless; below light silvery green, with sparse hairs along the midrib; midrib distinct; secondary veins thinner, 8-9 on each side; finer venation scalariform and reticulate, 10-16 x 2.5-5.5 cm;

petioles 8-13 mm long,

sparingly hairy. **Flowers:** inflorescences axillary in erect panicles of unisexual spikes; male flowers numerous, fragrant, in spaced clusters, c. 4 mm long; tepals pale light yellow; stamens several, prominent; anthers pale light yellow; filaments white; female flowers solitary, spaced, inconspicuous, bractate, lacking tepals; ovary dull light green; styles 3, pale light yellow.



**FRUIT/SEED:** nut, entirely enclosed in spiny cupule; spines rigid, mostly branched, sharp-tipped, not completely covering the cupule epidermis; cupules green when unripe, brown when ripe, 9.6 x 8.4 x 8.2 mm, each nut containing a single brown, ovoid seed, 7.2 x 6.4 x 5.9 mm (see photo on page 130); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous, evergreen, evergreen + pine; elevation 875-1,500 m.

**USES:** the seeds are edible.

## *C. tribuloides*

**DISTRIBUTION:** northern Thailand, Myanmar, China and Indo-China

**SEEDLINGS:** **Cotyledons:** not emergent, hypogeal germination.

**Stem:** hypocotyl not emergent; epicotyl dull dark brown-green, hairless; internodes dull light brown-green with sparse tiny light brown-white hairs; first few nodes with small stipules and prophylls (scales).

**Leaves:** spirally arranged, simple; first blades thickened,

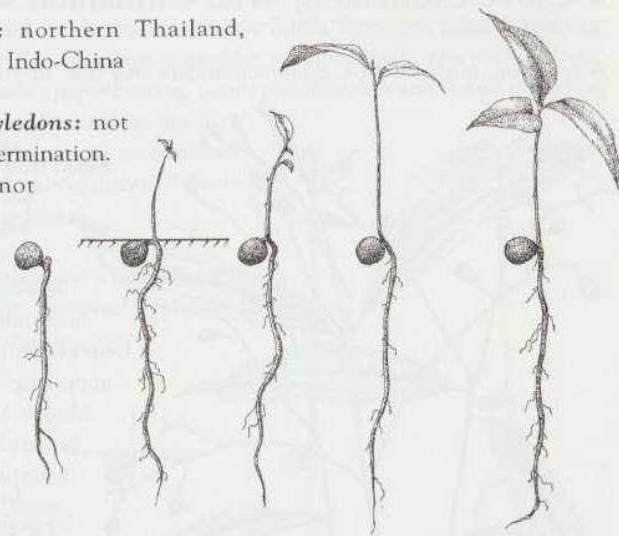
elliptic, apex acuminate, base acute, thereafter lanceolate, apex acuminate, base attenuate, margin entire; first three blades 35 x 20, 32 x 17 and 67 x 21 mm; above dull mid-green, hairless; below dull light green, hairless; young blades maroon.

**Venation:** pinnate, light green, with 7 veins on either side of the midrib, sub-opposite near base, alternate towards apex; secondary venation reticulate. **Petiole:** dull mid-green, 2 mm long with tiny white hairs.

**Stipules:** subulate, 2 mm long with white hairs.

### PROPAGATION

**RECOMMENDATIONS:** collect brown nuts in September-November and sow them in trays in partial shade; expected GR up to 86%, over 25-144 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.

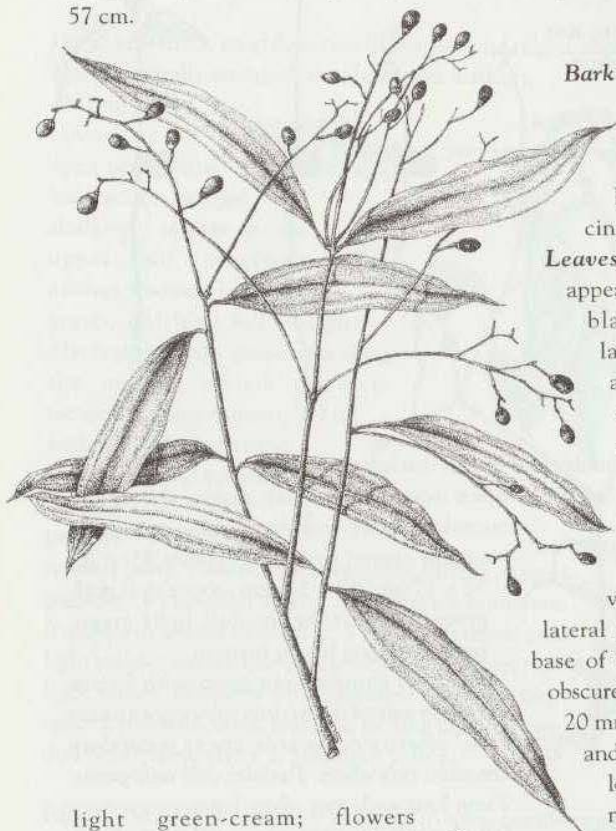




## *Cinnamomum iners* Reinw. ex Bl. (LAURACEAE)

• Clove Cinnamon, Wild Cinnamon • เขียด, อบเชย

A common, medium-sized, evergreen understory tree, up to 16 m tall, dbh up to 57 cm.



**Bark:** thin to slightly thickened, nearly smooth to finely roughened, dark grey to cream with pale brown lenticels; sap with distinctive cinnamon odour.

**Leaves:** spirally arranged, often appearing sub-opposite, simple; blades leathery; oblong to lanceolate, apex obtuse to acuminate, base obtuse to acute, margin entire; 14-24 x 4-8 cm; above glossy dark green, hairless; below light green to dull yellow-green with tiny white hairs, mainly on the primary veins; primary venation, the lateral pair opposite and from the base of the blade; other venation obscure, finely reticulate; petioles 8-20 mm long. **Flowers:** in axillary and terminal panicles of cymes, less often racemose; axes pale

light green-cream; flowers long; perianth deeply 6-lobed, pale yellow-cream sometimes greenish; anthers and stigma yellow.

**FRUIT/SEED:** an elliptic to ovoid dry berry, tip obtuse, base narrowed, green when unripe, dark purple-black when ripe, mean dimensions 17.1 x 8.0 x 7.9 mm, each containing a single ellipsoid seed with a smooth brown testa, 9.5 x 6.6 x 6.4 mm; dispersed by animals.

**HABITAT:** mixed evergreen + deciduous, and evergreen forest, often in disturbed areas; elevation 600-1,800 m.

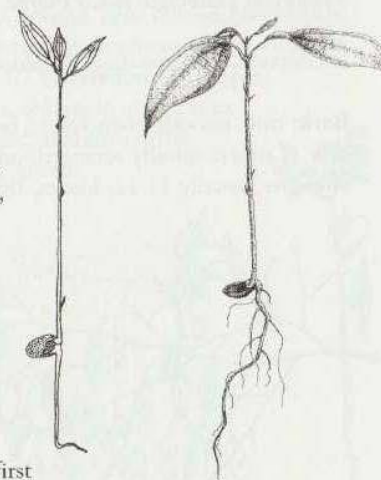
## *C. iners*

**USES:** the wood is used for decorative interior finish, furniture, cabinet-making, carving and plywood. The mucilage is used for mosquito coils, joss sticks, plastic products, glue, high quality paper coating, paints and fibreglass and the oil is used for perfumes. The bark and roots are used in Thailand as a spice. The nectar is consumed by birds and attracts a variety of insects. Insects are also attracted to the leaves.

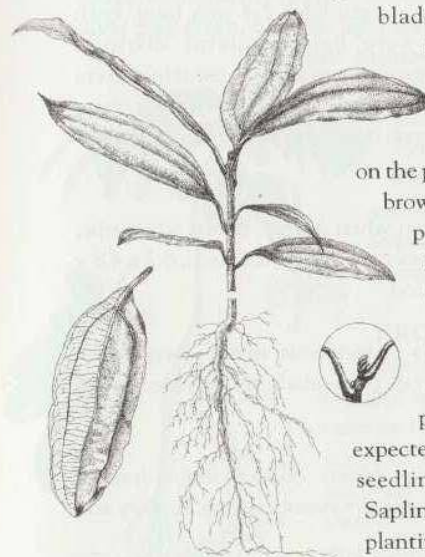
**DISTRIBUTION:** throughout Thailand, India, Myanmar, Indo-China, peninsular Malaysia, Sumatra, Java, Borneo, southern Philippines, Sulawesi

### SEEDLINGS:

**Cotyledons:** not emergent, hypogeal germination. **Stem:** hypocotyl not emergent; epicotyl very dark green, dark brown base with tiny sparse, brown hairs; first few nodes with subulate prophylls; internodes dark green with tiny



sparse cream hairs. **Leaves:** spirally arranged, simple; first blades elliptic, apex acuminate, base cuneate, thereafter oblong, apex acuminate, base cuneate, margin entire; first three blades 70 x 29, 69 x 29 and 60 x 23 mm; above dark green, hairless; below light green-grey with tiny golden hairs on the primary veins. **Venation:** pinnate, medium green-brown with 3 distinctive veins; secondary venation parallel pinnate; finest venation reticulate. **Petiole:** dark green-maroon with tiny golden hairs 6-9 mm long. **Stipules:** absent.



**PROPAGATION RECOMMENDATIONS:** collect dark purple fruits in April. Remove the pericarp and sow the seeds in trays in partial shade; expected GR up to 75%, over 17-80 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.



*Dalbergia cultrata* Grah. ex Bth. var. *cultrata*  
(LEGUMINOSAE, PAPILIONOIDEAE) • Rosewood •

กระพี้เขาควาย

Synonym: *Dalbergia fusca* Pierre

A common, medium-sized, deciduous tree, up to 22 m tall, dbh up to 36 cm.

**Bark:** thin, smooth when young, becoming finely roughened and cracked with age, grey. **Leaves:** spirally arranged, once imparipinnate, 45-71 x 85-198 mm; leaflets alternate, usually 11-12; blades, thin, elliptic to obovate, apex obtuse and usually shallowly emarginate, base



obtusely acute, margin entire; up to 34 x 14 mm; above dull dark green, hairless; below dull light green with sparse hairs, denser along the midrib and near the base; midrib distinct; secondary venation pinnate with 10-12 thin veins on each side; finer venation reticulate; petioles 15-30 mm long; petiolules 2-4 mm long, both very hairy; pulvini distinct. **Flowers:** inflorescence, an axillary panicle, 4-6 cm long, appearing with the developing leaves; axes green; flowers numerous, bisexual, 7-8 mm long; calyx cream or yellow-green; corolla cream-white, occasionally with a pale lilac hue.

**FRUIT/SEED:** pods flat, linear-lanceolate, green when unripe, brown when ripe, mean dimensions 62.1 x 15.4 x 2.9 mm, each containing 1-4 brown seeds, 6.2 x 4.8 x 2.0 mm (see photo on page 130); dispersed by wind.

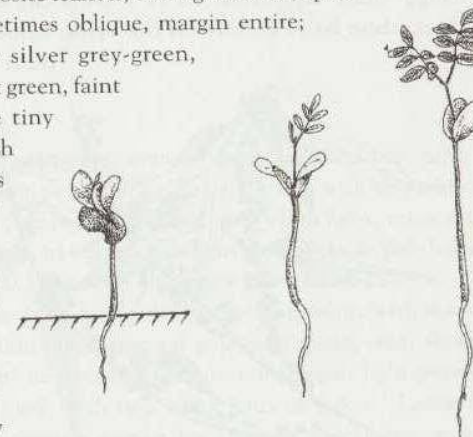
**HABITAT:** deciduous dipterocarp-oak, bamboo + deciduous, mixed evergreen + deciduous, evergreen and evergreen + pine forest, particularly in degraded areas; elevation 350-1,300 m.

**USES:** wood is used for high quality furniture, cabinets, doors, window frames, agricultural implements, musical instruments, plywood, veneer, carving, turnery and fuel-wood. It is used as a shade tree for agro-forestry.

*D. cultrata*

**DISTRIBUTION:** northern and north-eastern Thailand, Indo-China, Myanmar and Yunnan

**SEEDLINGS:** **Cotyledons:** opposite, thickened, oblong, apex obtuse, base obtuse, margin entire, minutely petiolate; inside and outside light green-yellow with very sparse, tiny white hairs; venation indistinct. **Cotyledonary leaves:** imparipinnate, opposite; 7 thin opposite leaflets, oblong to ovate, apex obtuse to acute, base obtuse, sometimes oblique, margin entire; above mid-green, hairless; below silver grey-green, hairless. **Stem:** hypocotyl pale light green, faint dark green striations, with sparse tiny white hairs near the apex, base whitish and hairless; epicotyl and internodes bright mid-green, with frequent tiny white hairs. **Leaves:** imparipinnate, alternate; 7 alternate leaflets, oblong to ovate, apex obtuse to acute, base obtuse, sometimes oblique, margin entire; first three leaflets 12 x 7, 12 x 6 and 8 x 4 mm; above mid-green, hairless; below silver grey-green, hairless; light green when young.



**Venation:** pinnate, light green, with 4-5 alternate pairs of veins; secondary venation reticulate. **Petiole:** bright mid-green, 6-8 mm long, with dense tiny white hairs. **Petiolules:** bright mid-green, less than 1 mm long, with dense tiny white hairs. **Rachis:** bright mid-green, 4-6 mm long, with many tiny white hairs. **Stipules:** subulate, papery, mid-green, 3 mm long with many tiny white hairs.

**PROPAGATION RECOMMENDATIONS:** collect brown pods in March. Leave them to dry until they split open, then remove the seeds and soak them in cold water for 1-2 days, before sowing them in trays in partial shade; expected GR up to 45%, over 9-22 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.





*Debregeasia longifolia* (Burm. f.) Wedd.  
(URTICACEAE) ไผ่ปลาก

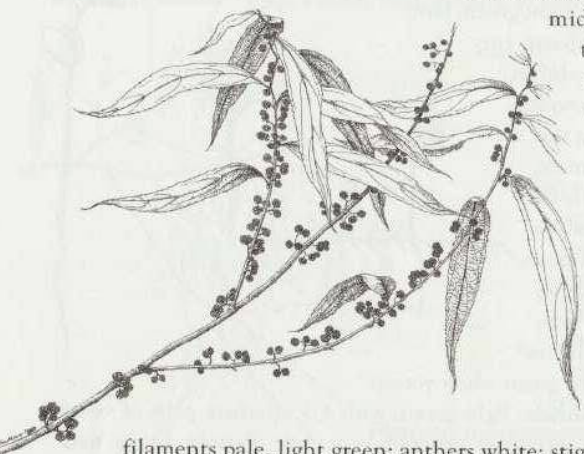
A common, small, evergreen tree, treelet or shrub, up to 7 m tall, dbh up to 16 cm.

**Bark:** thin, slightly rough with pustular lenticels and shallow vertical fissures; grey to dark brown; branches brown-red to light green, branchlets villous. **Leaves:** spirally arranged, simple; blades thin, linear-lanceolate, apex sharply acuminate, base acute, margin shallowly serrate; 7.5-23 x 2-6.5 cm; above dull, dark green with sparse, short white hairs, mainly on the veins; below silvery-grey to white, with many short white hairs, longer on the veins;

midrib distinct, with a pair of thinner veins from the base and 5-6 secondary veins on each side; finer venation prominently reticulate, especially below; petioles 1.5-4 cm long.

**Flowers:** from axillary and leafless nodes, of paired, dichotomous cymes, 5-20 mm long, with glomerules of numerous unisexual flowers, 1.5 mm long; tepals light green;

filaments pale, light green; anthers white; stigmas and styles white.



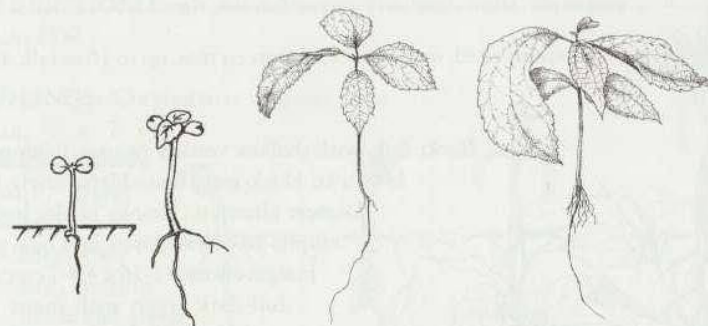
**FRUIT/SEED:** achenes surrounded by a fleshy receptacle, dark green when unripe, orange when ripe, mean dimensions 0.5 x 0.5 x 0.5 mm, each containing a single light brown seed, fractionally smaller than the achene when dry (see photo on page 130); dispersed by birds.

**HABITAT:** degraded evergreen + pine, mixed evergreen + deciduous, often along streams; elevation 925-1,525 m.

**USES:** the fruits are high in vitamin C and are eaten by Karen and Lua hill tribe people as a medicine.

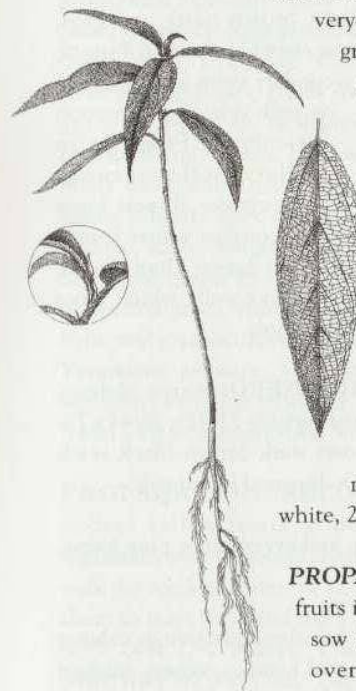
**DISTRIBUTION:** Thailand, India, Sri Lanka, Himalayas, China, Indo-China, Myanmar, Philippines, Indonesia and Borneo

*D. longifolia*



**SEEDLINGS:** **Cotyledonary leaves:** opposite, ovate or orbicular, shed very early, apex retuse, base obtuse, margin entire, petiolate; inside light green, with tiny white hairs; outside pale light green, with tiny white hairs; venation very obscure, tri-veined, pale light green; petiole, pale light green, 0.5 mm with many tiny white hairs.

**Stem:** hypocotyl pale light green to white with short white hairs; epicotyl pale light green, with short white spreading hairs; internodes pale light green-pink, with tiny white hairs or spikes. **Leaves:** opposite, simple; first 2 pairs of blades ovate, apex acute, base truncate, thereafter elliptic, apex acute, base cuneate, margin crenate-serrate at first, strongly serrate later; first three blades 7 x 6, 11 x 9 and 20 x 13 mm; above light to mid-green with tiny sparse white hairs; below light green to silvery grey with many short white hairs or spikes. **Venation:** pinnate, pale light green, veins 3-5 alternate. **Petiole:** pale light green-pink, 2-4 mm long with many short white hairs. **Stipules:** linear, white, 2 mm long with white hairs.



**PROPAGATION RECOMMENDATIONS:** collect orange fruits in March. Separate the seeds from the fruit flesh and sow them in trays in partial shade; expected GR 100%, over 15-29 days. Prick out seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.



## *Diospyros glandulosa* Lace (EBENACEAE)

### • Zebra-wood, Streaked Ebony • กฉำฉา

A fairly common, medium-sized, understory, evergreen tree, up to 16 m tall, dbh up to 69 cm.

**Bark:** thin, with shallow vertical fissures, flaking, dark brown to black-grey, branchlets, finely hairy.

**Leaves:** alternate, simple; blades leathery, elliptic to oblong, apex and base acute, margin entire; 11-16 x 4.5-7 cm; above dull dark green with many short white-cream hairs on veins and brown furfuraceous indumentum on the midrib; below pale light green with many short light brown hairs on veins, sparse elsewhere; midrib distinct; secondary veins alternate, 4-5 on each side; finer venation reticulate. **Flowers:** in axillary inflorescences, males cymose, flowers 7 mm long; corollas white; female flowers larger than males, solitary; corolla white, lobes dark pink.



**FRUIT/SEED:** berries globose, green when unripe, yellow when ripe, with silky hairs, size variable 27-42 x 26-44 x 29-48 mm, each containing 6-8 ovoid, flattened, glossy dark brown-black seeds approximately 18 x 10 x 4 mm (see photo on page 131); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous, evergreen, and evergreen + pine forest, often in disturbed areas; elevation 650 m-1,700 m.

**USES:** wood (ebony), high quality, very dense, used for furniture and carvings, cabinet making, interior fittings, turnery, household utensils, tool handles, veneer, musical instruments, toys, inlaying, boxes, posts, bridges and as fuel wood. The fruit is very sweet. It is eaten by animals and taken medicinally by people.

## *D. glandulosa*

**DISTRIBUTION:** north and north-east Thailand, India, Myanmar and Lao PDR

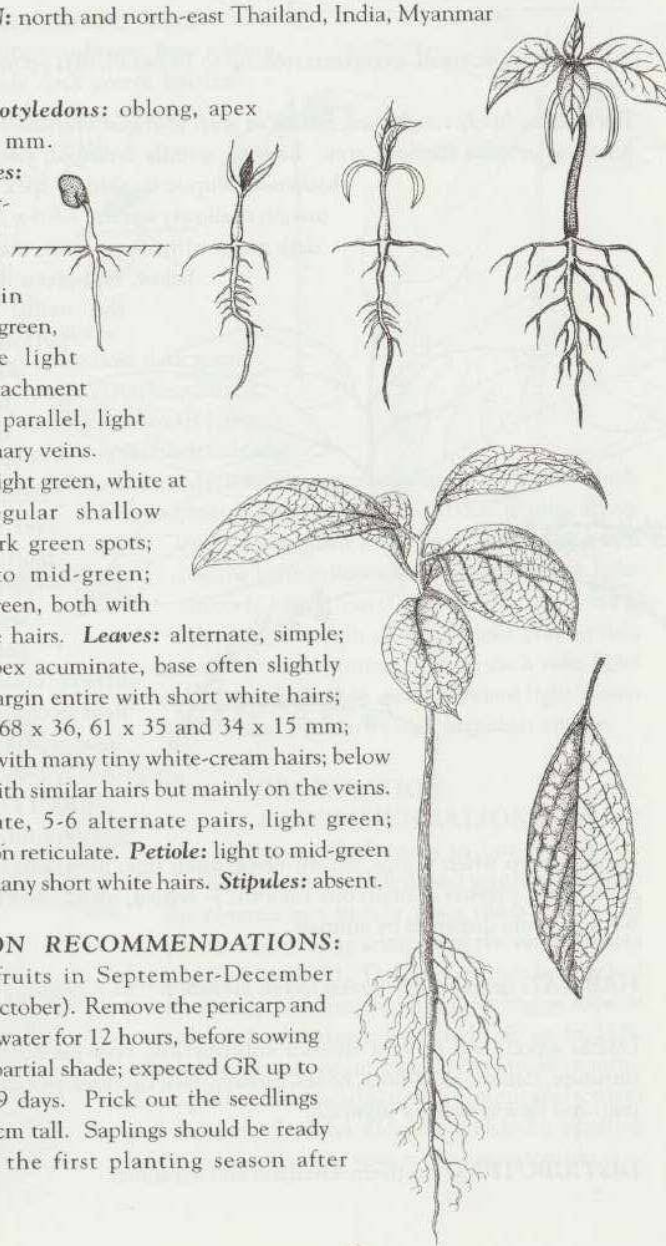
**SEEDLINGS:** **Cotyledons:** oblong, apex obtuse, 9 x 7 mm.

**Cotyledonary leaves:** opposite, linear-lanceolate, apex acuminate, base attenuate, margin entire; inside mid-green, hairless; outside light green, hairless, attachment sessile; venation parallel, light green, with 5 primary veins.

**Stem:** hypocotyl light green, white at base, with irregular shallow striations and dark green spots; epicotyl light to mid-green; internodes mid-green, both with many short white hairs. **Leaves:** alternate, simple; blades elliptic, apex acuminate, base often slightly oblique, acute, margin entire with short white hairs; first three blades 68 x 36, 61 x 35 and 34 x 15 mm; above mid-green with many tiny white-cream hairs; below light-mid green with similar hairs but mainly on the veins. **Venation:** pinnate, 5-6 alternate pairs, light green; secondary venation reticulate. **Petiole:** light to mid-green 6 mm long with many short white hairs. **Stipules:** absent.

### PROPAGATION RECOMMENDATIONS:

collect yellow fruits in September-December (optimally after October). Remove the pericarp and soak the seeds in water for 12 hours, before sowing them in trays in partial shade; expected GR up to 80%, over 27-209 days. Prick out the seedlings when they are 5 cm tall. Saplings should be ready for planting in the first planting season after germination.



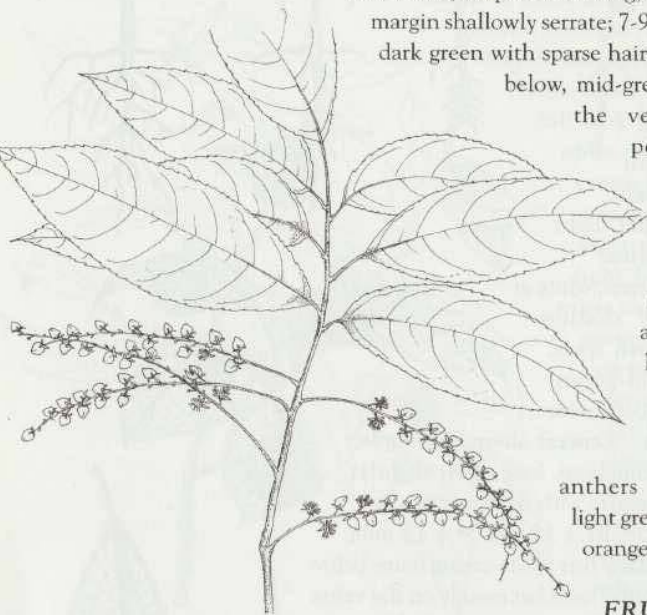


## *Elaeocarpus braceanus* Watt ex Cl.

(ELAEOCARPACEAE) มุ่นดอย

An uncommon, small, evergreen tree, up to 14 m tall, dbh up to 32 cm.

**Bark:** thin, finely roughened, brown or grey, youngest branchlets with many brown hairs, older ones hairless, grey. **Leaves:** spirally arranged, simple; blades slightly thickened, elliptic to oblong, apex acute, base obtuse, margin shallowly serrate; 7-9.5 x 2.5-4 cm; above dull dark green with sparse hairs, mainly on the midrib;



below, mid-green with many hairs on the veins; venation pinnate; petioles 9-11 mm long with many brown hairs. **Flowers:** inflorescences from leafless nodes, racemose, 7-10 cm long; axes with many brown hairs; flowers numerous, bisexual, c. 7 mm long; sepals dull light green; petals 5, cream-white; anthers cream; stigma and style light green; ovary dull green, disc orange, slightly fragrant.

**FRUIT/SEED:** drupes obovoid, tip obtuse, base obtuse, green when unripe, brown-black when ripe, mean dimensions 29.2 x 19.0 x 18.5 mm; pyrenes contain one smooth, 3-angled, ovoid, dark brown seed, 17.4 x 6.9 x 5.7 mm; dispersed by animals.

**HABITAT:** degraded evergreen forest; elevation 950-1,775 m.

**USES:** wood used in light interior construction, boat-building, aircraft building, furniture, joinery, mouldings, boxes, turnery, oars, carvings, particleboard, fibreboard, pulp and face veneer for plywood.

**DISTRIBUTION:** northern Thailand and Myanmar

## *E. braceanus*

**SEEDLINGS:** **Cotyledonary leaves:** oblong, opposite, apex acute to obtuse, base obtuse, margin entire; inside dark green, hairless; outside light green, hairless; venation pinnate, light green with 3 primary veins; petiole 4 mm long.

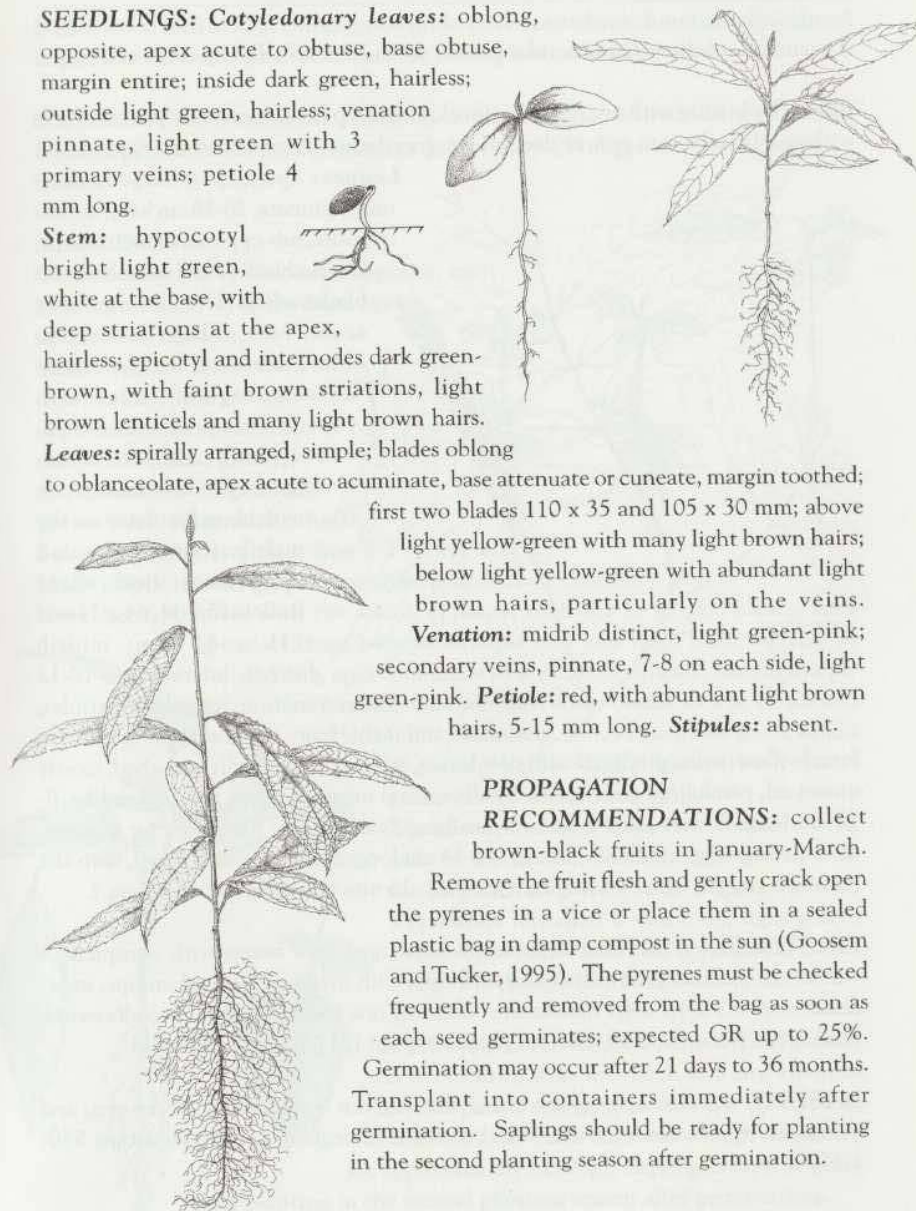
**Stem:** hypocotyl bright light green, white at the base, with deep striations at the apex, hairless; epicotyl and internodes dark green-brown, with faint brown striations, light brown lenticels and many light brown hairs.

**Leaves:** spirally arranged, simple; blades oblong to oblanceolate, apex acute to acuminate, base attenuate or cuneate, margin toothed; first two blades 110 x 35 and 105 x 30 mm; above light yellow-green with many light brown hairs; below light yellow-green with abundant light brown hairs, particularly on the veins. **Venation:** midrib distinct, light green-pink; secondary veins, pinnate, 7-8 on each side, light green-pink. **Petiole:** red, with abundant light brown hairs, 5-15 mm long. **Stipules:** absent.

### PROPAGATION

**RECOMMENDATIONS:** collect brown-black fruits in January-March.

Remove the fruit flesh and gently crack open the pyrenes in a vice or place them in a sealed plastic bag in damp compost in the sun (Goosem and Tucker, 1995). The pyrenes must be checked frequently and removed from the bag as soon as each seed germinates; expected GR up to 25%. Germination may occur after 21 days to 36 months. Transplant into containers immediately after germination. Saplings should be ready for planting in the second planting season after germination.



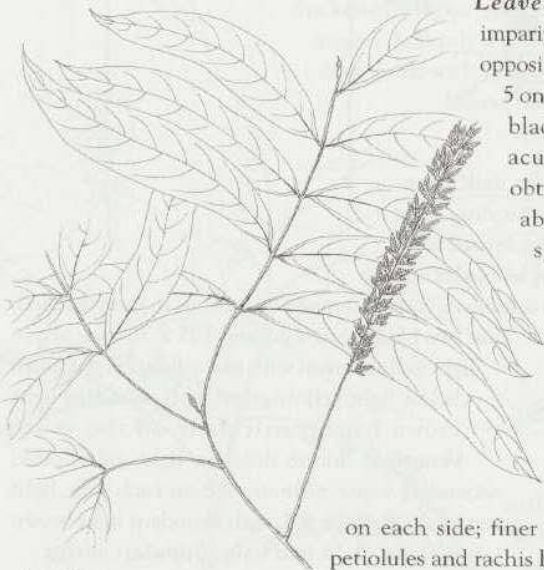


*Engelhardia spicata* Lechen. ex Bl. var. *spicata*  
(JUGLANDACEAE) • Great Malay Beam • กำหนัด

A common, medium-sized, deciduous tree, up to 20 m tall, dbh up to 64 cm.

**Bark:** thickening with age, flaking, developing deep horizontal and vertical cracks with age, light brown, grey, or dark brown-grey; branchlets sparsely and finely hairy.

**Leaves:** spirally arranged, once imparipinnate, 26-38 cm long; leaflets opposite, sub-opposite or alternate, 3-5 on each side of the main leaf axis; blades elliptic to oblong, apex acute, base obliquely acute to obtuse, leathery; margin entire; above glossy dark green with sparse hairs on the midrib, becoming hairless when mature; below mid-green with abundant hairs on the midrib; young blades dull red-brown; first three leaflets 85 x 34, 64 x 24 and 131 x 41 mm; midrib distinct, lateral veins 10-12 on each side; finer venation reticulate; petioles, petiolules and rachis hairy. **Flowers:** inflorescences



from leafless nodes, produced with new leaves, spicate, occasionally branched, mostly unisexual, pendulous; male spikes usually several together, dense and catkin-like, 9-15 cm long; flowers numerous, c. 3 mm long; bracts green, membranous; stamens, several; female spikes fewer, solitary, 16-34 cm long; bracts deeply 3-lobed, with the mid-lobe largest, tips rounded, light green, c. 15 mm and accrescent; stigmas 2.

**FRUIT/SEED:** nuts "winged" (due to 3 enlarged thin bracts with conspicuous venation), globose, green when unripe, brown with irritating hairs when ripe, mean dimensions 5.9 x 4.7 x 4.5 mm, each containing one (occasionally 2) broadly ovoid, black seed, 4.6 x 4.0 x 3.9 mm (see photo on page 131); dispersed by wind.

**HABITAT:** deciduous + bamboo, mixed evergreen + deciduous, evergreen, and evergreen + pine forest, a common coloniser of degraded areas; elevation 550-1,850 m.

*E. spicata*

**USES:** wood used in light construction under cover, cartwheels, furniture, agricultural implements, turnery, gunstocks, packing cases, plywood and firewood.

**DISTRIBUTION:** northern Thailand, northern India to Indo-China, Yunnan, Hainan, peninsular Malaysia, Sumatra, Java, Borneo, Philippines, Lesser Sunda Islands

**SEEDLINGS:**

**Cotyledonary leaves:** bifoliate, opposite, each lobe deeply cleft  $\frac{2}{3}$  to the base, apex obtuse, base cuneate.

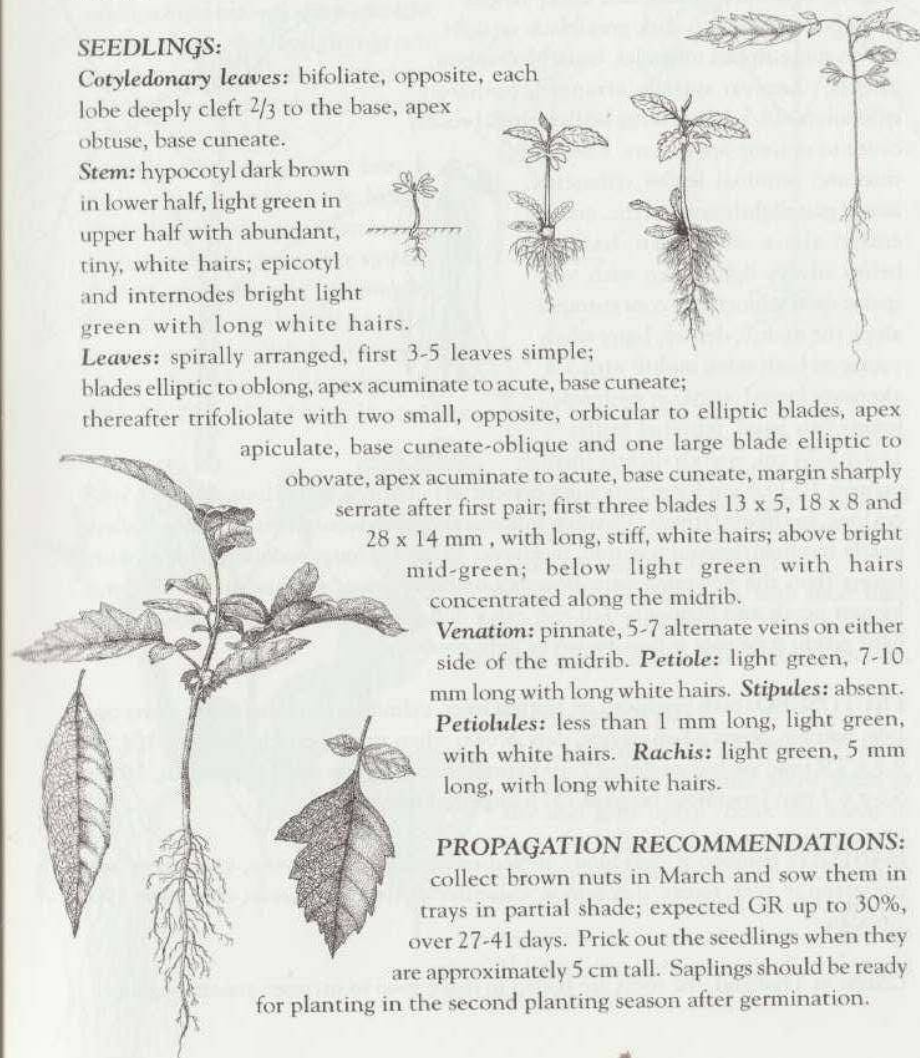
**Stem:** hypocotyl dark brown in lower half, light green in upper half with abundant, tiny, white hairs; epicotyl and internodes bright light green with long white hairs.

**Leaves:** spirally arranged, first 3-5 leaves simple; blades elliptic to oblong, apex acuminate to acute, base cuneate;

thereafter trifoliate with two small, opposite, orbicular to elliptic blades, apex apiculate, base cuneate-oblique and one large blade elliptic to obovate, apex acuminate to acute, base cuneate, margin sharply serrate after first pair; first three blades 13 x 5, 18 x 8 and 28 x 14 mm, with long, stiff, white hairs; above bright mid-green; below light green with hairs concentrated along the midrib.

**Venation:** pinnate, 5-7 alternate veins on either side of the midrib. **Petiole:** light green, 7-10 mm long with long white hairs. **Stipules:** absent. **Petiolules:** less than 1 mm long, light green, with white hairs. **Rachis:** light green, 5 mm long, with long white hairs.

**PROPAGATION RECOMMENDATIONS:** collect brown nuts in March and sow them in trays in partial shade; expected GR up to 30%, over 27-41 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.



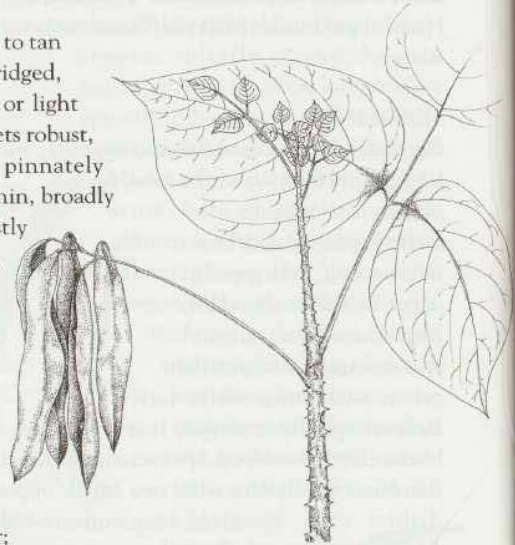


*Erythrina stricta* Roxb. (LEGUMINOSAE,  
PAPILIONOIDEAE) • Coral Tree (for genus)

• ทองเดือนห้า

A common, medium-sized deciduous tree, up to 20 m tall, dbh up to 65 cm.

**Bark:** smooth when young, pale cream to tan or grey, becoming thickened, corky-ridged, roughly cracked with dark grey-black or light brown spine-tipped tubercles, branchlets robust, prickly. **Leaves:** spirally arranged, pinnately trifoliolate, 18.5-27 cm long; leaflets thin, broadly ovate to oblong; apex acute, base mostly truncate; terminal leaflet symmetric, lateral pair slightly asymmetric, margin entire; above dark green, hairless; below silvery light green with very sparse short white hairs, concentrated along the midrib, densely hairy when young on both sides; midrib with 5-6 alternate lateral veins on each side, lowest pair basal, terminal leaflet 9-11 x 7.5-14 cm, laterals slightly smaller; petioles 10-11.5 cm long; petiolules present as pulvini, 4-5 mm long, rachis 3.5-4.5 cm long, ear-shaped stipels. **Flowers:** inflorescences produced when the tree is leafless, nearly terminal, several together, racemose, 12-20 cm long; peduncle dark pinkish, longer than the flowering part; flowers numerous spreading, bisexual, 4 cm long; longest petals and filaments dull red; calyx dull green; anthers pale yellow; stigma light green; style pale yellow-brown or light green.



**FRUIT/SEED:** pods produced on leafless trees, cylindrical, thin, dehiscent along one side, hairless, green when unripe, dark brown when ripe, mean dimensions 104.5 x 9.3 x 7.9 mm, each containing 2-10 kidney-shaped, glossy red-brown seeds, 10.0 x 5.8 x 6.2 mm (see photo on page 131); dispersed by wind.

**HABITAT:** bamboo + deciduous, mixed evergreen + deciduous, evergreen, and evergreen + pine forest, a common coloniser of degraded areas; elevation 350-1,680 m.

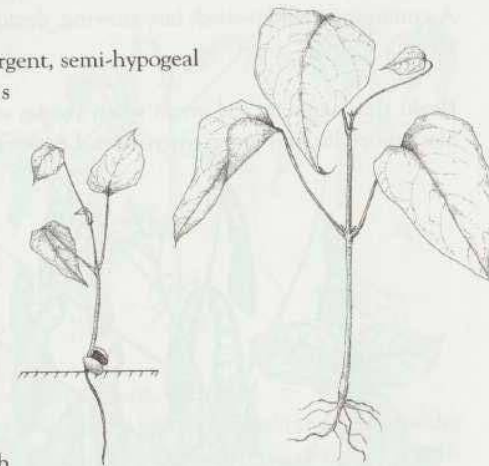
**USES:** in Thailand, the roots are boiled to make soup to increase general vigour.

*E. stricta*

**DISTRIBUTION:** northern Thailand, India, Nepal, Myanmar, Indo-China, Langkawi Islands, Eastern Java, Philippines, Lesser Sunda Islands

**SEEDLINGS:** **Cotyledons:** not emergent, semi-hypogeal germination. **Stem:** hypocotyl is emergent just below soil surface, light green-white with light green striations; epicotyl pale light green, white at base; internodes light green, all stem parts hairless.

**Leaves:** unifoliate up to at least 6 nodes, opposite at first node; blades ovate to deltoid, apex acuminate, base truncate; thereafter spiral, deltoid, apex acute or acuminate, base truncate or slightly cordate, margin entire or slightly sinuous with short white hairs; first three blades



29 x 21, 70 x 64 and 81 x 78 mm; above bright light to mid-green, hairless; below bright light to mid-green with sparse short white hairs on the base of the midrib.

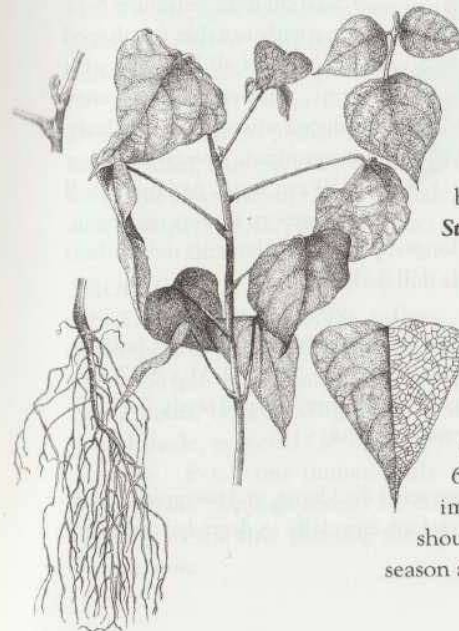
**Venation:** pinnate, pale light green, 8-9 veins alternate on either side of the midrib; secondary venation reticulate.

**Petiole:** bright mid-green, with short light brown hairs, pulvini distinct, 15-76 mm long.

**Stipules:** triangular, pale light green, 3 mm long.

**PROPAGATION**

**RECOMMENDATIONS:** collect brown pods in May and allow them to dry and split open. Soak the seeds in water for 12 hours, before sowing them in trays in partial shade; expected GR up to 67%, over 10-17 days. Prick out the seedlings immediately after germination. Saplings should be ready for planting in the first planting season after germination.





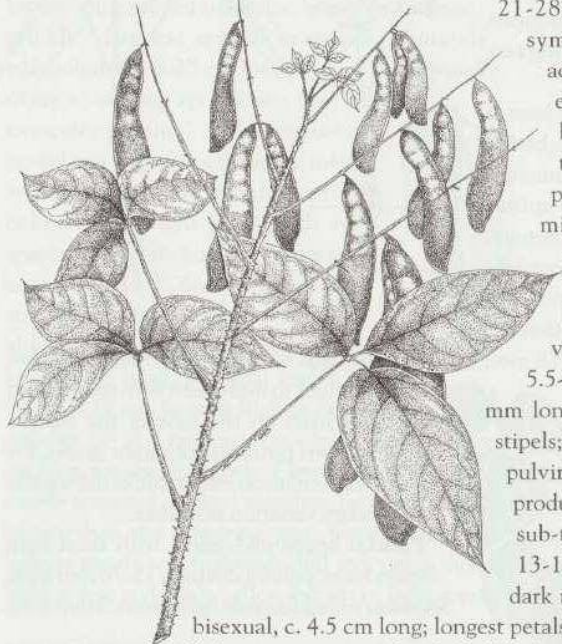
## *Erythrina subumbrans* (Hassk.) Merr.

(LEGUMINOSAE, PAPILIONOIDEAE)

• December Tree • ทองหลางป่า

A common, medium-sized, fast-growing, deciduous tree, up to 25 m tall, dbh up to 86 cm.

**Bark:** thin, smooth and green when young, often cracked with spine-tipped grey-black tubercles, grey or tan when older. **Leaves:** spirally arranged, pinnately trifoliolate, 21-28 cm long; leaflets thin, symmetrically ovate, apex acute, base truncate, margin entire, hairless; terminal leaflet 10.5-14 x 8-12 cm, twice as large as the lateral pair; above dark green; below mid-green; midrib with 7-8 sub-opposite to alternate lateral veins on each side, lowest pair basal; finer venation scalariform; petioles 5.5-10 cm long; petiolules 8-12 mm long with notable ear-shaped stipels; bases of all leaf axes with pulvini. **Flowers:** inflorescence produced when the tree is leafy, sub-terminal, several together 13-19 cm long; peduncle dull dark maroon; flowers numerous, bisexual, c. 4.5 cm long; longest petals and filaments red; anthers light brown; stigma and style dull dark red.



**FRUIT/SEED:** pods produced when tree is leafy, dehiscent into 2 valves, hairless, green when unripe, dark brown and drying when ripe, 95-171 x 11-31 x 8-12 mm, each containing 1-4 dark brown, mostly ellipsoid and kidney-shaped seeds, 9-16 x 7-11 x 7-9 mm (see photo on page 131); dispersed by wind.

**HABITAT:** Bamboo + deciduous, mixed evergreen + deciduous, and evergreen forest; elevation usually 400-1,250 m, at lower elevations especially in degraded areas and along stream valleys.

## *E. subumbrans*

**USES:** the lightweight wood is used for canoe making, carving and kitchen utensils. Planted as a shade tree in agro-forestry, to provide green manure and as a living fence. Copious nectar attracts wildlife.

**DISTRIBUTION:** northern Thailand, India, Sri Lanka, Myanmar, Indo-China, peninsular Malaysia, Java and the Philippines

### SEEDLINGS:

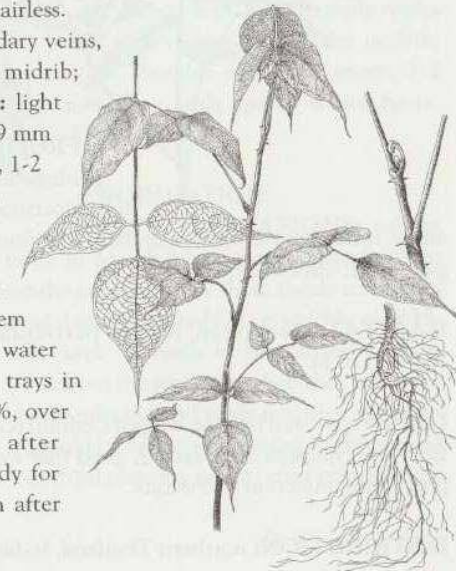
**Cotyledons:** not emergent, hypogeal germination.

**Stem:** hypocotyl not emergent; epicotyl mid-green, lighter at the base, shallow and deep striations resulting in grooved appearance; internodes mid-green, hairless with 2 deep striations; sharp epidermal spines developing with age. **Leaves:** first pair opposite, unifoliate, ovate, apex acuminate, base truncate to cordate, margin entire, 92 x 61 mm; thereafter spiral, unifoliate or trifoliolate, leaflet blades ovate, apex acuminate, base truncate, margin entire; 45 x 51 mm; above bright dark-green; below shiny light green, hairless.

**Venation:** pinnate, light green; secondary veins, 6-7 alternate on either side of the midrib; secondary venation pinnate. **Petiole:** light to mid-green, hairless, grooved, 27-59 mm long. **Stipules:** and stipels ear-shaped, 1-2 mm, mid-green, firm, pulvini distinct.

### PROPAGATION

**RECOMMENDATIONS:** collect brown pods in January-May. Allow them to dry and split open. Soak the seeds in water for 12 hours, before sowing them in trays in partial shade; expected GR up to 63%, over 21 days. Prick out immediately after germination. Saplings should be ready for planting in the first planting season after germination.





*Eurya acuminata* DC. var. *wallichiana* Dyer  
(THEACEAE) ปลายทาน

A common, medium-sized, evergreen tree, up to 16 m tall, dbh up to 67 cm.

**Bark:** thin, very slightly roughened, with fine cracks and flakes, brown or grey, branchlets and terminal buds have dense brown hair.

**Leaves:** alternate, simple; blades leathery, lanceolate or linear-lanceolate, apex acuminate, base acute, margin finely serrate especially in upper half; 4-10 x 1.5-2.5 cm; above dull dark green, hairless; below, dull light green with sparse white hairs, especially along the midrib; midrib with 11-13 thin veins on each side; finer venation reticulate; petioles densely hairy.

**Flowers:** axillary and from leafless nodes, glomerulate; flowers several together, often unisexual, c. 3 mm long; corollas white to pale yellow; anthers orange; filaments dull light yellow; stigma pale orange; style green.

**FRUIT/SEED:** globose berries, scarcely fleshy, hairless, dull light green when unripe, black when ripe, dimensions 4.3 x 2.9 x 2.9 mm, each containing many, seeds, light brown, irregularly suborbicular, 1 mm in diameter (see photo on page 131); dispersed by animals.

**HABITAT:** evergreen forest, particularly in disturbed areas; elevation 10,002,150 m.

**USES:** fruits eaten by Blue-winged Leafbird (*Chloropsis cochinchinensis*) and Mountain Bulbul (*Hypsipetes mcclllandii*), good fuel wood, leaves are used as fodder and for preventing infection in wounds.

**DISTRIBUTION:** northern Thailand, India, Yunnan, Indo-China

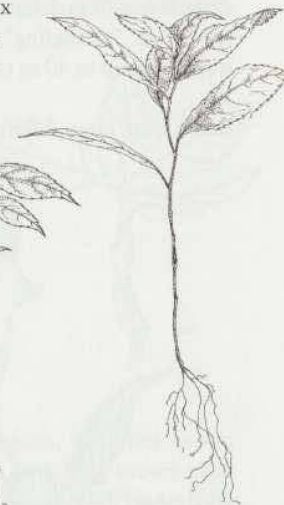


*E. acuminata*

**SEEDLINGS:** **Cotyledonary leaves:** opposite, ovate, apex minutely retuse, base acute, margin entire, hairless; inside light to mid-green; outside light grey-green; venation very obscure, pinnate; petiole light green, hairless, 1 mm.

**Stem:** hypocotyl pale light green, pink-green at first with very pale striations and tiny white hairs; epicotyl pale light green, with tiny white hairs; internodes pale light green, with short white hairs.

**Leaves:** spirally arranged, simple; first blades ovate, apex obtuse, base



acute, 8 x 5 mm;

thereafter elliptic becoming lanceolate, apex acute, base attenuate; second and third blades 12 x 6 and 25 x 9 mm; hairless; above dark green; below light green. **Venation:** pinnate, light green, with 4-6 alternate veins on either side of the midrib.

**Petiole:** pale light green, 1-2 mm long with sparse white hairs. **Stipules:** absent.

**PROPAGATION**

**RECOMMENDATIONS:** collect black fruits in March-May. Squash the fruits to extract the seeds and sow them thinly in trays in partial shade; expected GR up to 69%, over 25-151 days. Growth in the nursery is slow. Prick out the seedlings when they are about 2 months old and apply fertiliser. Saplings should be ready for planting in the second or third planting season after germination.





*Ficus altissima* Bl. (MORACEAE) ฝรั่ง (สูง)

A fairly common, large, mostly evergreen tree; usually starts life as an epiphyte, crown spreading; "strangling" root system becoming massive and extensive, often appearing fluted, up to 40 m tall, dbh up to 250 cm.

**Bark:** thin, often flaking, grey, sometimes with small blackish pustular lenticels, cut parts with white latex. **Leaves:** spirally arranged

simple; blades leathery, elliptic to oblong, apex obtuse, base acute to obtuse, margin entire; 12-23 x 7-12 cm, hairless; above dark green; below dull light green; midrib prominent, with 8-10 conspicuous secondary veins on each side; finer venation reticulate; petioles 3.5-7 cm long.

**Flowers:** inflorescences axillary, sessile; flowers numerous, unisexual or sterile (gall), minute, contained in the figs.

**FRUIT/SEED:** fig, an ellipsoid to subglobose syconium, green when unripe, yellow-orange when ripe, dimensions 25.3-28.0 x 23.0-24.5 x 22.1-23.5 mm, numerous tiny brown achenes inside the fig, each containing a single seed, (see photo on page 132); dispersed by animals.

**HABITAT:** disturbed areas in bamboo + deciduous, deciduous dipterocarp-oak, mixed evergreen + deciduous, and evergreen forest; elevation 350-1,250 m.

**USES:** the wood is used for small domestic articles, temporary construction, and interior work. The latex is used medicinally to treat wounds and as a wax for batik cloth production. Particularly important for attracting seed-dispersing wildlife. The fig is edible by humans, as well as birds. Hmong hill tribe people use the leaves in an aromatic sauna.



*F. altissima*

**DISTRIBUTION:** northern Thailand, India, Yunnan, Indo-China, Myanmar and Malesia

**SEEDLINGS: Cotyledonary leaves:**

opposite; blades orbicular, apex obtuse and shallowly emarginate, base obtuse, margin entire, hairless; outside light green; inside mid-green; venation basal, mid-green with 4 secondary veins.

**Stem:** hypocotyl mid-green with dark

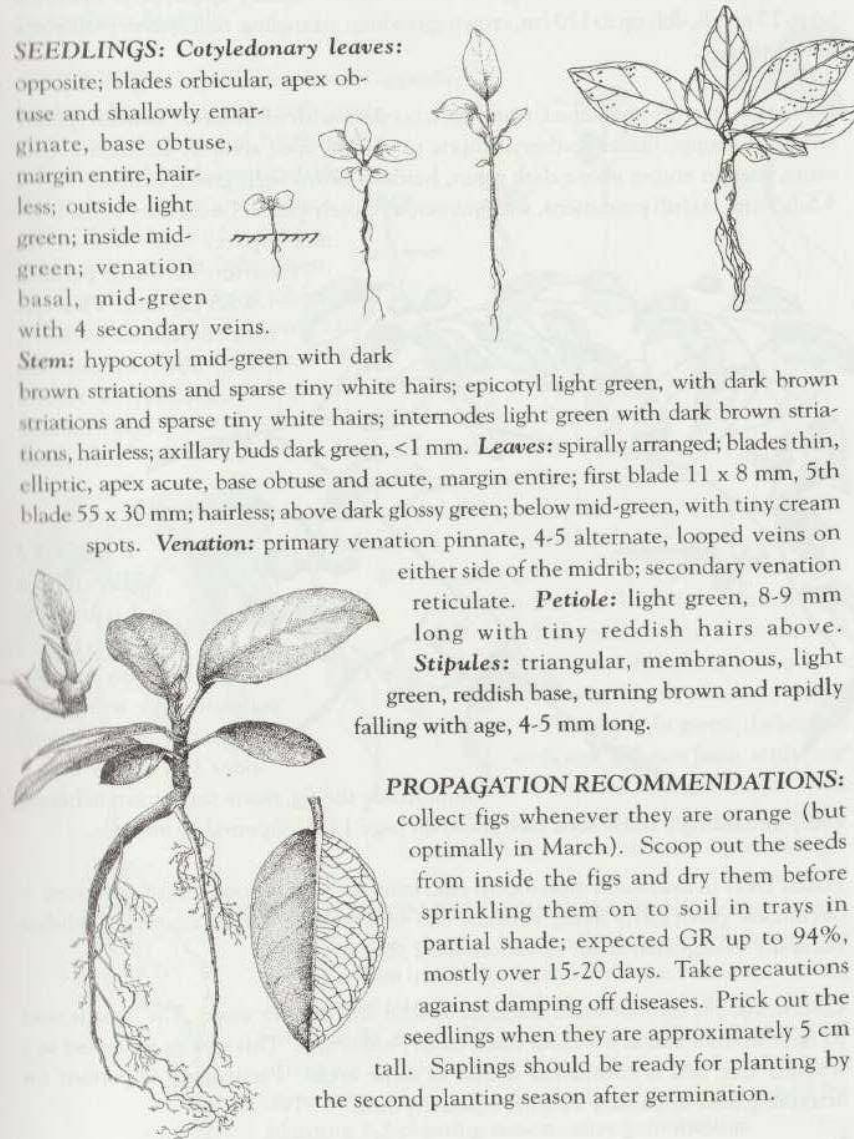
brown striations and sparse tiny white hairs; epicotyl light green, with dark brown striations and sparse tiny white hairs; internodes light green with dark brown striations, hairless; axillary buds dark green, <1 mm. **Leaves:** spirally arranged; blades thin, elliptic, apex acute, base obtuse and acute, margin entire; first blade 11 x 8 mm, 5th blade 55 x 30 mm; hairless; above dark glossy green; below mid-green, with tiny cream spots. **Venation:** primary venation pinnate, 4-5 alternate, looped veins on

either side of the midrib; secondary venation reticulate. **Petiole:** light green, 8-9 mm long with tiny reddish hairs above.

**Stipules:** triangular, membranous, light green, reddish base, turning brown and rapidly falling with age, 4-5 mm long.

**PROPAGATION RECOMMENDATIONS:**

collect figs whenever they are orange (but optimally in March). Scoop out the seeds from inside the figs and dry them before sprinkling them on to soil in trays in partial shade; expected GR up to 94%, mostly over 15-20 days. Take precautions against damping off diseases. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting by the second planting season after germination.





*Ficus benjamina* L. var. *benjamina* (MORACEAE)

• Golden fig • ทุเรียน

A common, medium-sized, evergreen tree or shrub, initially epiphytic or epilithic, up to 25 m tall, dbh up to 110 cm, crown spreading; strangling root system prominent and extensive.

**Bark:** thin, slightly roughened, white-grey, cut parts with white latex. **Leaves:** spirally arranged, simple; blades leathery, elliptic to oblong, apex abruptly acuminate, base acute, margin entire; above dark green, hairless; below light green, hairless, 7-11 x 4.5-6.5 cm; midrib prominent, with numerous closely parallel secondary veins 1-1.5

mm apart, fine reticulate venation between; petioles 1.5-2.5 cm long. **Flowers:** inflorescences axillary, sessile; flowers numerous, unisexual or sterile (gall), minute, contained in figs.

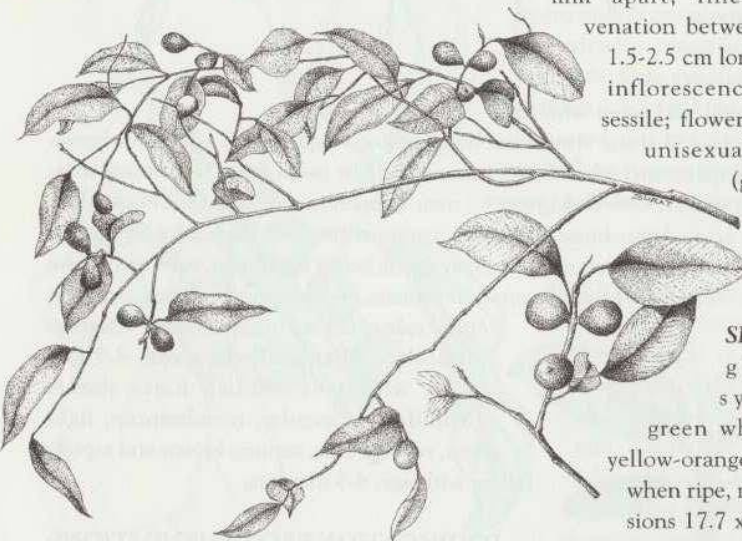
**FRUIT/**

**SEED:** fig is a globose syconium, green when unripe, yellow-orange to maroon when ripe, mean dimensions 17.7 x 15.9 x 15.8

mm. Inside the fig, many tiny brown achenes, each containing a single seed (see photo on page 132); dispersed by animals.

**HABITAT:** in deciduous dipterocarp-oak, bamboo + deciduous, mixed evergreen + deciduous, particularly along streams, and in evergreen forest; readily establishes naturally in degraded areas; elevation 460-1,050 m.

**USES:** wood is used for small domestic articles and interior work. The latex is used to treat wounds and as a wax for batik cloth production. This species is planted as a wayside tree and is considered sacred in some areas. Particularly important for attracting seed-dispersing wildlife, especially birds.



*F. benjamina*

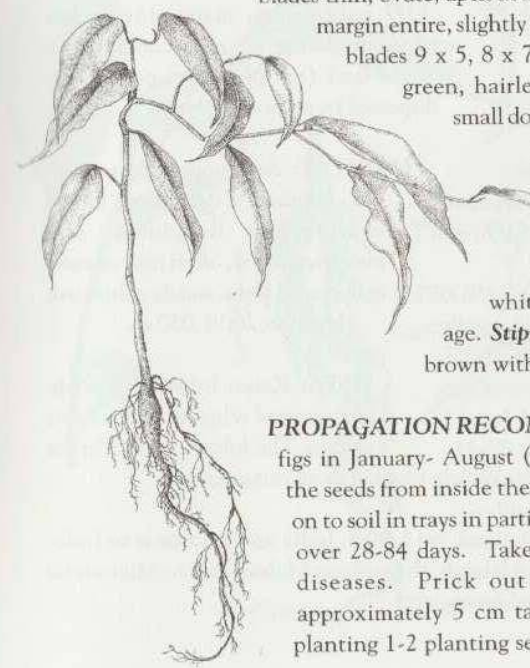
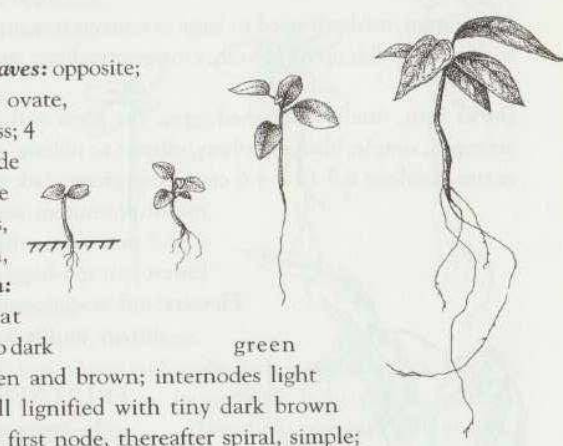
**DISTRIBUTION:** throughout Thailand, India to Myanmar, Indo-China, southern China, throughout Malesia east to the Solomon Islands, and south wards to northern Australia

**SEEDLINGS:** *Cotyledonary leaves:* opposite;

blades suborbicular to broadly ovate, apex retuse, base obtuse, hairless; 4 x 3 mm; inside mid green; outside light green; venation palmate with 2 distinct main basal veins, mid-green; petiole light green, hairless, 1.5-2 mm long. **Stem:** hypocotyl light green at cotyledonary stage, darkening to dark

green and brown; epicotyl dark green and brown; internodes light green, darkening with age; all lignified with tiny dark brown lenticels. **Leaves:** opposite at first node, thereafter spiral, simple;

blades thin, ovate, apex acuminate, base obtuse, margin entire, slightly toothed on young blades; first three blades 9 x 5, 8 x 7 and 13 x 9 mm; above mid-dark green, hairless; below light green with many small dots, hairless. **Venation:** pinnate with 5-6 alternate veins either side of the midrib, light to mid-green; finer venation reticulate. **Petiole:** light green, darkening with age, 2-5 mm long, with tiny white hairs turning light brown with age. **Stipules:** triangular, light green turning brown with age, membranous, 1.5 mm long.



**PROPAGATION RECOMMENDATIONS:** collect orange figs in January- August (optimally in January). Scoop out the seeds from inside the fig and dry them before sprinkling on to soil in trays in partial shade; expected GR up to 100%, over 28-84 days. Take precautions against damping off diseases. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting 1-2 planting seasons after germination.



*Ficus microcarpa* L. f. var. *microcarpa*  
**forma microcarpa** (MORACEAE) • Chinese Banyan,  
 Laurel Fig, Malayan Banyan • ไทรย้อยใบทู่

A common, medium-sized to large evergreen tree, initially epiphytic or epilithic, up to 25 m tall, dbh up to 158 cm, crown spreading; strangling root system extensive.

**Bark:** thin, finely roughened, grey, cut parts with white latex. **Leaves:** spirally arranged, simple; blades leathery, elliptic to oblong, apex obtuse, base acute, margin entire, hairless; 6.5-12 x 4-6 cm; above glossy dark green; below bright light green; midrib prominent; secondary veins 8-11 on each side, c. 2-3 mm apart with reticulate venation between, lowest pair sub-basal; petioles 5-12 mm long.

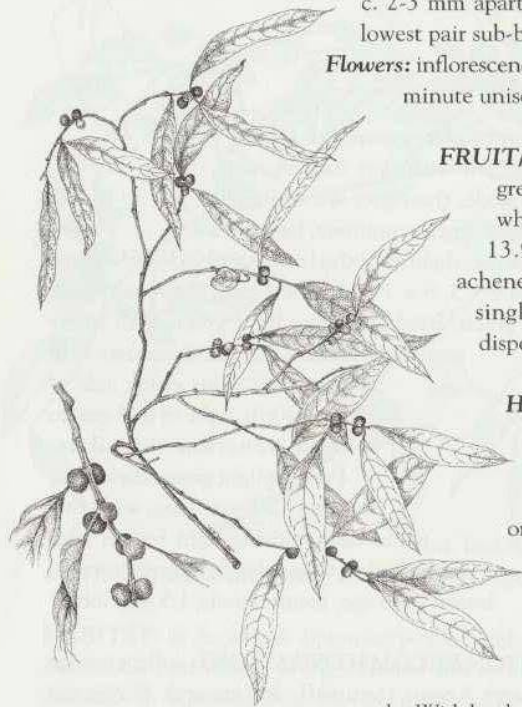
**Flowers:** inflorescences axillary, sessile; flowers numerous, minute unisexual or sterile (gall) in figs.

**FRUIT/SEED:** fig is a globose syconium, green when unripe, pink to yellow-red when ripe, mean dimensions 14.3 x 13.9 x 13.4 mm, many tiny brown achenes inside the fig, each containing a single seed (see photo on page 132); dispersed by animals.

**HABITAT:** deciduous dipterocarp-oak, bamboo + deciduous, mixed evergreen + deciduous, and evergreen forest, often near streams or in degraded areas, widely cultivated; elevation 200-1,050 m.

**USES:** Karen hill tribe people have several religious uses for this species. The foliage is a fodder for cattle. Widely planted as an ornamental.

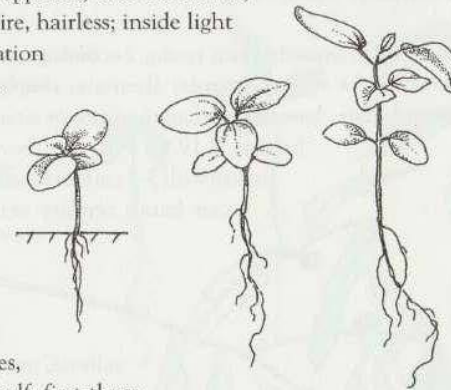
**DISTRIBUTION:** throughout Thailand, Sri Lanka, India and Myanmar to Indo-China, southern China, the Ryukyu Islands, throughout Malesia east to Micronesia and the Solomon islands, south to Queensland



*F. microcarpa*

**SEEDLINGS:** *Cotyledonary leaves:* opposite; blades orbicular, apex retuse, base obtuse, margin entire, hairless; inside light green; outside light green-grey; venation pinnate, indistinct, light green.

**Stem:** hypocotyl light green, with shallow light green striations and tiny white hairs; epicotyl and internodes light green, with tiny white hairs. **Leaves:** first pair opposite, thereafter spiral, simple; blades ovate, apex acute, base obtuse and acute, slightly oblique in first pair of blades, margin obscurely crenate in apical half; first three blades 9 x 7, 14 x 11 and 14 x 10 mm; above mid-green with many tiny dots, hairless; below pale light green, hairless.



below pale light green, hairless.

**Venation:** pinnate, dark green, 5 alternate veins on either side of the midrib after first opposite pair; secondary venation indistinct. **Petiole:** light green, 2-4 mm long with abundant short white hairs.

**Stipules:** triangular, membranous, translucent white, falling rapidly with age, 1 mm long.

**PROPAGATION RECOMMENDATIONS:** collect yellow-red figs in August. Scoop out the seeds from inside the fig and dry them before sprinkling them on to soil in trays in partial shade; expected GR up to 100%; over 15-89 days. Take precautions against damping off diseases. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the first planting season after germination.





*Ficus subulata* Bl. var. *subulata* (MORACEAE) เตื่อ

A common, small, evergreen treelet, up to 5 m tall, dbh up to 7.5 cm.

**Bark:** thin, smooth when young, becoming finely roughened with age, light or dark brown; latex white. **Leaves:** alternate, simple; blades thin, oblong to lanceolate, apex caudate, base acute, margin entire or sinuous to denticulate in the apical half, hairless; 9-19.5 x 3-5.5 cm; above glossy dark green; below light green; midrib with 5-7 pairs of mostly opposite secondary veins, the lowest pair basal; tertiary venation scalariform; finest venation reticulate; petiole 6-8 mm long.

**Flowers:** inflorescences in axillary, solitary figs, on stalks 5-8 mm long; flowers numerous, minute, unisexual or sterile (gall) in figs.

**FRUIT/SEED:** fig is a subglobose syconium, light green-yellow when unripe, orange-red when ripe, mean dimensions 13 x 12.6 mm, many tiny brown achenes inside the fig, each containing a single seed; dispersed by animals. Fruiting can occur as early as 2 years of age.

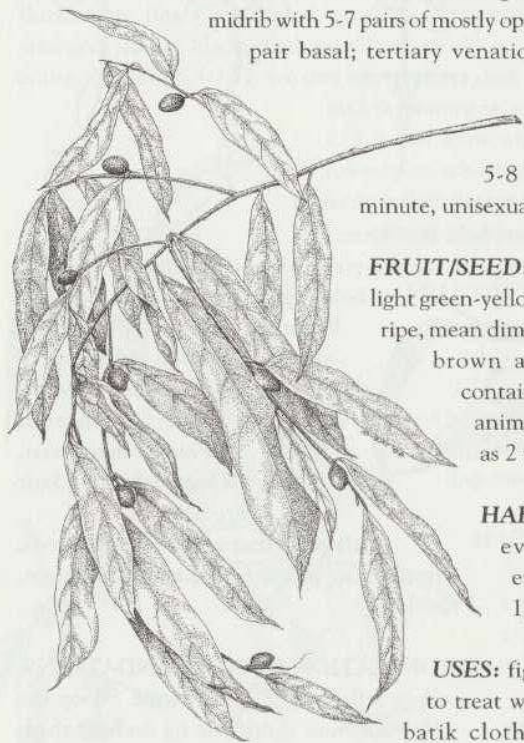
**HABITAT:** disturbed areas in mixed evergreen + deciduous, and evergreen forest; elevation 650-1,700 m.

**USES:** figs are edible. The latex is used to treat wounds and as a wax for making batik cloth. Particularly important for attracting seed-dispersing birds.

Hmong hill tribe people use the leaves in aromatic saunas.

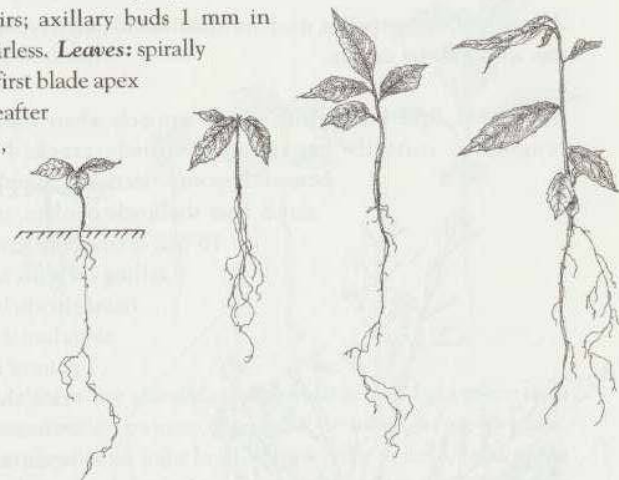
**DISTRIBUTION:** Thailand, Himalayas, Yunnan, Indo-China, Myanmar, and Malaysia

**SEEDLINGS:** *Cotyledonary leaves:* opposite; blades orbicular, apex obtuse, base obtuse, inside light green, outside paler green outside, hairless, margin entire; venation pinnate; petiole light green, 1 mm long. *Stem:* hypocotyl light green at first ageing



*F. subulata*

to dull olive; epicotyl and internodes light green-olive, with fine, tiny white hairs; axillary buds 1 mm in diameter, green-brown, hairless. **Leaves:** spirally arranged, simple, elliptic; first blade apex acute, base cuneate, thereafter apex acute, base cuneate, slightly oblique, margin shallowly serrate in apical half with tiny white hairs; first two blades 26 x 14 and 48 x 14 mm; above dark green; below light green, with scattered small



outgrowths and tiny white hairs on both sides, sparser below, mainly along the midrib. **Venation:** pinnate, light green; primary veins 5-7 on either side of the midrib, alternate, looped. **Petiole:** light green, 2-3 mm long with tiny white hairs. **Stipules:** triangular, firm, white-light yellow initially, ageing to dark red/brown, 3 mm long.

**PROPAGATION**

**RECOMMENDATIONS:** collect orange-red figs in January. Scoop out the seeds from inside the fig and sow them thinly in trays in partial shade; expected GR up to 70%, over 20-60 days. Prick out the seedlings when they are 4-6 cm tall (2-3 months after germination). Apply slow-release fertiliser and stake because of slightly trailing habit. Saplings should be ready for planting in the second planting season after germination.





## *Gmelina arborea* Roxb. (VERBENACEAE)

• Yemane • ช้อ

A common, fast-growing, medium-sized, deciduous tree, up to 30 m tall, dbh up to 64 cm, with a dense crown.

**Bark:** thin, light brown with cream lenticels when young, becoming grey, finely roughened initially becoming shallowly cracked and flaking with age.

**Leaves:** opposite, decussate, simple; blades thin, ovate, apex acute, base shallowly cordate, margin entire; 13-21 x 13-

16 cm; above dark green with many tiny hairs, falling off with age, with a pair of distinct basal glands; below dull light green with

abundant woolly hairs; midrib with 5-

7 pairs of mostly opposite secondary veins, the lowest pair basal; tertiary venation scalariform; finer venation reticulate; petiole 6-8

mm long. **Flowers:** inflorescences mostly appearing when the tree is

leafless, terminal, paniculate,

10-20 cm long, axes brown and hairy;

flowers numerous, 3 cm long; corolla red

brown outside, cream-yellow inside; anthers light yellow; filaments yellow, slightly fragrant; stigma and style yellow.



**FRUIT/SEED:** an obovoid drupe, bright green when unripe, yellow when ripe, 20-24 mm in diameter,

containing 1-4 pyrenes, each with 1 seed (see photo on page 132); dispersed by animals. Fruiting occurs 3-4 years after planting.

**HABITAT:** secondary growth in almost all forest types, establishes naturally in disturbed areas, sometimes planted; elevation 250-1,500 m.

**USES:** high value timber for floors, ceilings, furniture, carvings, musical instruments, boats and tools. Also used for plywood, veneers, pulp, paper, fuel and charcoal. The unripe fruits are used to make an infusion to treat stomach ailments. All parts are used in Hindu medicine. A yellow dye is extracted from the fruits and wood ash. The fruit is very attractive to insects and is eaten by deer and cattle. Leaves are used for silkworm culture and as cattle-fodder.

## *G. arborea*

### DISTRIBUTION:

throughout Thailand, India south to Sri Lanka, Indo-China, Myanmar and Malesia.

### SEEDLINGS:

#### Cotyledonary

leaves: opposite,

elliptic, apex

obtuse and

shallowly

emarginate,

base acute,

margin entire;

inside mid-green with abundant white glandular hairs; outside pale light green with sparse white glandular hairs; venation pinnate, very faint; petiole light green-white, grooved, 9 mm long. **Stem:** hypocotyl light bright green paler at base, light green striations, with abundant white glandular hairs; epicotyl and internodes light bright green, with white glandular hairs disappearing with age. **Leaves:** opposite, simple;

blades papery; first blades ovate, apex acuminate, base acute; thereafter ovate to deltoid, apex acuminate, base cuneate to truncate, margin with several shallow lobes on each side; first three blades 44 x 30, 75 x 60 and 72 x 60 mm; above mid-green with sparse tiny white hairs that disappear with age; below pale light green-grey, hairless.

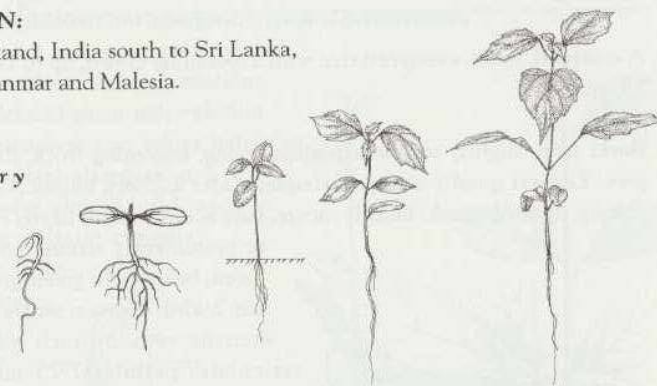
**Venation:** pinnate, light green with a pair of basal veins and 7-8 secondary veins on either side of the midrib. **Petiole:** pale light green-pink, with tiny white hairs, 35 mm long. **Stipules:** absent.

**PROPAGATION RECOMMENDATIONS:** collect yellow fruits in March-June. Remove the fruit flesh by hand. Wash and soak the pyrenes in water for 12-24 hours before sowing them 2-5 cm apart shallowly in trays, in partial shade; expected GR up to 83%, over 18-32 days. Prick out the seedlings when the first leaf pair has expanded, 4-12 days after germination. May require pruning and reduced fertiliser application to prevent seedlings outgrowing their containers. Saplings should be ready for planting in the second planting season after germination (i.e. after about 13-16 months).

**FRUIT/SEED:** an obovoid drupe, bright green when unripe, yellow when ripe, 20-24 mm in diameter, containing 1-4 pyrenes, each with 1 seed (see photo on page 132); dispersed by animals. Fruiting occurs 3-4 years after planting.

**HABITAT:** secondary growth in almost all forest types, establishes naturally in disturbed areas, sometimes planted; elevation 250-1,500 m.

**USES:** high value timber for floors, ceilings, furniture, carvings, musical instruments, boats and tools. Also used for plywood, veneers, pulp, paper, fuel and charcoal. The unripe fruits are used to make an infusion to treat stomach ailments. All parts are used in Hindu medicine. A yellow dye is extracted from the fruits and wood ash. The fruit is very attractive to insects and is eaten by deer and cattle. Leaves are used for silkworm culture and as cattle-fodder.





## *Helicia nilagirica* Bedd. (PROTEACEAE)

### • High Mountain Silky Oak • หม้อดตัวผู้

A common, small, evergreen tree with a spreading crown, up to 14 m tall, dbh up to 35 cm.

**Bark:** thin, slightly roughened when young, becoming thick, deeply ridged, dark grey. **Leaves:** spirally arranged, simple; blades leathery, elliptic, oblong or obovate-oblong, apex obtuse to bluntly acute, base acute, margin nearly entire to obscurely or prominently serrate, hairless; above dark green; below light green-grey; 15-24 x 4.5-11 cm; midrib distinct; secondary venation, 6-8 alternate veins on each side; finer venation reticulate; petioles 7-25 mm long; stipules abundantly



hairy. **Flowers:** inflorescences from leafless nodes; pendulous, mostly racemose, 10-14 mm long; main axis dull green; pedicels 3-4 mm long; flowers numerous, bisexual, 12-15 mm long, often fragrant; petals 5, white; anthers light yellow; stigma and style white-cream.

**FRUIT/SEED:** subglobose nut, smooth, bright green when unripe, brown when ripe, mean dimensions 33.5 x 28.6 x 27.4 mm, containing a single globose seed, light brown-white, 20.4 x 19.9 x 18.9 mm (see photo on page 132); animal dispersed.

**HABITAT:** evergreen and evergreen + pine forests, particularly forest edges and disturbed, fire-prone areas; elevation 675-2,250 m.

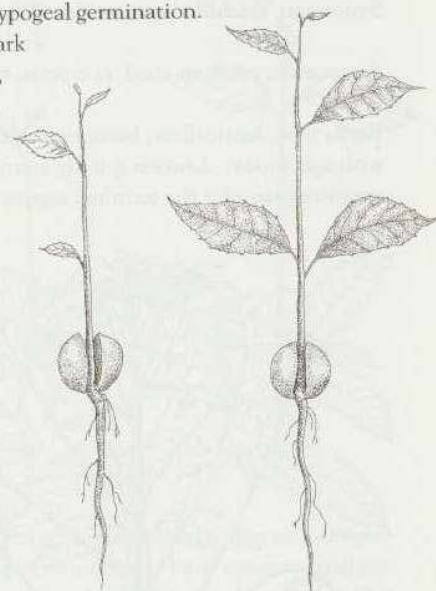
**USES:** wood used for construction, interior finish, joinery and cabinet-making. Rodents and monkeys eat the fruits.

**DISTRIBUTION:** north and north-east Thailand, India, Yunnan, Myanmar, Indo-China

## *H. nilagirica*

**SEEDLINGS:** **Cotyledons:** not emergent, hypogeal germination.

**Stem:** hypocotyl not emergent; epicotyl dark green, red-brown at base, thin red striations, hairless; internodes mid-green-red, with thin red striations and sparse tiny white hairs easily shed. **Leaves:** alternate at first, simple; first blades almost bifid, apex obcordate, base oblique cuneate; thereafter elliptic, apex sharply acuminate, base cuneate, margin sharply serrate cuspidate, white-yellow; first three blades 41 x 41, 45 x 30 and 92 x 57 mm; above



mid-green with sparse tiny white hairs; below light green, with sparse white or brown hairs on the midrib, easily shed. **Venation:** pinnate, light green; veins 3-5 arching, alternate on either side of the midrib; finer venation reticulate. **Petiole:** light green-purple, 3-4 mm long, with sparse tiny white hairs. **Stipules:** absent.

### PROPAGATION

**RECOMMENDATIONS:** collect brown or black fruits, usually in July. Extract the seeds and sow them 5 cm apart in trays in partial shade, or in individual containers; expected GR up to 70%, over 18-120 days. Prick out the seedlings when they are 5-7 cm tall. Saplings should be ready for planting in the first planting season after germination.





## *Heynea trijuga* Roxb. ex Sims (MELIACEAE) ตะเคียนทู่

Synonym: *Trichilla connaroides* (Wight & Arn.) Benth.

A common, medium-sized, evergreen tree, up to 20 m tall, dbh up to 45 cm.

**Bark:** thin, lenticellate, becoming thick and roughly vertically ridged and cracked, with age, brown. **Leaves:** spirally arranged, imparipinnate, 35-50 cm long; leaflets 3 opposite pairs plus the terminal segment; blades thin, elliptic, apex acuminate, base acute, margin entire, slightly sinuous; 12-22 x 5-9 cm; above dull dark green, hairless; below light green-grey with sparse tiny white hairs denser on the veins; midrib with 13-16 alternate, secondary veins on either side; tertiary venation reticulate; petioles 10-14 cm long with abundant short brown hairs; petiolule of opposite leaflets 5-12 mm long, of terminal leaflet up to 55 mm long.

**Flowers:** inflorescence axillary, panicle, 20-26 cm long; axes hairy, green, peduncles 14-18 cm long; flowers numerous; calyx light green; corolla cream-white; anthers light yellow; filaments cream-white, slightly fragrant.

**FRUIT/SEED:** a globose, fleshy, septicidal, 2-valved, capsule, light green when unripe, dark red when ripe, mean dimensions 13.4 x 12.2 x 11.8 mm, containing 2 dark purple seeds, enclosed in a white juicy aril, 10.4 x 9.6 x 8.9 mm (see photo on page 133); animal dispersed

**HABITAT:** bamboo + deciduous, mixed evergreen + deciduous, evergreen, and evergreen + pine forest, particularly in degraded areas; elevation 550-1,550 m.

**USES:** fuel-wood. The bark and leaves are used medicinally. Mammals eat the seeds.

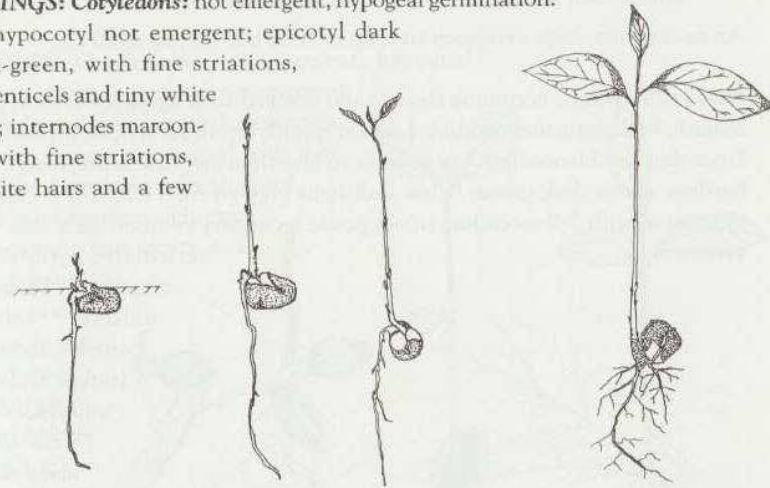
**DISTRIBUTION:** northern Thailand, India, southern China, Indo-China, peninsular Malaysia, Sumatra, Borneo, Philippines



## *H. trijuga*

**SEEDLINGS:** **Cotyledons:** not emergent, hypogeal germination.

**Stem:** hypocotyl not emergent; epicotyl dark maroon-green, with fine striations, cream lenticels and tiny white prickles; internodes maroon-green, with fine striations, tiny white hairs and a few



prophylls, 1-2 mm long. **Leaves:** spirally arranged, simple; blades oblong, apex acuminate, base cuneate, margin entire; first three blades 50 x 25, 45 x 21 and 40 x 17 mm; above dark green, slightly maroon; below light grey-green, both sides hairless; young blades maroon above, light green-red below. **Venation:** pinnate, light green, with 7-9 alternate pairs of veins; finer venation reticulate. **Petiole:** mid-green, maroon stripes, 16 mm long with tiny white hairs. **Stipules:** absent.

### PROPAGATION

**RECOMMENDATIONS:** collect dark red fruits from the tree or the ground, usually in November. Remove the seeds and sow them in trays in partial shade; expected GR up to 83%, mostly over 40-96 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.



*Horsfieldia amygdalina* (Wall.) Warb. var. *amygdalina*  
(MYRISTICACEAE) • Penarahan, Horsfieldia • เตือนก

An uncommon, large evergreen tree, up to 30 m tall, dbh up to 90 cm.

**Bark:** thin, rough, becoming thicker and cracked with age, grey-brown, pith sap reddish, branching monopodial. **Leaves:** spirally arranged, simple; blades leathery, lanceolate to oblanceolate, apex obtuse to bluntly acute, base acute, margin entire, hairless; above dark green; below dull light grey-green; 11-25 x 4-8 cm; midrib prominent with 7-9 ascending sub-opposite secondary veins on each side; tertiary venation

reticulate; petioles 10-17 mm long. **Flowers:** in axillary unisexual panicles, mostly from leafless nodes; male inflorescences 10-15 cm long and many-flowered; female ones shorter and fewer



flowered;  
flowers numerous,  
globose, hardly opening, 1-2 mm in diameter;  
perianth pale light green to light yellow or orange with 2-4 erect lobes; anthers grey.

**FRUIT/SEED:** an ellipsoid, bivalved, loculicidal capsule, glossy light green when unripe, ripening to maroon-brown, mean dimensions 40.7x 25.1 x 23.7 mm, containing a single ovoid seed covered by a thin tan aril with prominent venation, endosperm mottled, 24.3 x 16.2 x 15.4 mm (see photo on page 133); animal dispersed.

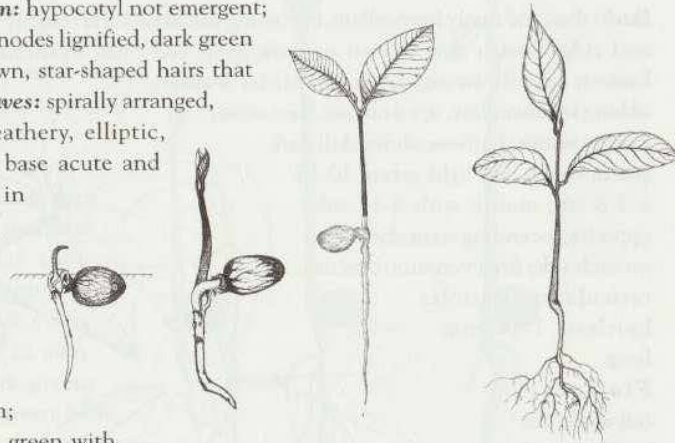
**HABITAT:** mixed evergreen + deciduous, evergreen, evergreen + pine forest, particularly in disturbed areas; elevation 650-1,225 m.

**USES:** wood is used for light and temporary construction, boat building, interior trim, joinery, sporting goods, packing cases, particle board and plywood. In Thailand the sap is used as a red dye.

*H. amygdalina*

**DISTRIBUTION:** northern Thailand, India, Yunnan, Myanmar, Indo-China

**SEEDLINGS:** **Cotyledons:** not emergent, hypogeal germination. **Stem:** hypocotyl not emergent; epicotyl and internodes lignified, dark green with minute, brown, star-shaped hairs that fall-off easily. **Leaves:** spirally arranged, simple; blades leathery, elliptic, apex acuminate, base acute and slightly oblique in young leaves, becoming less oblique later, margin entire; first three blades 91 x 50, 101 x 55 and 99 x 40 mm; above glossy dark green with



minute, brown, star-shaped hairs; below light green-grey with light brown star-shaped hairs. **Venation:** pinnate, with 12-13 mid-dark green, alternate veins; finer venation reticulate. **Petiole:** dark green, 9 mm long, with brown star-shaped hairs. **Stipules:** absent.

**PROPAGATION**

**RECOMMENDATIONS:** collect brown fruits in late May. Remove the aril and sow the seeds at least 5 cm apart in trays or into containers in deep shade, taking precautions to prevent fungal diseases; expected GR up to 90%, over 23-58 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination (i.e. after about 13 months).





*Horsfieldia thorelii* Lec. (MYRISTICACEAE)

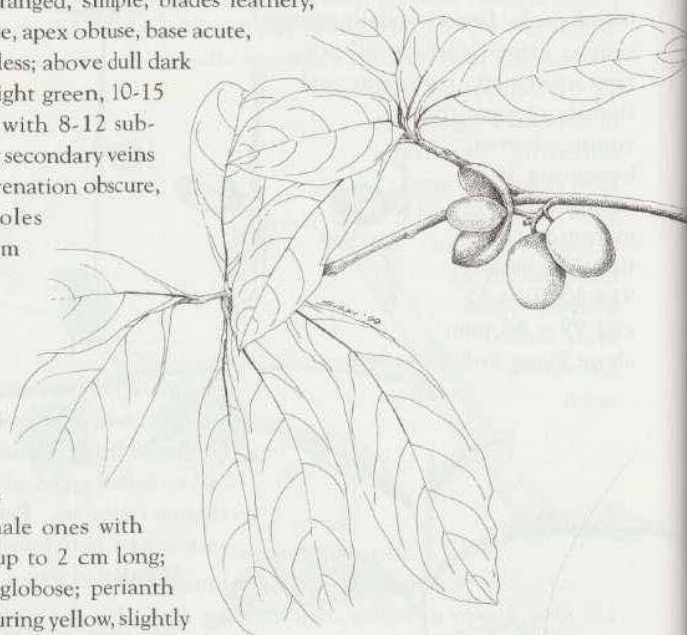
• Penarahan, Horsfieldia • เลือดม้า

An uncommon, medium-sized, evergreen tree, up to 20 m tall, dbh up to 75 cm.

**Bark:** thin and finely lenticellate, becoming thickened and roughly vertically cracked and ridged with age, brown or dark grey, red pith, branching monopodial.

**Leaves:** spirally arranged, simple; blades leathery, oblong to lanceolate, apex obtuse, base acute, margin entire, hairless; above dull dark green; below dull light green, 10-15 x 3-8 cm; midrib with 8-12 sub-opposite, ascending secondary veins on each side; finer venation obscure, reticulate; petioles hairless, 7-16 mm long.

**Flowers:** inflorescences unisexual, panicle, mostly from leafless nodes; male inflorescences 6-21 cm long; female ones with fewer flowers and up to 2 cm long; flowers numerous, globose; perianth light green and maturing yellow, slightly fragrant, 1-2 mm diameter.



**FRUIT/SEED:** an ellipsoid, bivalved, loculicidal capsule, green when unripe, light yellow to orange when ripe, mean dimensions 44.9 x 31.0 x 29.0 mm, containing a single ellipsoid, tan seed, covered in an orange aril; endosperm mottled, 33.4 x 18.3 x 17.9 mm (see photo on page 133); animal dispersed.

**HABITAT:** bamboo + deciduous, mixed evergreen + deciduous, and evergreen forest, often in disturbed areas; elevation 550-1,175 m.

**USES:** sap is used as a red dye, in Thailand.

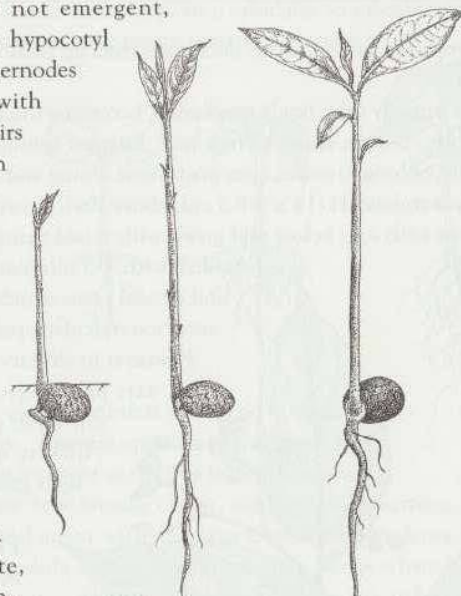
**DISTRIBUTION:** central and northern Thailand and Indo-China

*H. thorelii*

**SEEDLINGS:** **Cotyledons:** not emergent, hypogeal germination. **Stem:** hypocotyl not emergent; epicotyl and internodes firm, medium green-brown, with minute brown star-shaped hairs that fall off easily; light brown striations on the epicotyl and scale-like prophylls.

**Leaves:** spirally arranged, simple; blades oblong, apex acuminate, base attenuate in the first leaf then cuneate, margin entire; first three blades 8 x 3.5, 43 x 20 and 45 x 22 mm; above glossy dark green; below glossy mid-green, both with brown star-shaped hairs.

**Venation:** pinnate, medium green-



brown, 5-7 arching alternate veins on either side of the prominent midrib; finer venation obscure.

**Petiole:** mid-green, 5-7 mm long with brown star-shaped hairs. **Stipules:** absent.

**PROPAGATION**

**RECOMMENDATIONS:** collect yellow fruits in May. Remove the aril and sow the seeds, at least 5 cm apart, in trays or containers in deep shade, taking precautions against fungal diseases; expected GR up to 94%, over 21-56 days. Prick out at seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination (i.e. after about 13 months).





## *Hovenia dulcis* Thunb. (RHAMNACEAE)

### • Japanese Raisin Tree, Coral Tree • หมอนหิน

A rare, large, fast-growing, deciduous tree, up to 30 m tall, dbh up to 55 cm.

**Bark:** initially thin, finely roughened, becoming thickened, roughly vertically cracked with age, brown; fissures brick red. **Leaves:** spirally arranged, simple; blades thin, elliptic, oblong to ovate, apex acute, base obtuse and abruptly acute above the petiole; finely serrulate; 11-14 x 5-8.5 cm; above dark glossy green, sparsely hairy becoming hairless with age; below mid green with raised veins covered with fine brown hairs; midrib with 4-5 alternate secondary veins on each side and 2 basal veins which are also pinnately veined; finer venation reticulate; petioles finely hairy, 7-20 mm long.

**Flowers:** in axillary panicles of cymes, 5-6 cm long; axes light green, finely hairy; peduncles 1.5-3.5 cm long; pedicels recurved, 3 mm long; flowers numerous, 2.5 mm long; calyx light green.

**FRUIT/SEED:** infructescences usually leafless, up to 45 cm long; upper axes becoming swollen, fleshy, juicy and brown; capsules globose, 3-lobed, septicidally dehiscent, green when unripe, red-brown or black and drying upon ripening, calyx remnant ring-like at the base, mean dimensions 7.7 x 6.7 x 6.8 mm, containing 1 smooth, blackish seed per lobe, 4 mm in diameter (see photo on page 133); dispersed by birds and small mammals.

**HABITAT:** in stream valleys in primary evergreen forest; elevation 1,000-1,300 m.

**USES:** the wood is suitable for pulp and fibre. The swollen axes of the infructescence are used in a traditional treatment of hangovers and are attractive to birds. Small mammals eat the fruits and the nectar is attractive to birds. Hmong hill tribe people use the bark as a laxative.

**DISTRIBUTION:** northern Thailand, subtropical Himalayas, China, Korea and Japan



**SEEDLINGS:** **Cotyledonary leaves:** thin, opposite, orbicular to suborbicular, apex obtuse, base broadly obtuse, hairless, mid-green; venation pinnate, obscure; petiolate. **Stem:** hypocotyl

light green with orange-brown longitudinal striations and minute dense white hairs; epicotyl light green, with abundant white hairs; internodes light

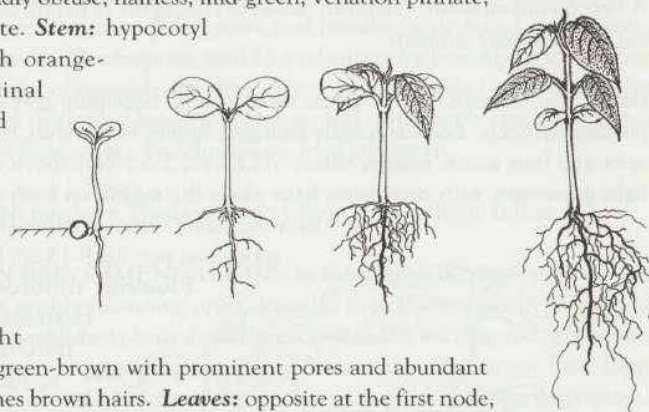
green ageing to green-brown with prominent pores and abundant white or sometimes brown hairs. **Leaves:** opposite at the first node, spiral at later nodes; simple; blades ovate at the first node, broadening at higher nodes, apex acuminate, base broadly obtuse, margins doubly serrate; up to 122 x 85 mm; above mid-green with fine sparse white hairs, dense on the midrib; below light green with dense white hairs on the midrib, less dense on other veins.

**Venation:** pinnate with 4-6 alternate pairs of light green veins each side of the midrib, all lateral veins are arching, mostly free-ending; finer venation reticulate. **Petiole:** green, 50 mm long, with abundant light brown hairs.

**Stipules:** subulate, acuminate at apex, 4 mm long with abundant short white hairs.

#### PROPAGATION RECOMMENDATIONS:

collect brown or black fruits in November-January. Remove the seeds and soak them in water for 1-2 days before sowing them shallowly in trays in partial shade; expected GR up to 70%, mostly over 20-80 days. Prick out the seedlings once they have developed 4-5 leaves. Seedling growth is rapid. Saplings should be ready for planting in the first or second planting season after germination.



## *H. dulcis*



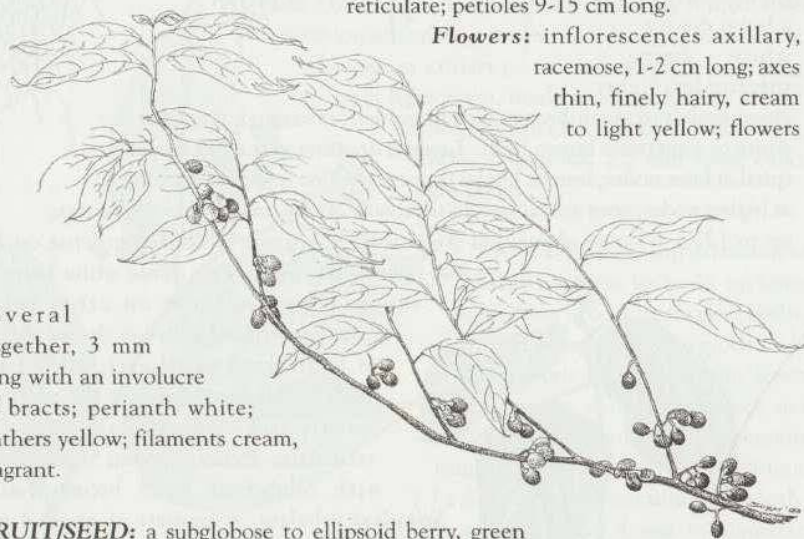
*Litsea cubeba* (Lour.) Pers. (LAURACEAE)

• Medang, Bollywood • ตะไคร้ต้น

A very common, small, evergreen treelet or tree, up to 12 m tall, dbh up to 25 cm, all cut parts strongly aromatic.

**Bark:** thin, smooth, yellow green when young, becoming grey-brown with small pustular lenticels. **Leaves:** spirally arranged, simple; blades thin, lanceolate to ovate, apex and base acute, margin entire; 7-13.5 x 2.2-5.5 cm; above dark green; below light green-grey with tiny sparse hairs along the midrib on both sides; midrib with 6-9 thin secondary veins on either side; finer venation reticulate; petioles 9-15 cm long.

**Flowers:** inflorescences axillary, racemose, 1-2 cm long; axes thin, finely hairy, cream to light yellow; flowers



several together, 3 mm long with an involucre of bracts; perianth white; anthers yellow; filaments cream, fragrant.

**FRUIT/SEED:** a subglobose to ellipsoid berry, green when unripe, dark purple-maroon when ripe, mean dimensions 7.9 x 7.7 x 7.6 mm, containing 1 subglobose to ellipsoid brown seed, 5.8 x 5.6 x 5.3 mm (see photo on page 133); dispersed by birds.

**HABITAT:** very common coloniser of degraded, fire-prone areas in evergreen and evergreen + pine forest; elevation 875-1,825 m.

*L. cubeba*

**USES:** wood is used for interior finish, panelling, furniture, cabinet-making, rotary veneer, plywood, packing cases, poles, posts, tool handles, agricultural implements, carving and fuel-wood. The fruits are used as a substitute for lemongrass in cooking and for the treatment of stomach disorders. Thais make an herbal bath essence for fighting cocks from the boiled leaves and Hmong hill tribe people crush the leaves with water to treat headaches. The flowers are fried and eaten.

**DISTRIBUTION:** northern Thailand, Indo-China and southern Yunnan

**PROPAGATION RECOMMENDATIONS:** as this species is commonly found as coppicing treelets, readily colonising open, degraded sites, there is usually no need to plant it. Naturally established plants should be encouraged by weeding and application of fertiliser. Attempts to propagate this species from seed in the nursery have been unsuccessful so far. Therefore, no seedling specimens were available for description.



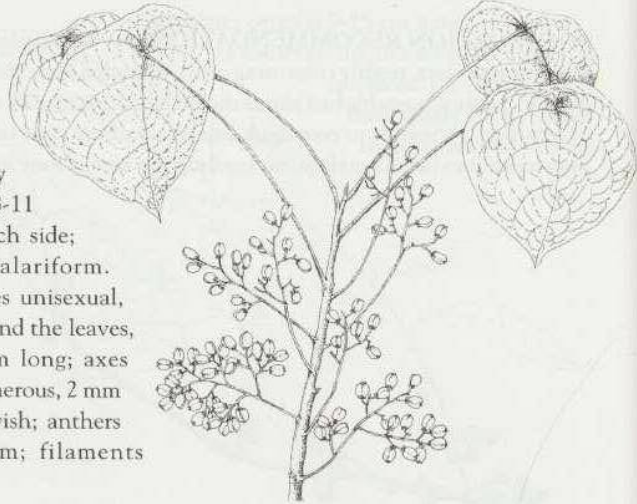
*Macaranga denticulata* (Bl.) M. -A. (EUPHORBIACEAE) • Mildew Mahang • ตองแตบ (เต้าแก้ว)

A very common, fast-growing, small to medium-sized, evergreen tree, up to 19 m tall, dbh up to 40 cm.

**Bark:** thin, finely roughened slightly cracked with age, usually with pustular lenticels, light brown or light grey, cut branches with red sap. **Leaves:** spirally arranged, simple; blades leathery, ovate; apex acute, base broadly obtuse, peltate, margin entire to shallowly crenulate; 15-34 x 13-32 cm; initially both surfaces with cream-brown furfuraceous indumentum,

later becoming mostly smooth above; above dull dark green; below dull light green-grey, sparsely hairy and minutely granular; midrib with 8-11 secondary veins on each side; finer venation scalariform.

**Flowers:** inflorescences unisexual, from leafless nodes behind the leaves, paniculate, c. 3-15 cm long; axes finely hairy, flowers numerous, 2 mm long; sepals dull yellowish; anthers light yellow or cream; filaments translucent white.



**FRUIT/SEED:** a septicidal, depressed globose, 3-lobed capsule, green when unripe, light green-brown when ripe, mean dimensions 4.4 x 3.5 x 3.1 mm, containing 1 seed per lobe, 2.4 x 2.3 x 2.2 mm (see photo on page 134); dispersed by wind.

**HABITAT:** degraded areas and secondary growth, in bamboo + deciduous, mixed evergreen + deciduous, and evergreen forest; elevation 525-1,370 m.

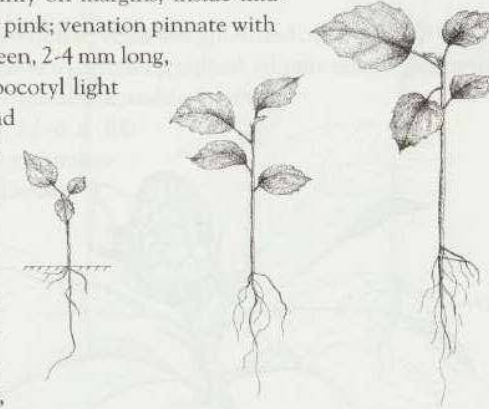
**USES:** the wood is used for temporary construction, interior trim, moulding, shingles, packing cases, outriggers for canoes and match splints.

**DISTRIBUTION:** north, south-west and peninsular Thailand, eastern Himalayas to Indo-China, southern China, peninsular Malaysia, Hainan, Sumatra, Java

*M. denticulata*

**SEEDLINGS:** **Cotyledonary leaves:** thin, opposite, orbicular to ovate, apex acute, base obtuse and slightly cordate, margin entire; 11 x 7 mm at maturity, with sparse tiny white hairs, mainly on margins; inside mid-dark green; outside mid-green and pink; venation pinnate with 2 basal veins; petiole light pink-green, 2-4 mm long, with tiny white hairs. **Stem:** hypocotyl light green and pink-red; epicotyl and internodes light green, all lignified with tiny white hairs.

**Leaves:** spirally arranged, simple; blades thin, slightly rough, ovate, apex acute, base obtuse in first blades, becoming cordate and basifixed, then peltate by 8th or 9th node, margin scarcely toothed; first three blades 22 x 15, 29 x 19 and 42 x 26 mm, with sparse



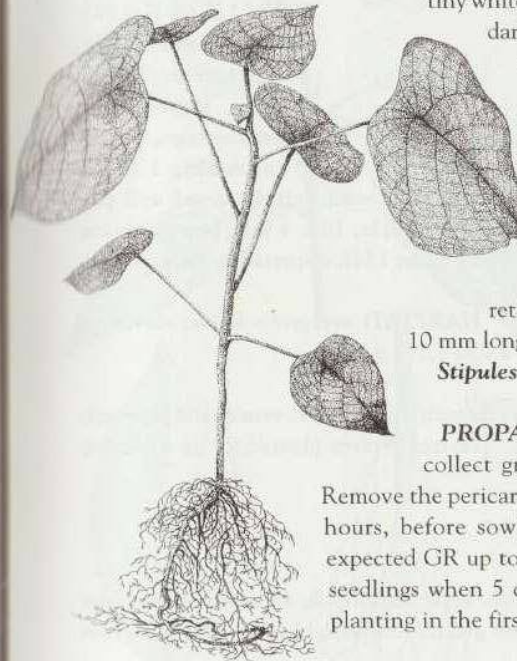
tiny white hairs on the midrib and margin; above dark green; below pink-green, especially the younger leaves; small protuberances above match indentations below.

**Venation:** pinnate, with 4-5 alternate veins on either side of the midrib, except for the first basal pair which is opposite, mid green or pink depending on age; finer venation obscurely scalariform; finest venation reticulate. **Petiole:** cream to light pink, 10 mm long, with many short white hairs.

**Stipules:** narrow triangular, reddish, 1.5 mm.

**PROPAGATION RECOMMENDATIONS:**

collect green-brown fruits in August-October. Remove the pericarp and soak the seeds in water for 12-24 hours, before sowing them in trays in partial shade; expected GR up to 90%, over 18-39 days. Prick out the seedlings when 5 cm tall. Saplings should be ready for planting in the first planting season after germination.





## *Manglietia garrettii* Craib (MAGNOLIACEAE)

### • Garrett's Champaka • มณฑาป่า, มณฑาดอย

An uncommon, medium-sized, deciduous tree, up to 18 m tall, dbh up to 41 cm.

**Bark:** thin, smooth, becoming markedly pustular-lenticellate, grey. **Leaves:** spirally arranged; blades simple, leathery, elliptic to oblong, apex and base acute, margin entire, hairless; above dull dark green; below light green; 22-30 x 6-11 cm; midrib with 20-24 thin secondary veins on each side; finer venation reticulate; petiole hairless, 3-4 cm long.

**Flowers:** inflorescences terminal, with a solitary, bisexual flower 5.5-6.5 cm long; pedicels 2-3 cm long; stamens and carpels numerous.

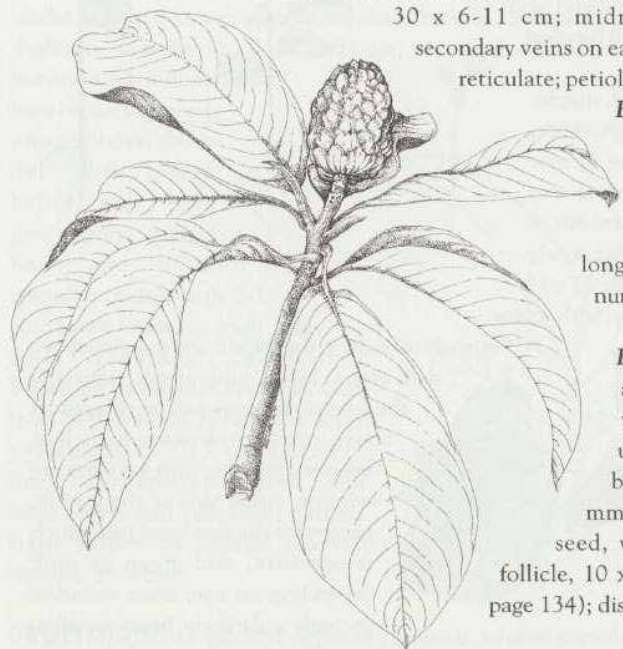
**FRUIT/SEED:** aggregate follicle, light yellow-green when unripe, maroon to brown when ripe, 95 x 60 mm, containing 1 black seed, within a red aril per follicle, 10 x 4 mm (see photo on page 134); dispersed by birds.

**HABITAT:** evergreen forest; elevation 1,050-1,550 m.

**USES:** wood used for house and bridge construction, furniture, veneer and plywood. The seeds are eaten by small mammals. The tree is often planted for its attractive flowers.

**DISTRIBUTION:** northern Thailand

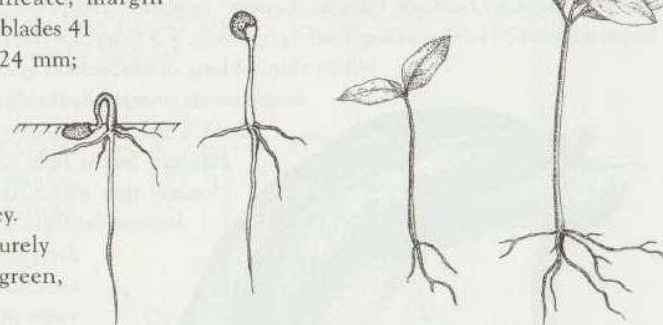
**SEEDLINGS:** *Cotyledonary leaves:* thin, opposite, elliptic, apex acuminate, base acute, margin entire, hairless; inside dark green; outside light green-grey; venation



obscurly pinnate, light green. **Stem:** hypocotyl light green with pale green striations, hairless; epicotyl and internodes bright light green, with sparse short white hairs, epicotyl with faint striations.

**Leaves:** spirally arranged, simple; blades elliptic, apex acute, base cuneate, margin entire; first two blades 41 x 24 and 42 x 24 mm; hairless; above bright mid-green; below light green-silvery grey.

**Venation:** obscurely pinnate, light green,



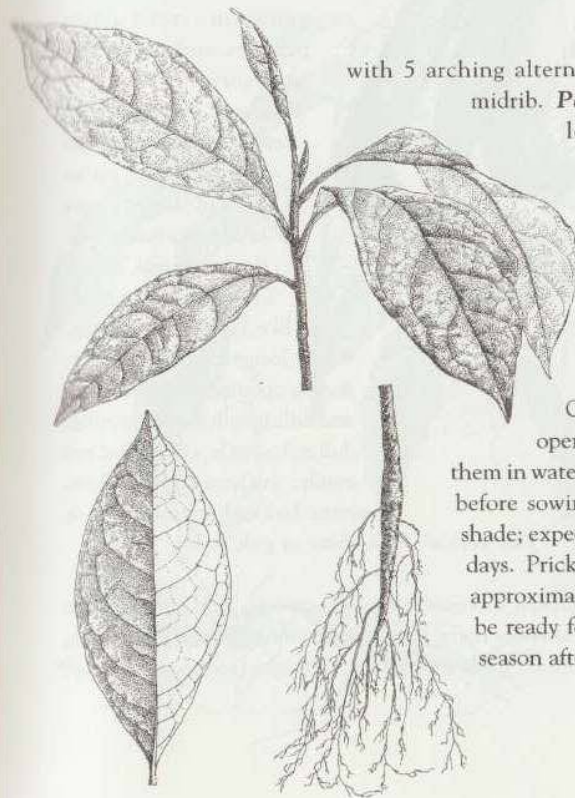
## *M. garrettii*

with 5 arching alternate veins on each side of the midrib. **Petiole:** pale light green, 7-9 mm long with sparse short white hairs. **Stipules:** absent; bud-scales membranous, light green, 4 mm long; falling off leaving a ring around the stem.

### PROPAGATION

#### RECOMMENDATIONS:

collect maroon-brown follicles October, after they dry and split open. Remove the seeds and soak them in water for 24 hours; scrape off the testa before sowing the seeds in trays in partial shade; expected GR up to 75%, over 32-179 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the first planting season after germination.





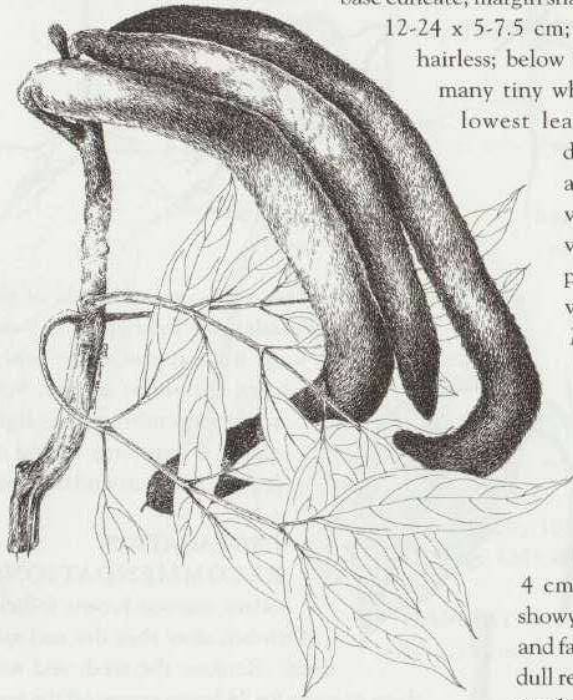
*Markhamia stipulata* (Wall.) Seem. ex K. Sch. var. *kerrii* Sprague (BIGNONIACEAE) แดหางคำ

A common, medium-sized deciduous tree, up to 20 m tall, dbh up to 28 cm.

**Bark:** very finely roughened when young, becoming vertically and horizontally cracked, light to medium brown. **Leaves:** opposite, compound, decussate, once imparipinnate, 35-60 cm long; leaflets opposite, 4-5 pairs plus the terminal segment; blades thin, oblong or lanceolate, apex narrowly acute, base cuneate, margin shallowly sinuate-serrulate; 12-24 x 5-7.5 cm; above dull dark green, hairless; below light green-yellow with many tiny white hairs on the veins; lowest leaflets smallest; midrib distinct, with 9-11 ascending secondary veins on each side; finer venation reticulate; petioles and petiolules very hairy.

**Flowers:** inflorescences terminal, racemose to thyrsoid, erect, up to 25 cm long; axes brown furfuraceous; flowers several, 7-9 cm long; calyx spathe-like, brown furfuraceous, 4 cm long; corolla tubular, showy, opening in the evening and falling following morning, dull red outside, cream and red inside; anthers light yellow; filaments dark red; stigma white or pale yellow; style white or pale red.

**FRUIT/SEED:** a pendulous loculicidal, elongate, strap-like capsule, light green-yellow when unripe, brown when ripe, densely hairy, mean dimensions 550 x 50 x 20 mm, containing many winged, light brown seeds 19.8 x 11.9 x 1.9 mm (see photo on page 134); dispersed by wind.

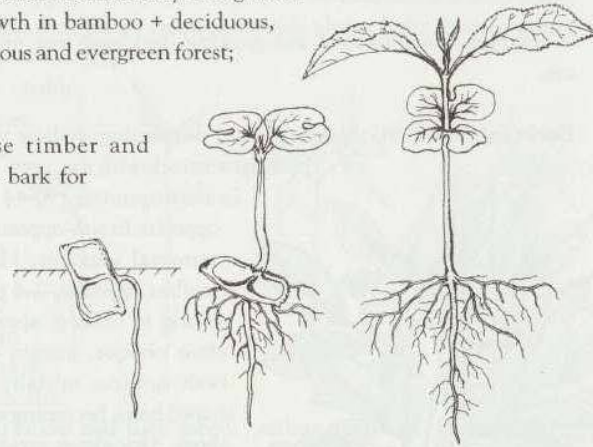


*M. stipulata*

**HABITAT:** commonly establishes naturally in degraded fire-prone secondary growth in bamboo + deciduous, mixed evergreen + deciduous and evergreen forest; elevation 250-1,125 m.

**USES:** general-purpose timber and firewood. Thais use the bark for herbal baths.

**DISTRIBUTION:** northern Thailand, China, Indo-China, Philippines



**PROPAGATION**

**RECOMMENDATIONS:**

as this species readily colonises open, degraded sites, there is usually no need to plant it. Naturally established plants should be encouraged by weeding and application of fertiliser. No seedling specimens were available for description when drafting this book.





# Melia toosendan Sieb. & Zucc. (MELIACEAE)

เกรียน, เลี่ยน

A common, medium-sized, fast-growing, deciduous tree, up to 19 m tall, dbh up to 47 cm.

**Bark:** initially thin, thickening and developing shallow vertical cracks and brown pustular lenticels with age, grey. **Leaves:** spirally arranged, 2x imparipinnate, 30-44 cm long; primary leaflets opposite to sub-opposite, mostly 3 pairs plus the terminal segment, 11-16 cm long; secondary leaflets opposite, 2-4 pairs, leaflets thin, ovate-oblong to oblong, apex acuminate, base obtuse often oblique, margin entire to slightly serrate; both surfaces initially covered in brown star-shaped hairs, becoming mostly hairless at maturity; above dark glossy green; below dull light green; midrib with 9-12 ascending secondary veins on each side; finer venation reticulate; petioles 9-13 cm long with star-shaped hairs.

**Flowers:** inflorescences axillary, paniculate 10-19 cm long; peduncles up to 10 cm long; pedicels 4-5 mm long; flowers numerous, 10 mm long, slightly fragrant; petals white and faintly lilac.

**FRUIT/SEED:** a globose drupe, light green when unripe, yellow with reddish-brown spots when ripe, mean dimensions 21 x 21 x 20 mm; a woody, ridged, pyrene with up to 7 locules, each containing one ovoid black shiny seed, 6 x 3 mm (see photo on page 134); dispersed by animals.

**HABITAT:** commonly establishes in degraded, fire-prone secondary growth in bamboo + deciduous, mixed evergreen + deciduous, evergreen, and evergreen + pine forest, elevation 325-1,300 m.

**USES:** Hmong hill tribe people use the bark for saunas. The nectar is attractive to wildlife, particularly sunbirds.

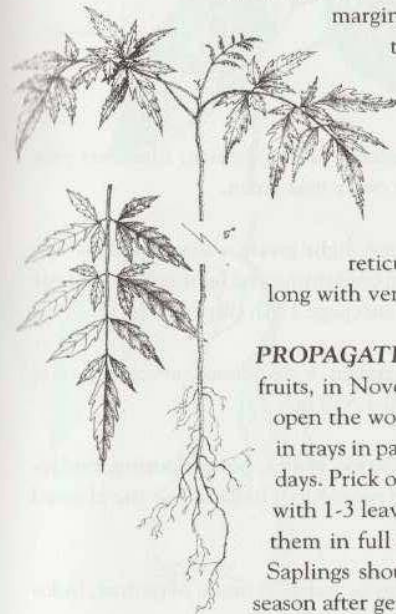
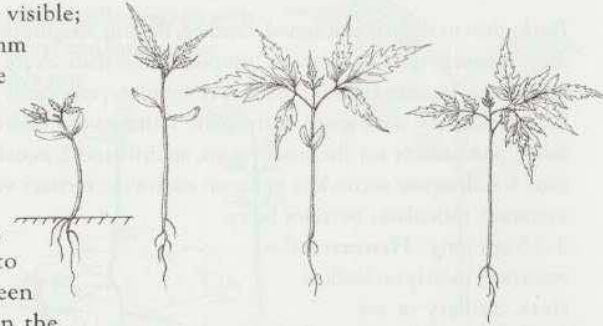
**DISTRIBUTION:** northern Thailand, Assam, Indo-China, Yunnan, Myanmar, Japan



# M. toosendan

**SEEDLINGS: Cotyledons:** opposite, thick, oblong, apex obtuse, base cuneate, margin entire, petiolate; inside dull dark green, hairless; outside glossy, light green, turning light yellow-pink, eventually wrinkled; venation not visible; petiole light green, 1 mm long, with tiny, very sparse white hairs. **Cotyledonary leaves:** opposite, compound trifoliolate; leaflets thin, asymmetrically ovate, apex acute, base obliquely acute to obtuse; above, light green with tiny white hairs on the midrib and primary veins; below pale light green, hairless; venation pinnate.

**Stem:** hypocotyl pale light green-white, with minute white hairs at apex; epicotyl and internodes bright light green with tiny white hairs. **Leaves:** pinnate 5-foliolate, alternate; first three leaves ovate, 47 x 47, 50 x 47 and 59 x 65 mm; leaflets thin, asymmetrically ovate, apex acute, base obliquely acute to obtuse, margin minutely hairy, deeply and irregularly dentate to lobed, the lobe deepest proximally; terminal segment largest; above, light green with tiny white hairs on the midrib and primary veins; below pale light green, hairless. Basal pair of leaflets always have a receding leaflet attached. **Venation:** pinnate, pale light green, 7-9 alternate pairs of veins; secondary venation reticulate. **Petiole:** light green, grooved, 20-22 mm long with very sparse tiny white hairs. **Stipules:** absent.



**PROPAGATION RECOMMENDATIONS:** collect yellow fruits, in November-April. Remove the fruit flesh and crack open the woody pyrene to remove the seeds. Sow the seeds in trays in partial shade; expected GR up to 67%, over 15-85 days. Prick out the seedlings when they are about 10 cm tall, with 1-3 leaves, usually 10-14 days after germination. Grow them in full sunlight with fertiliser and frequent watering. Saplings should be ready for planting in the first planting season after germination.

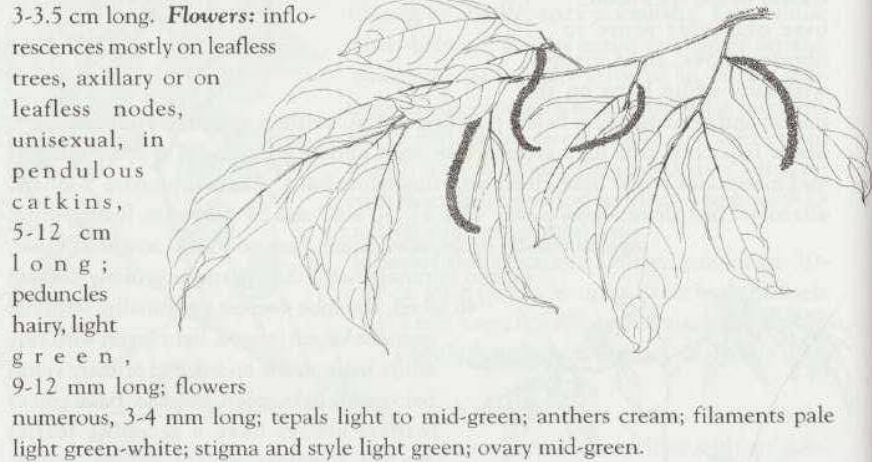


*Morus macroura* Miq. (MORACEAE)

• White Mulberry • หม่อนหลวง (หม่อนฮอ)

A common, large, deciduous tree, up to 26 m tall, dbh up to 70 cm.

**Bark:** thin to slightly thickened, cracked, flaking, roughly pustular-lenticellate, brown-grey. **Leaves:** spirally arranged, simple; blades thin, ovate, apex caudate-acuminate, base acute, margin entire to shallowly serrulate, especially in the apical half; 11-20 x 7-10 cm; above dark green with sparse hairs on the midrib; below dull light green, hairy, particularly on the main veins; midrib and 2 equally prominent basal veins, plus 3-4 alternate secondary veins on each side; tertiary venation scalariform, finest venation reticulate; petioles hairy, 3-3.5 cm long. **Flowers:** inflorescences mostly on leafless trees, axillary or on leafless nodes, unisexual, in pendulous catkins, 5-12 cm long; peduncles hairy, light green, 9-12 mm long; flowers numerous, 3-4 mm long; tepals light to mid-green; anthers cream; filaments pale light green-white; stigma and style light green; ovary mid-green.



**FRUIT/SEED:** a suborbicular, flattened achene, light green when unripe, brown when ripe, mean dimensions 1.5 x 1.0 x 1.0 mm, containing one light brown seed per achene, dimensions 1.0 x 1.0 x 1.0 mm (see photo page 134); dispersed by birds.

**HABITAT:** bamboo + deciduous, mixed evergreen + deciduous, evergreen, and degraded evergreen + pine forest; elevation 600-1,550 m.

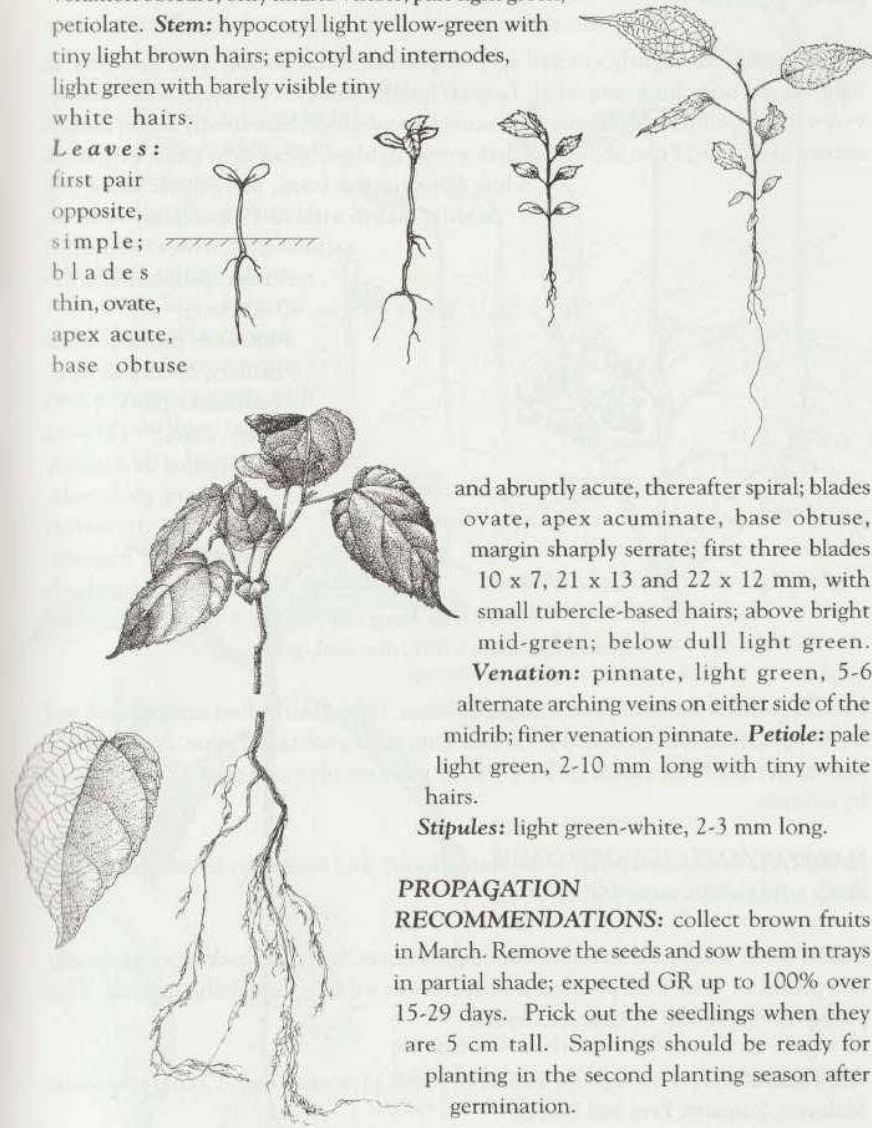
**USES:** wood weak, used for furniture, cabinet-work, beams, posts, flooring, bridge-building and firewood. The Hmong hill tribe people in Thailand use the chewed cambium to treat scalds.

**DISTRIBUTION:** northern Thailand, Himalayas, India, Yunnan, Myanmar, Indo-China, Sumatra

*M. macroura*

**SEEDLINGS:** *Cotyledonary leaves:* opposite; blades ovate, apex acute, base obtuse, margin entire, hairless; inside pale light yellow-green; outside pale light green; venation obscure, only midrib visible, pale light green, petiolate. **Stem:** hypocotyl light yellow-green with tiny light brown hairs; epicotyl and internodes, light green with barely visible tiny white hairs.

**Leaves:** first pair opposite, simple; blades thin, ovate, apex acute, base obtuse



and abruptly acute, thereafter spiral; blades ovate, apex acuminate, base obtuse, margin sharply serrate; first three blades 10 x 7, 21 x 13 and 22 x 12 mm, with small tubercle-based hairs; above bright mid-green; below dull light green.

**Venation:** pinnate, light green, 5-6 alternate arching veins on either side of the midrib; finer venation pinnate. **Petiole:** pale light green, 2-10 mm long with tiny white hairs.

**Stipules:** light green-white, 2-3 mm long.

**PROPAGATION**

**RECOMMENDATIONS:** collect brown fruits in March. Remove the seeds and sow them in trays in partial shade; expected GR up to 100% over 15-29 days. Prick out the seedlings when they are 5 cm tall. Saplings should be ready for planting in the second planting season after germination.



# *Nyssa javanica* (Bl.) Wang. (NYSSACEAE)

• Kirung • ภาวะคาก

A fairly common, medium-sized, evergreen or briefly deciduous tree, up to 30 m tall, dbh up to 90 cm.

**Bark:** thickened, slightly cracked and roughened, often flaking with age, grey to light-brown, branching sympodial. **Leaves:** spirally arranged, simple; blades leathery, very variable, elliptic to oblong, apex acute to acuminate, base mostly acute, margin entire; 13-22 x 6-12 cm; above dull dark-green, hairless; below light green with short white hairs on the veins, particularly along the midrib; midrib with 12-17 secondary veins on either side; finer venation

reticulate; petioles hairy, 22-40 mm long.

**Flowers:** inflorescence axillary, 20-25 mm long, peduncles hairy, 12-30 mm long. Flowers terminal in a usually solitary glomerule, 15 mm diameter; numerous, fragrant, 3-4 mm long on pedicels

1-2 mm long; corollas light yellowish; anthers cream; filaments white, disc dark-green.



**FRUIT/SEED:** an ovoid juicy drupe, hairless, light green when unripe, dark red when ripe, mean dimensions 17.9 x 12.7 mm, with a solitary pyrene, containing 1 flattened, light brown seed, 15.1 x 7.9 x 2.9 mm (see photo on page 135); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous forest, and evergreen forest, particularly along streams; elevation 550-1,700 m.

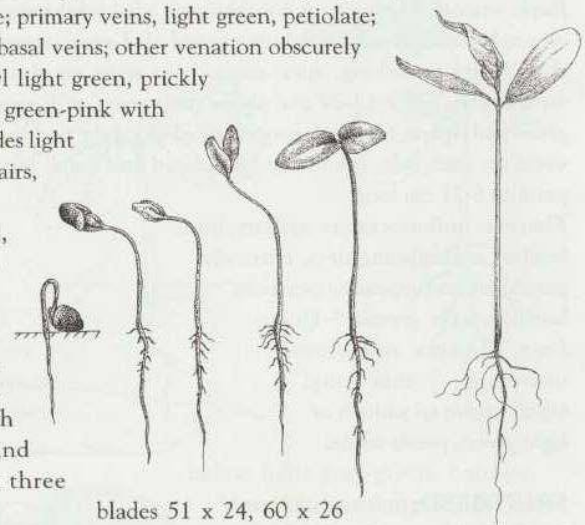
**USES:** dense wood used for house-building, interiors, furniture, packing cases, veneer and plywood. The fruit pericarp is attractive to wildlife, especially squirrels. Thai people cook the fruit in syrup as a sweet.

**DISTRIBUTION:** throughout Thailand, India, Myanmar, Indo-China, peninsular Malaysia, Sumatra, Java and Borneo

# *N. javanica*

**SEEDLINGS: Cotyledonary leaves:** opposite; blades thin, oblong, apex obtuse, base acute, margin entire; inside mid-green, hairless; outside light green, hairless; venation palmate; primary veins, light green, petiolate; midrib with 2 prominent basal veins; other venation obscurely pinnate. **Stem:** hypocotyl light green, prickly at the base; epicotyl pale green-pink with short white hairs; internodes light green with short white hairs, denser when young.

**Leaves:** spirally arranged, nodes very close, simple; first blade elliptic, apex acuminate, base cuneate; older blades oblanceolate, apex acuminate-caudate, base cuneate, margin with spaced shallow teeth and short white hairs; first three

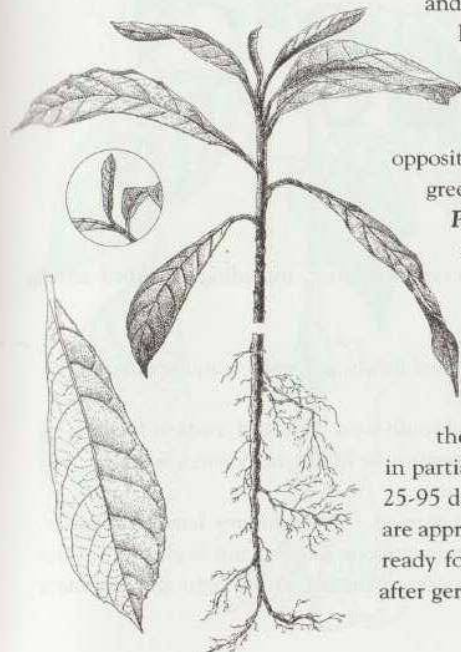


blades 51 x 24, 60 x 26 and 110 x 37 mm, with sparse short white hairs, concentrated along the midrib, hairless when older; above, glossy light to mid-green; below light to mid-green. **Venation:** pinnate, with 6-8 sub-opposite arching secondary pairs of veins, light green; finer venation reticulate.

**Petiole:** light green, 5 mm long with short dense white hairs. **Stipules:** absent.

### PROPAGATION

**RECOMMENDATIONS:** collect dark red fruits in September. Soak them in water for 12-24 hours, remove the fruit flesh and sow the pyrenes in trays in partial shade; expected GR up to 65%, over 25-95 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the first planting season after germination.





*Ostodes paniculata* Bl. (EUPHORBIACEAE) มะคังคาง

A fairly common, medium-sized, evergreen tree, up to 16 m tall, dbh up to 25 cm.

**Bark:** smooth when young, rougher with age, developing cracks and lenticels, from grey to brown, sap red, branching sympodial. **Leaves:** spirally arranged, simple; blades thin, ovate to oblong, apex acute, base acute to obtuse, margins with shallow serrulations; 5-9 x 12-29 cm; above dark green with sparse tiny hairs; below light green with sparse tiny hairs concentrated along the midrib; midrib with 7-9 secondary veins on each side, the lowest two paired and basal; tertiary venation scalariform; petioles 6-21 cm long.

**Flowers:** inflorescences axillary from leafless nodes/branchlets, narrowly paniculate and appearing racemose, hairless; axes green, 9-16 cm long; flowers numerous, unisexual, 7 mm long; sepals cream to whitish or light green; petals white.

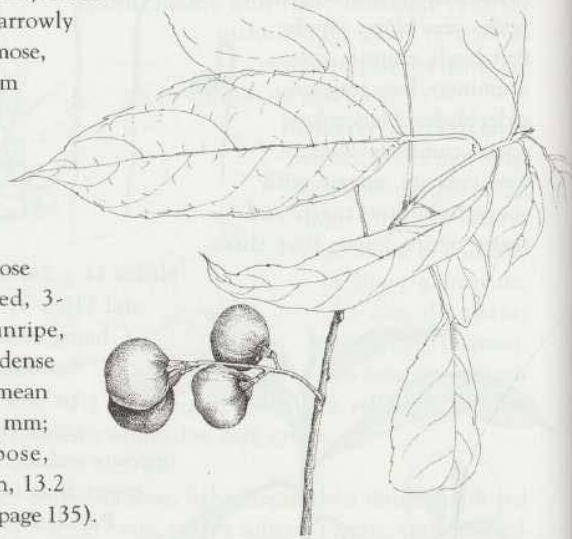
**FRUIT/SEED:** fruit a subglobose to obovoid capsule, 3-lobed, 3-valved, light green when unripe, yellow-brown when ripe with dense fine hairs, which irritate skin; mean dimensions 32.4 x 31.8 x 28.4 mm; seeds 1 per lobe, subglobose, flattened, mottled dark brown, 13.2 x 12.6 x 8.6 mm (see photo on page 135).

**HABITAT:** bamboo + deciduous, and evergreen forest, including disturbed areas and by streams; 825-1,350 m elevation.

**USES:** fuelwood, a gum is extracted and used for sizing locally manufactured paper.

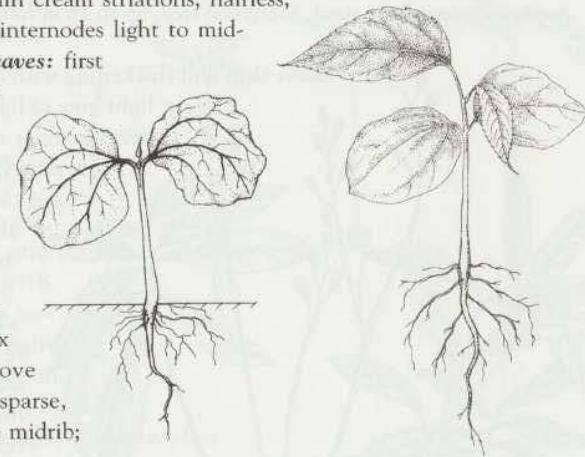
**DISTRIBUTION:** north, south-east and south-west Thailand, eastern Himalayas, Assam, Yunnan, Indo-China, Myanmar, peninsular Malaysia, Borneo, Sumatra, Java

**SEEDLINGS:** **Cotyledons:** ovate, thick, curved. **Cotyledonary leaves:** opposite, orbicular, apex obtuse, base truncate, margin sinuous, hairless; inside glossy, medium to dark green; outside medium green; venation palmate, with 3 light green primary



*O. paniculata*

veins, petiolate. **Stem:** hypocotyl reddish pink towards apex, base light green, with thin cream striations, hairless; epicotyl dark green-red; internodes light to mid-green, both hairless. **Leaves:** first pair opposite arranged at right angles to the cotyledonary leaves, thereafter subopposite, simple; blades ovate, apex acuminate, base acute to obtuse, margin shallowly serrate; first three blades 21 x 21, 21 x 23 and 15 x 10 mm; above mid-green, glossy, with sparse, short, white hairs on the midrib;



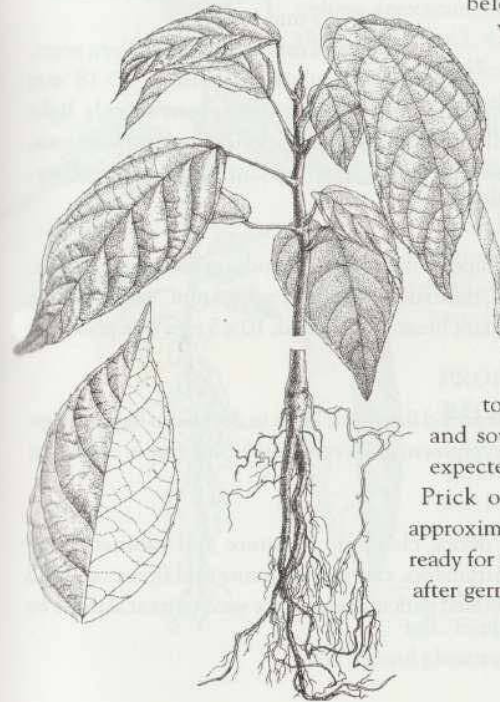
below light grey-green, hairless.

**Venation:** pinnate, pale light green, with 6-7 pairs of alternate secondary veins. **Petiole:** light green, 25 mm long, hairless. **Stipules:** oblong, white, papery, 3 mm long, leaving small red lumps after falling off.

**PROPAGATION**

**RECOMMENDATION:**

collect yellow fruits in November. Allow the capsules to dry until they split, remove the seed and sow them in trays in partial shade; expected GR up to 53%, over 26-229 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the first planting season after germination.





## *Phyllanthus emblica* L. (EUPHORBIACEAE)

• Malacca • มะขามป้อม

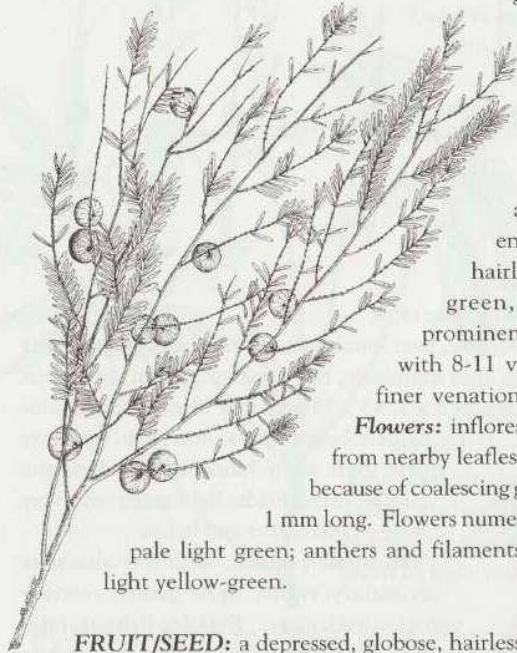
A common, small, deciduous tree, up to 12 m tall, dbh up to 21 cm.

**Bark:** thin, smooth and becoming shallowly cracked, often flaking or peeling, dark grey or mottled, light to medium brown. **Leaves:** alternate, simple, on slender, hairy branchlets appearing as a once-pinnate leaf; blades papery, linear-lanceolate, apex obtuse to bluntly acute, base asymmetrically obtuse, margin entire, thickened, often dull reddish, hairless; above dark green; below light green, 11-15 x 2-3 mm; midrib prominent; secondary venation pinnate, with 8-11 veins on each side of the midrib; finer venation obscure; petioles 0.5 mm long. **Flowers:** inflorescences glomerulate, axillary and from nearby leafless nodes, usually appearing spicate because of coalescing glomerules, 1-2.5 cm long; pedicels 1 mm long. Flowers numerous, unisexual, 1 mm long; sepals pale light green; anthers and filaments light yellow; stigmas and styles light yellow-green.

**FRUIT/SEED:** a depressed, globose, hairless, slightly juicy capsule, dull light green when unripe, dull light yellow when ripe, mean dimensions 20.1 x 19.8 x 17.1 mm, splitting into 3 valves, each containing 2 brown, 3-angled seeds, 5.6 x 2.9 x 2.7 mm (see photo on page 135); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous, evergreen, and evergreen + pine forest, often in degraded, fire-damaged, areas; elevation 750-1,300 m.

**USES:** wood used for agricultural tools, low quality furniture, coffins, poles, houses, tools, floors, fuelwood and makes good quality charcoal. The sour fruit is edible, high in vitamin C and is used to make preserves and in Thailand, as a laxative and to reduce high blood pressure. The bark, leaves and fruit are used for tanning. The Hmong hill tribe people use the bark to make a herbal bath for treating broken bones. The seeds are eaten by squirrels.



**DISTRIBUTION:** throughout Thailand, Myanmar, Yunnan, Indo-China, India, peninsular Malaysia, Sumatra, Borneo, Java

### SEEDLINGS: Cotyledonary leaves:

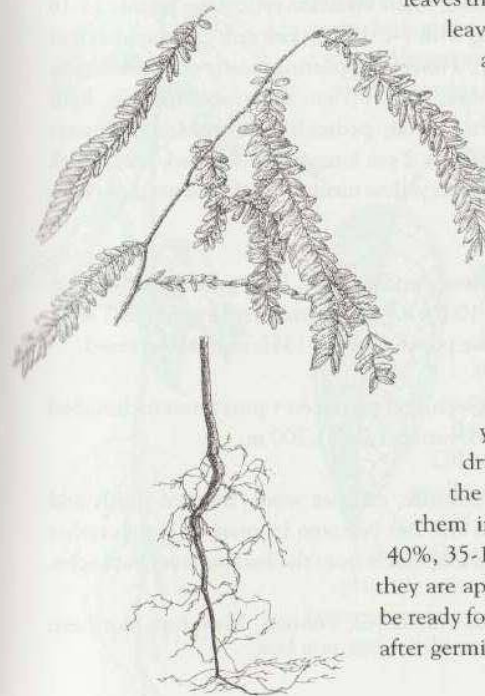
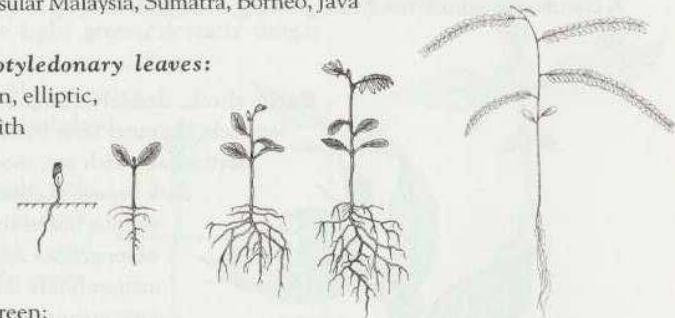
opposite; blades thin, elliptic, apex obtuse often with a minute mucro, base cuneate, margin entire, hairless; inside bright mid-green; outside dull light green; venation pinnate, indistinct, light to mid-green.

**Stem:** hypocotyl dull light green to pink-cream, with shallow striations and tiny white hairs; epicotyl and internodes bright light green, with tiny white hairs.

**Leaves:** first 2 leaves alternate, simple; blades obovate, apex obtuse, base cuneate; 11 x 6 mm; thereafter appearing as spirally arranged pinnate leaves that are actually closely spaced (distichous) leaves on lateral branches; blades oblong, apex obtuse-mucronate, base acute, margin entire, hairless; 11 x 3 mm; above mid-green; below medium green-grey. **Venation:** pinnate, mid-green, indistinct. **Petiole:** light green, 0.5 mm long with tiny white hairs. **Stipules:** subulate, initially translucent pale light green then dark brown, papery, 1 mm long.

### PROPAGATION

**RECOMMENDATIONS:** collect yellow fruits in January. Leave them to dry until the capsules dehisce, then soak the seeds in water for 1-2 days before sowing them in trays in partial shade; expected GR 40%, 35-119 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.





*Prunus cerasoides* D. Don (ROSACEAE)

• Tenangau • นางพญาเสือโคร่ง

A common, medium-sized, fast-growing, deciduous tree, up to 16 m tall, dbh up to 38 cm.

**Bark:** thick, densely roughened with pustular-lenticels, the outer layer thin, cracked and peeling horizontally with age, medium to dark grey or dark brown. **Leaves:** spirally arranged, simple; blades thin, oblong to ovate-oblong, apex acuminate, base acute, margin finely serrulate; above shiny dark green; below light green with sparse, short, white hairs on veins on both sides; young leaves, glossy dark maroon above and below; 9-12 x 3-5 cm; midrib with 9-11 ascending secondary veins on each side; finer venation scalariform, finest venation reticulate; petiole 14-16 mm long with 1-2 dorsal, dark red, circular glands at the tip. **Flowers:** appearing mostly on leafless trees, racemes, each 4-5 cm long; axes hairless, light green to red; pedicels 7-9 mm long; flowers numerous, 2 cm long; calyx dark red, bracts dark maroon; petals pink; anthers yellow turning tan; filaments pink; style light green; stigma green.



**FRUIT/SEED:** an ellipsoid drupe, hairless, pericarp juicy, light green when unripe, bright red when ripe, mean dimensions 10.6 x 8.7 x 7.9 mm, pyrene contains 1 seed, mean dimensions 9.7 x 7.5 x 6.1 mm (see photo on page 135); animal dispersed.

**HABITAT:** evergreen + deciduous, evergreen, and evergreen + pine forest in disturbed areas, often planted as an ornamental; elevation 1,040-1,700 m.

**USES:** wood used for construction, furniture, cabinet work, interior finish and firewood. The fruit is attractive to birds and can be eaten by man, although rather acidic. Hmong hill tribe people believe a soup made from the bark relieves backache.

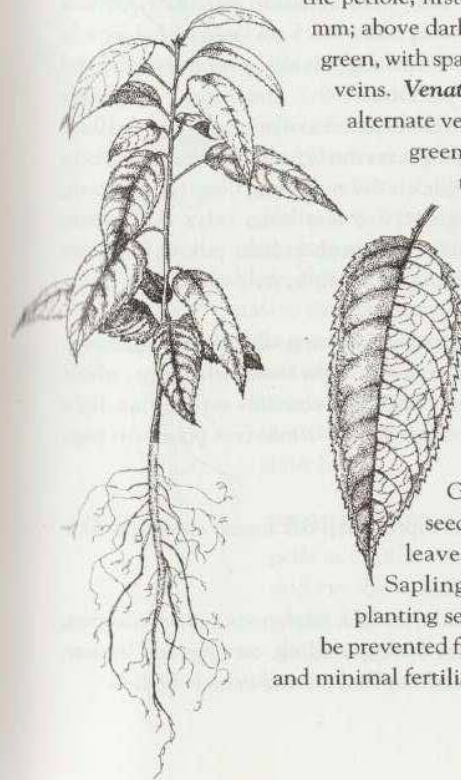
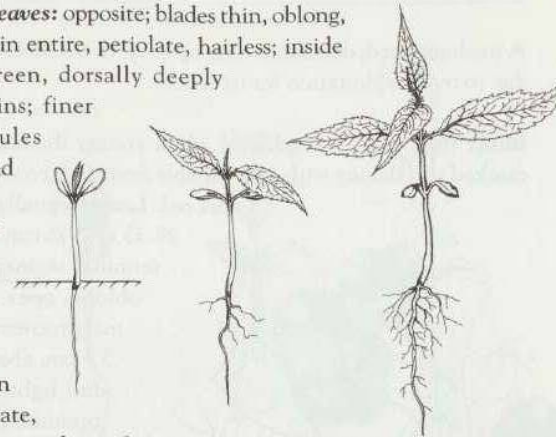
**DISTRIBUTION:** northern Thailand, Himalayas, Yunnan, Myanmar, northern Indo-China

*P. cerasoides*

**SEEDLINGS: Cotyledonary leaves:** opposite; blades thin, oblong, apex obtuse, base acute, margin entire, petiolate, hairless; inside mid-green; outside light green, dorsally deeply grooved, due to sunken veins; finer venation not visible; stipules bristle-like with a terminal gland on each segment.

**Stem:** hypocotyl pale light green, white-pink at base, hairless; epicotyl and internodes pale light green, with white hairs.

**Leaves:** alternate initially then spiral, simple; first blades ovate, apex acuminate, base cuneate, thereafter ovate-oblong, apex cuspidate, base cuneate, margin doubly serrate with a few glandular bristles near the petiole; first three blades 56 x 36, 54 x 37 and 63 x 30 mm; above dark green with sparse white hairs; below light green, with sparse, white, hairs especially along the primary veins. **Venation:** pinnate, light green, with 7-9 arching alternate veins, looping near the margin. **Petiole:** light green, 12-14 mm long with sparse white gland-tipped hairs. **Stipules:** pale light green, 4 mm long branching, with glands at the tip.



**PROPAGATION**

**RECOMMENDATIONS:** collect red fruits in March-April. Remove the fruit flesh. Then gently crack open the pyrene using a small vice and completely remove the endocarp (pyrene wall). Sow the seeds in trays in partial shade; expected GR up to 76% over 12 days. Prick out the seedlings when they are 5-7 cm tall with 4-5 leaves (usually 7-10 days after germination). Saplings are ready for planting by the second planting season after germination. The saplings must be prevented from outgrowing their containers by pruning and minimal fertiliser application.



*Pterocarpus macrocarpus* Kurz (LEGUMINOSAE, PAPILIONOIDEAE) • Red Sandalwood, Narra • ประดู่

A medium-sized, deciduous tree, up to 25 m tall, dbh up to 84 cm. Now uncommon, due to over-exploitation for its timber.

**Bark:** thin, lightly roughened when young, thickening and becoming vertically cracked and flaking with age, variable from dark brown to grey, sap brown, cambium dark red. **Leaves:** spirally arranged, once imparipinnate, 29-35 x 40-76 cm; leaflets alternate, 8-10 plus the terminal segment, slightly leathery, ovate to oblong, apex acute, base obtuse to acute, margin entire, slightly sinuous; 4-9.5 x 2.5-3.5 cm; above dark green, hairless; below dull light green, sparsely hairy; midrib prominent, with many hairs, although often becoming hairless with maturity, with 12-15 thin, secondary veins on each side; finer venation reticulate; petiole very hairy, 3-3.5 cm long, including a 5-6 mm long pulvinus; petiolules hairy and pulvinate, 6-7 mm long. **Flowers:** inflorescences axillary, racemose, 6-10 cm long; axes finely furfuraceous, light green; pedicels 6-7 mm long; flowers numerous, fragrant, 7-8 mm long; calyx dull green; petals yellow; anthers light yellow; filaments white; stigma light yellow; style white.



**FRUIT/SEED:** a subglobose, hard, indehiscent pod, 10-14 mm diameter, surrounded in one plane by a wing, green when unripe, light brown when ripe, whole unit mean dimensions 59.0 x 51.3 x 6.8 mm. Each pod contains several flat, light brown seeds, arranged in a compact spiral, 8.3 x 4.5 x 2.1 mm (see photo on page 135); wind dispersed.

**HABITAT:** bamboo + deciduous, deciduous dipterocarp-oak forest; elevation 325-825 m.

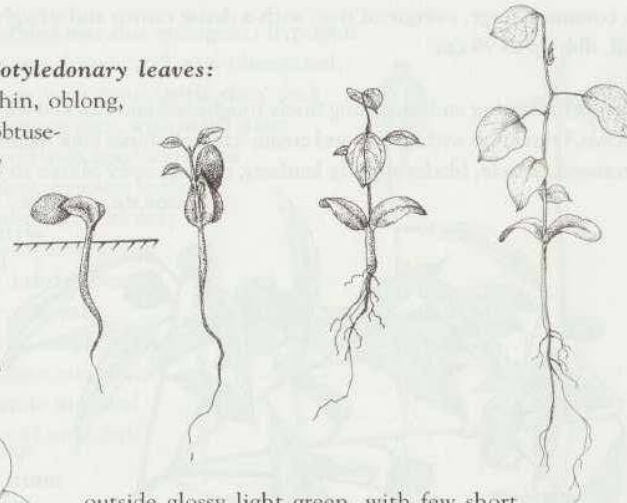
**USES:** one of the finest timbers for construction, bridges, piles, posts, railway sleepers, interior finish, high quality furniture, cabinet work, panelling, carvings and veneer. Also used for musical instruments, agricultural implements and vehicle bodies.

*P. macrocarpus*

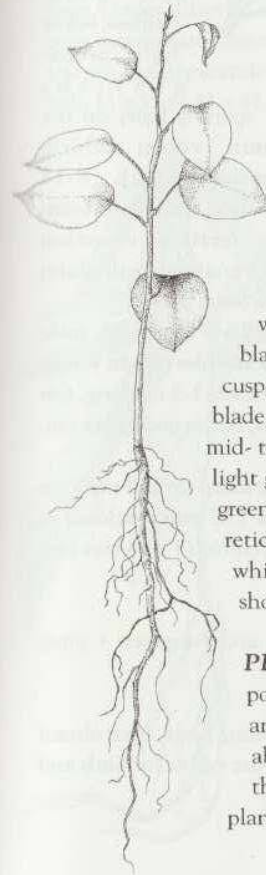
**DISTRIBUTION:** northern and eastern Thailand, Lao PDR, Myanmar

**SEEDLINGS: Cotyledonary leaves:**

opposite, blades thin, oblong, apex obtuse, base obtuse-acute, slightly oblique; 14 x 9 mm; inside glossy mid-green, hairless;



outside glossy light green, with few short white hairs, surface slightly wrinkled; venation with only the thick midrib visible. **Stem:** hypocotyl white to light brown-green, striations developing into deep grooves at top of stem; epicotyl and internodes light green, with white woolly hairs. **Leaves:** spirally arranged, simple; blades thin, ovate to suborbicular, apex obtuse with a prominent cusp, base obtuse to acute, margin entire, slightly sinuous in largest blade; first three blades 14 x 10, 20 x 12 and 21 x 21 mm; above mid- to dark green with tiny white hairs only on the midrib; below light green with sparse tiny white hairs. **Venation:** pinnate, light green with 5 subopposite pairs of secondary veins; tertiary venation reticulate. **Petiole:** bright light green, 4-11 mm long with tiny white hairs. **Stipules:** strap-shaped, light green, 3 mm long with short hairs.



**PROPAGATION RECOMMENDATIONS:** collect brown pods in September-March. Remove the seeds from the pods and sow them shallowly in trays in partial shade; expected GR about 12% over 64-240 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second or third planting season after germination.



*Quercus semiserrata* Roxb. (FAGACEAE)

• Oak, Mempening • ก่อตาทมูหลวง

A common, large, evergreen tree, with a dense crown and straight bole, up to 30 m tall, dbh up to 99 cm.

**Bark:** thickening and becoming finely roughened and cracked with age, grey or grey-brown, branchlets with brown and cream lenticels, inner bark reddish. **Leaves:** spirally arranged, simple; blades slightly leathery, oblong, apex obtuse to bluntly acute, base cuneate, oblique, margin shallowly serrate in the apical half; 16-25 x 3-8 cm; above dull dark green, hairless; below light green-greyish, sparsely hairy on the main veins; midrib prominent with 8-15 ascending secondary veins on each side; tertiary venation scalariform, finest venation reticulate; petioles hairy, 12-25 mm long.

**Flowers:** inflorescences axillary, unisexual; male ones pendulous, spicate with many glomerules of light yellow flowers 2.5-3 mm long; female ones erect, spicate, 1-2 cm long, few flowered; stamens, many, light green, maturing to light yellow, bracts and ovary tan.

**FRUIT/SEED:** an ellipsoid, sparsely hairy nut (acorn) with a sharp tip and truncate base, green when unripe, glossy mid-brown when ripe, 32.2 x 15.2 mm, enclosed in the lower half by a ridged cupule; one ellipsoid seed per nut, yellow, 24 x 14 mm (see photo page 136); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous forest, evergreen, and evergreen + pine; elevation 850-1,400 m.

**USES:** excellent timber for above-ground construction, beams, posts, agricultural tools, carts, furniture, interior finish and firewood. The nuts are edible for birds and mammals. The wood can be used for mushroom cultivation.

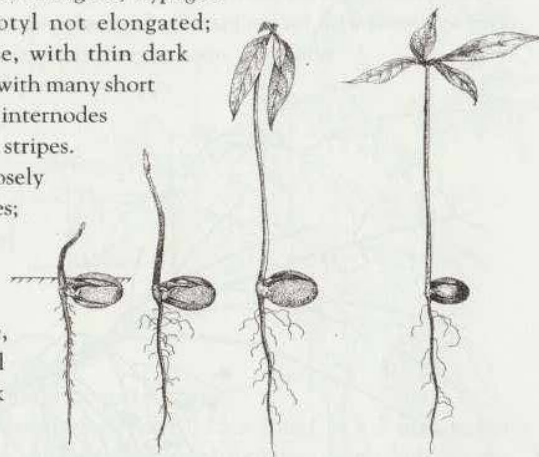


*Q. semiserrata*

**DISTRIBUTION:** northern Thailand, India, Myanmar, Indo-China

**SEEDLINGS:** **Cotyledons:** not emergent, hypogeal germination. **Stem:** hypocotyl not elongated; epicotyl dark green near base, with thin dark maroon stripes, lighter at apex, with many short cream hairs falling off with age; internodes mid-green, thin dark maroon stripes.

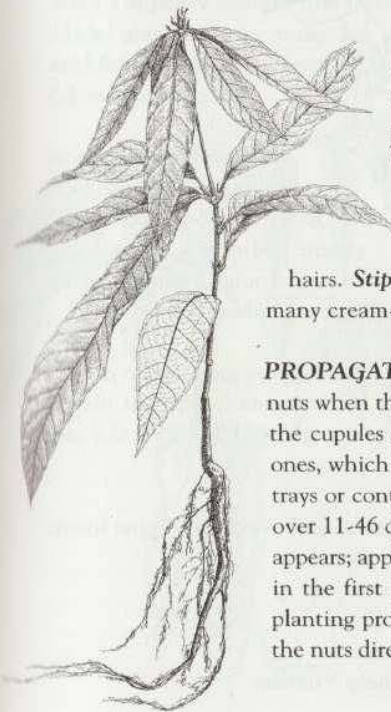
**Leaves:** concentrated in a closely spaced spiral at the top few nodes; first blade often bifid, apex obcordate, base cuneate; later blades elliptic, simple, apex acuminate, base cuneate, margin slightly serrate in apical half; 11 x 11 to 41 x 41 mm; dark



green above and below, hairless except for the midrib below; young blades light green and reddish with many white hairs.

**Venation:** pinnate, light green, 6-8 secondary veins alternate on either side of the midrib; tertiary venation reticulate. **Petiole:** light green, 3-4 mm long with short, wavy cream hairs. **Stipules:** subulate, villous, dark green, 4-6 mm, with many cream-light brown hairs.

**PROPAGATION RECOMMENDATIONS:** collect brown nuts when they begin to fall, optimally in June-July. Remove the cupules and soak the nuts in water to remove damaged ones, which float. Sow the nuts on their side 2-3 cm apart in trays or containers in partial shade; expected GR up to 92% over 11-46 days. Prick out the seedlings as soon as the shoot appears; apply fertiliser. Saplings should be ready for planting in the first planting season after germination. Some tree-planting projects have achieved successful results by sowing the nuts directly into deforested sites.





A common, medium-sized, deciduous tree, up to 25 m tall, dbh up to 27 cm.

**Bark:** thickening with age and becoming roughened and cracked into small pieces, grey to brown with brown pustular lenticels, sap often irritating. **Leaves:** spirally arranged, once imparipinnate, 30-35 cm long; leaflets in 4-5 opposite pairs plus the terminal segment; blades

thin, lanceolate to oblong, apex acute to acuminate, base slightly oblique cuneate, margin entire or sinuous; 9-15 x 2.5-5 cm; above dark green; below light green-grey with few tiny white hairs on veins on both sides; lowest pair smallest; midrib with 19-23 secondary veins on each side; finer venation reticulate; petioles 11-13 cm long; petiolules 4-5 mm long.

**Flowers:** inflorescences axillary, open panicate, 30-45 cm long; axes grey-green; pedicels 1.5 mm long.

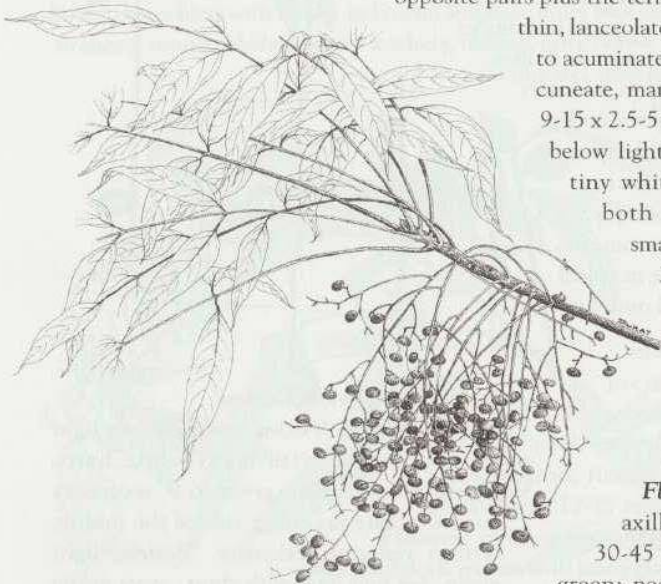
Flowers unisexual and bisexual, numerous, 1.5 mm long, male calyx tube green, lobes yellow-green; filaments light green; anthers yellow.

**FRUIT/SEED:** an asymmetrically ovoid, hairless drupe, glossy green when unripe, brownish-yellow when ripe, mean dimensions 8 x 5 x 3 mm, mesocarp thin, almost dry; one suborbicular, blackish pyrene containing a single seed 3 x 2.5 x 0.5 mm (see photo on page 136); dispersed by animals.

**HABITAT:** mixed evergreen + deciduous, evergreen, and evergreen + pine forest; elevation 1,050-1,530 m.

**USES:** the sap is used for making lacquer-ware.

**DISTRIBUTION:** northern Thailand and northern Vietnam



**SEEDLINGS:** **Cotyledonary leaves:** opposite; blades thin, ovate, apex acute, base obtuse, margin entire, petiolate, hairless; inside dark, glossy green; outside pale light green; venation pinnate, indistinct, dark green. **Stem:**

hypocotyl light green, paler yellow-pink at base with sparse short white hairs; epicotyl and internodes light green-pink, with short white hairs.

**Leaves:** initially opposite then alternate, compound; first leaves trifoliolate; leaflet blades thin, elliptic, apex acute, base cuneate, sometimes oblique, margin

deeply cleft with sparse short white hairs; next 4 leaves with 5 opposite leaflets; first three leaves 21 x 10, 15 x 7 and 14 x 7 mm; leaflet blades above light to mid-green with sparse short white hairs, particularly on the midrib and near the margin; below pale light green, hairless; young leaves paler.

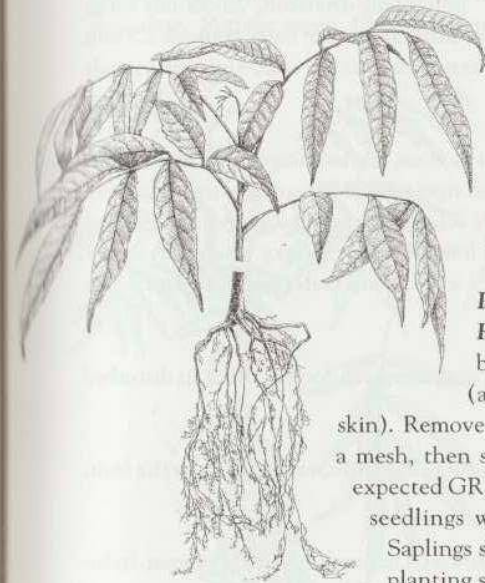
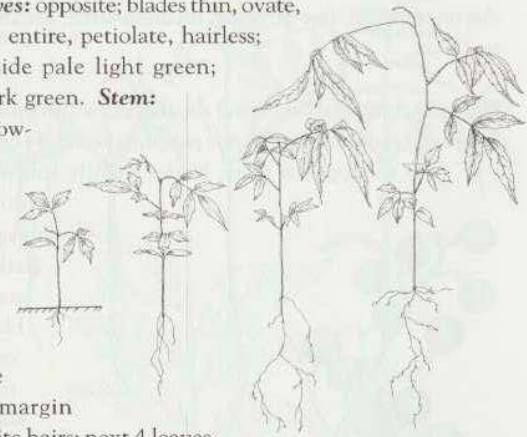
**Venation:** pinnate, light green, midrib pink, with 4-6 alternate pairs of secondary veins; tertiary venation reticulate. **Petiole:** light green-pink, 10 mm long with tiny white hairs.

**Petiolules:** light green-pink, 1 mm long, with tiny white hairs. **Rachis:** light green, with tiny white hairs.

**Stipules:** absent.

**PROPAGATION**

**RECOMMENDATIONS:** collect dry, brown-yellow to blackish fruits in December (avoid touching the sap, which inflames skin). Remove the fruit pulp by pushing the drupe through a mesh, then sow the pyrenes in trays in partial shade; expected GR up to 50%, over 10-38 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after germination.





*Sapindus rarak* DC. (SAPINDACEAE) • Soap Nut •

มะขำดีควาย (มะขำก)

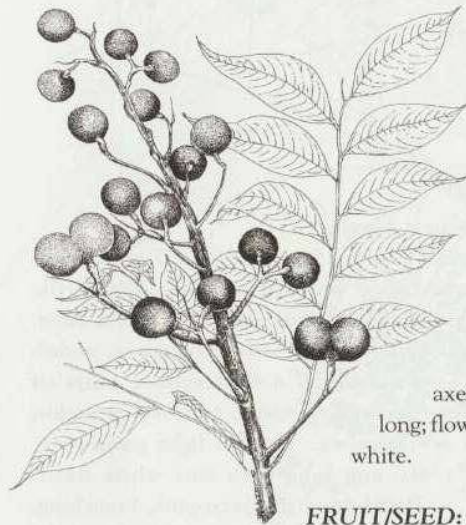
An uncommon, fast-growing, medium-sized, deciduous tree, up to 25 m tall, dbh up to 25 cm.

**Bark:** becoming thicker and roughened with fissures with age, grey to light brown.

**Leaves:** spirally arranged, once paripinnate, 38-44 cm long; leaflets 8-9 mostly opposite to subopposite pairs; blades slightly leathery, asymmetrically lanceolate to oblong, apex bluntly acute, base obliquely acute, margin entire; above dark green; below mid-green with sparse tiny white hairs on young blades and on margins of old blades, otherwise hairless, 7-13 x 2.5-3.5 cm; lowest leaflets smallest; midrib slightly eccentric; secondary veins 25-35 on each side of the midrib; tertiary venation reticulate; petiole 6-15 cm long; petiolules 2-3 mm long.

**Flowers:** inflorescences terminal, paniculate-thyrsoid, 25-35 cm long; axes with fine brown hairs; pedicels 1.5 mm long; flowers numerous bisexual, 4 mm long; petals white.

**FRUIT/SEED:** globose, hairless drupes, dull, light green when unripe, yellow-brown and drying when ripe; surface becoming wrinkled; mean dimensions 25.8 x 23.7 x 22.1 mm; usually solitary with 1 or 2 plano-convex and dorsally keeled aborted carpels, 10-15 mm long, mesocarp sticky when wet; seed 1 per drupe, globose, dull black, 16.4 x 15.9 x 15.1 mm (see photo on page 136); dispersed by animals.



**HABITAT:** mixed evergreen + deciduous, and evergreen forests, often in disturbed areas; elevation 615-1,620 m.

**USES:** wood used for construction and furniture. Saponins, extracted from the fruit, are used to make soaps and shampoos.

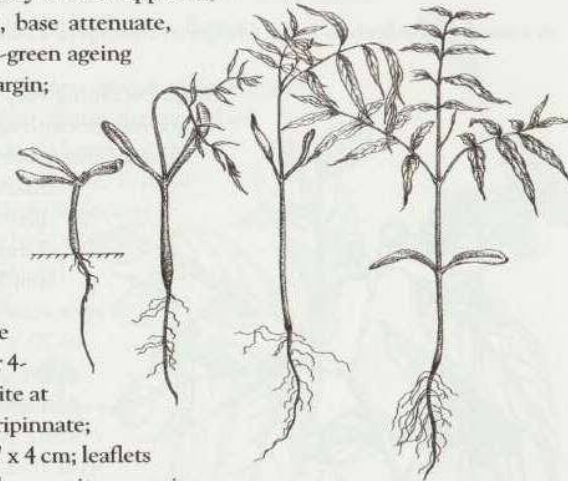
**DISTRIBUTION:** north, central and south-west Thailand; Assam, Myanmar, Indo-China, Taiwan, peninsula Malaysia, Sumatra (rare) and Java

*S. rarak*

**SEEDLINGS:** Cotyledonary leaves opposite, strap-shaped, apex obtuse, base attenuate, hairless; inside light yellow-green ageing to dark green with yellow margin; outside light green.

**Stem:** hypocotyl white, ageing to green with cream or yellow-white longitudinal striations and white buds; epicotyl and internodes green to dark green, developing white dots or brown lenticels after 4-node-stage.

**Leaves:** opposite at first node, spiral later; imparipinnate; first 3 leaves 6.5 x 4, 7 x 4, 7 x 4 cm; leaflets up to 15, alternate or sub-opposite, margins crenulate; 2.3 x 0.7 cm; above mid-green, hairless; below light green, with sparse, short white hairs. **Venation:** pinnate, 14-28 secondary veins alternate on either side of the midrib, mostly free-ending, green; tertiary venation reticulate. **Petiole:** green, 10-60 mm long, with tiny sparse white hairs; petiolule 0.5 mm long, often indistinct. **Stipules:** absent.



**PROPAGATION**

**RECOMMENDATIONS:** collect brown fruits, in August-January (but optimally in August). Chip away a small piece of the seed coat with a sharp knife before sowing the seeds at least 5 cm apart in trays or into containers, in partial shade; expected GR up to 81%, over 12 days. Prick out the seedlings when they are approximately 5 cm tall and the first leaf-pair has fully expanded (usually within 14 days after germination). Saplings from seed collected in August can be planted in the first planting season after germination; otherwise plant in the second planting season after germination.

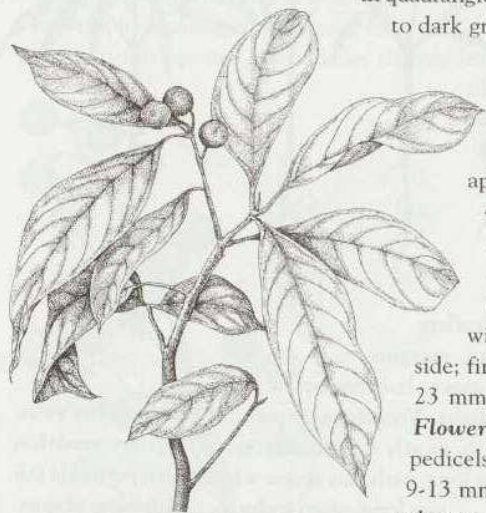




*Schima wallichii* (DC.) Korth. (THEACEAE)

• Needlewood, Schima • มังตาล, ทะโล้

A common, medium to large, evergreen tree, up to 22 m tall, dbh up to 65 cm.



**Bark:** becoming very thick and roughly cracked in quadrangles with age, varying from light brown to dark grey-blackish; inner bark fibrous and irritating; branchlets mostly dark grey with cream to tan lenticels.

**Leaves:** spirally arranged, simple; blades leathery, oblong, apex acute, base acute, margin entire; 49-70 x 120-215 mm; above dark glossy green, hairless; below light dull green-grey with sparse short white hairs on the veins; midrib with 10-13 secondary veins on each side; finer venation reticulate; petioles 7-23 mm long with sparse tiny dark hairs.

**Flowers:** solitary, axillary, 1.5 cm long; pedicels stout, finely hairy, dull light green, 9-13 mm long; sepals pale yellow; petals 5 white; anthers orange; filaments light yellow

or white; stigma glossy light yellow; style pale light green; fragrant.

**FRUIT/SEED:** a subglobose capsule with 5 valves, finely roughened, green when unripe, brown when ripe; mean dimensions 17.6 x 17.4 x 16.1 mm. Each valve contains several light brown, kidney-shaped to elliptic seeds, with a thin wing, 6.0 x 3.7 x 0.6 mm (see photo on page 136); dispersed by wind.

**HABITAT:** readily establishes naturally in disturbed fire-prone areas in bamboo + deciduous, deciduous dipterocarp-oak, mixed evergreen + deciduous, evergreen, and evergreen + pine forest; elevation sea level-2,500 m.

**USES:** wood used for construction, good quality plywood, floors, ceilings, building, bridges and boats, agricultural implements, boxes, poles, turnery and firewood; also used as shade trees in agro-forestry. The Akha hill tribe use it to make a pole, to which is tethered a buffalo that is sacrificed at the funerals of village elders. The leaves can be used as fodder. The young leaves are used to treat fevers and the bark is considered to be a laxative.

*S. wallichii*

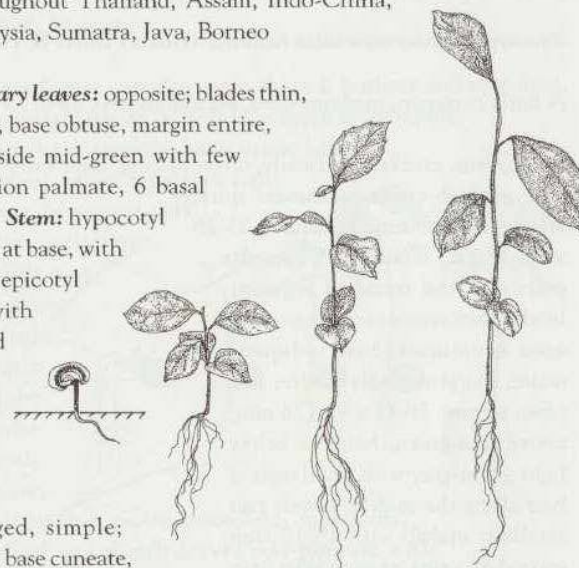
**DISTRIBUTION:** throughout Thailand, Assam, Indo-China, Yunnan, peninsular Malaysia, Sumatra, Java, Borneo

**SEEDLINGS: Cotyledonary leaves:** opposite; blades thin, suborbicular, apex obtuse, base obtuse, margin entire, petiolate; inside and outside mid-green with few tiny, white, hairs; venation palmate, 6 basal primary veins, mid-green. **Stem:** hypocotyl light brown-cream, rough at base, with defined cream striations; epicotyl light brown and pink, with faint cream striations and tiny white hairs; terminal buds white, villous; internodes pink, redder when young, with many, tiny white hairs.

**Leaves:** spirally arranged, simple; blades elliptic, apex acute, base cuneate, margin with widely spaced shallow, sharp serrulations; first three blades 26 x 15, 28 x 18 and 61 x 30 mm; above bright mid-green with tiny, white hairs when young; below light green with tiny white hairs, especially along the midrib; young leaves pink-green, hairy. **Venation:** pinnate, light yellow-green, with 4-5 secondary veins on either side of the midrib, arching; tertiary venation reticulate.

**Petiole:** light green-pink, fading to green with age, 4-5 mm long with abundant short white hairs. **Stipules:** absent.

**PROPAGATION RECOMMENDATIONS:** collect brown fruits in March-April. Remove the seeds as the capsules split open, soak the seeds in water for 12 hours, then sow them in trays in partial shade; expected GR up to 54%, highly synchronous over 12 days. Prick out the seedlings when they are approximately 5 cm tall. Saplings should be ready for planting in the second planting season after seed germination (after 14-15 months).





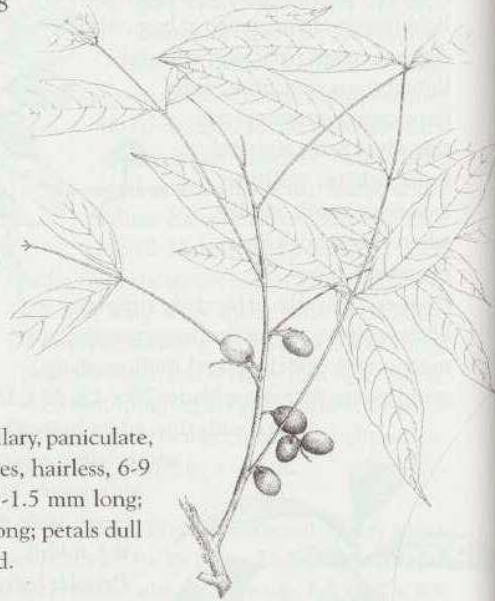
## *Spondias axillaris* Roxb. (ANACARDIACEAE)

• Hog Plum • มะกอก

Synonym: *Choerospondias axillaris* (Roxb.) Burt & Hill

A fairly common, medium-sized, deciduous tree, up to 25 m tall, dbh to 50 cm.

**Bark:** thin, cracked vertically, often flaking, dark brown or dark grey, inner bark pale pinkish-cream. **Leaves:** spirally arranged, once imparipinnate, 23-28 x 31-35 cm; leaflets 3-5 opposite pairs plus the terminal segment; blades thin, ovate to oblong-ovate, apex acuminate, base obliquely acute, margin mostly entire, less often serrate; 28-41 x 95-126 mm; above mid-green, hairless; below light green-grey with small tufts of hair along the midrib; lowest pair smallest; midrib with 15-18 thin secondary veins on each side; finer venation reticulate; petiole reddish, up to 11.5 cm long; petiolules 8-11 mm long. **Flowers:** inflorescences axillary, paniculate, often accompanying developing leaves, hairless, 6-9 cm long; axes light green; pedicels 1-1.5 mm long; flowers numerous, unisexual, 2 mm long; petals dull maroon; anthers yellow; filaments red.



**FRUIT/SEED:** an obovoid, fleshy, hairless drupe, usually one per infructescence, several per branch, grey-green when unripe, yellow when ripe; mean dimensions 25.3 x 22.4 x 22.6 mm; mesocarp pulpy, sour. Each drupe contains a solitary, obovoid pyrene with 4-5 depressions, each depression with a single, oblong, flattened, brown seed, 17.0 x 14.3 x 13.7 mm (see photo on page 136); dispersed by animals.

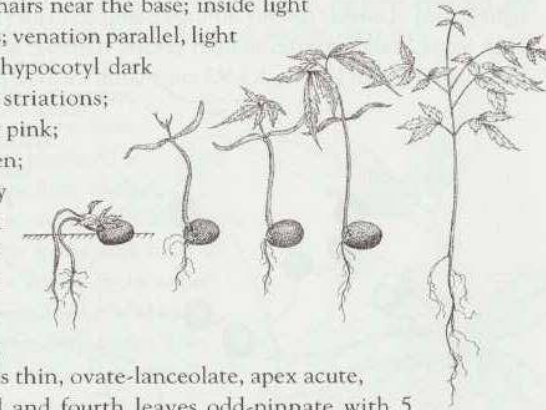
**HABITAT:** evergreen and evergreen + pine forest, often in degraded areas; elevation 700-1,600 m.

**USES:** wood used for interior finish, drawers, crates, carvings, turnery, plywood and pulp. The leaves are used as fodder and are edible for people when boiled. The trees are sometimes planted for shade.

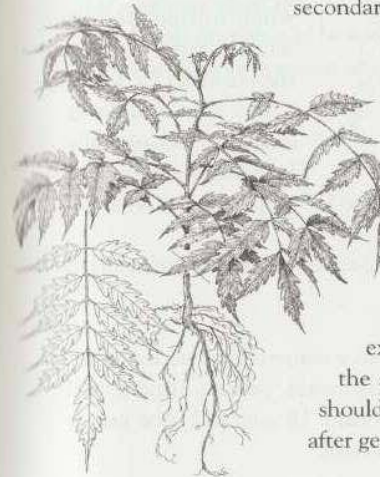
## *S. axillaris*

**DISTRIBUTION:** northern, north-eastern and eastern Thailand, Nepal, India, Myanmar, Hainan, Lao PDR, Vietnam

**SEEDLINGS:** **Cotyledonary leaves** opposite, strap-shaped, leathery and succulent, apex acute, base decurrent, margin entire; outside light green to light pink, with very sparse short white hairs near the base; inside light green, reddish at base, hairless; venation parallel, light green, 3 basal veins. **Stem:** hypocotyl dark pink to red with very fine striations; epicotyl mid-green to slightly pink; internodes light to mid-green; whole stem with sparse, tiny hairs; axillary buds less than 1 mm in diameter, light green-pink, with short white hairs. **Leaves:** compound, first pair opposite, trifoliolate, thereafter spiral; leaflet blades thin, ovate-lanceolate, apex acute, base cuneate, oblique; third and fourth leaves odd-pinnate with 5 leaflets; subsequently 7 and 9 leaflets, similar to the trifoliolate ones, margin on all leaflets deeply serrate, tips obtuse to acute; leaflets on first three leaves 22 x 10, 34 x 12, and 24 x 10 mm; above dark or mid-green, sparsely hairy, mainly on the midrib; below light green, hairless except for sparse white hairs on the midrib.

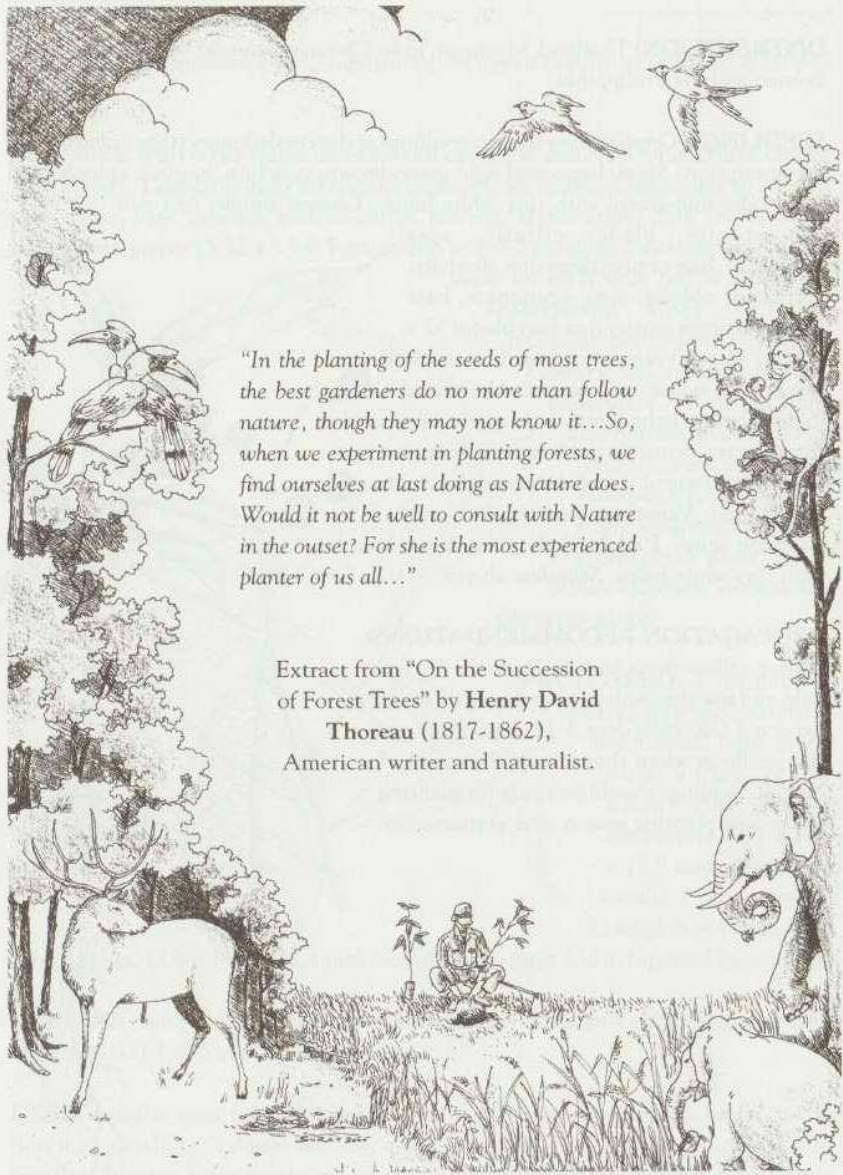


**Venation:** pinnate, mid-green above, light green below, 8-11 alternate secondary veins on each side of the midrib; tertiary venation reticulate. **Petiole:** light green, 9-13 mm long with sparse white hairs; petiolule light green, 1.5 mm, sparsely hairy. **Rachis:** 10-15 mm, light green, sparsely hairy. **Stipules:** absent.



**PROPAGATION RECOMMENDATIONS:** collect yellow fruits in March. Remove the fruit pulp and soak the pyrenes in water for 12 hours, before sowing them in trays in partial shade. Up to 5 seedlings can emerge from each pyrene; expected GR up to 43%, over 11-32 days. Prick out the seedlings immediately after germination. Saplings should be ready for planting in the second planting season after germination.





*"In the planting of the seeds of most trees, the best gardeners do no more than follow nature, though they may not know it...So, when we experiment in planting forests, we find ourselves at last doing as Nature does. Would it not be well to consult with Nature in the outset? For she is the most experienced planter of us all..."*

Extract from "On the Succession of Forest Trees" by **Henry David Thoreau** (1817-1862), American writer and naturalist.

# PART 3



## A COLOUR GUIDE TO SELECTED FRUITS AND SEEDS

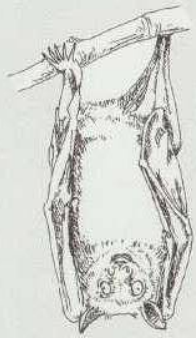


FORRU researcher, Puttipong Navakitbunrung describes fruit types to workshop participants at FORRU's research nursery on Doi Suthep.



# SEED-DISPERSING ANIMALS

These are some of the most important groups of animals that disperse seeds and fruits from the forest into open areas, thus playing a vital role in forest regeneration. Preventing the hunting of such animals is just as important for forest restoration as planting trees.



Fruit bats



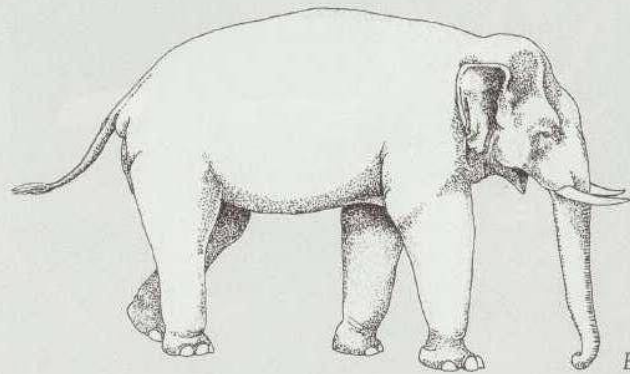
Pigeons



Bulbuls



Civets



Elephants



*Albizia chinensis* (see page 36)



*Betula alnoides* (see page 42)



*Albizia odoratissima* (see page 38)



*Bischofia javanica* (see page 44)



*Balakata baccata* (see page 40)





*Callicarpa arborea* (see page 46)



*Castanopsis acuminatissima* (see page 48)



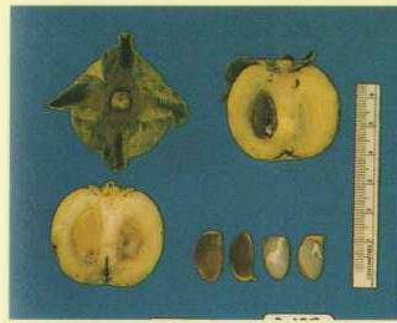
*Dalbergia cultrata* (see page 54)



*Castanopsis tribuloides* (see page 50)



*Debregeasia longifolia*  
(see page 56)



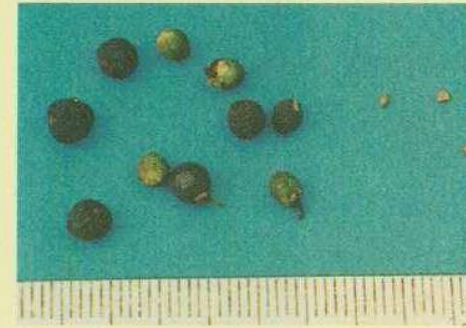
*Diospyros glandulosa* (see page 58)



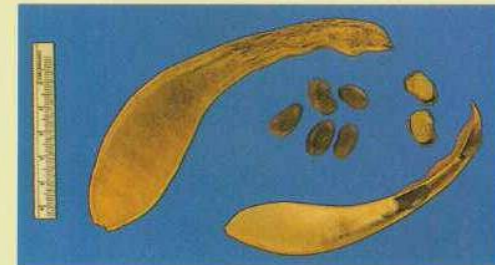
*Erythrina stricta* (see page 64)



*Engelhardia spicata*  
(see page 62)

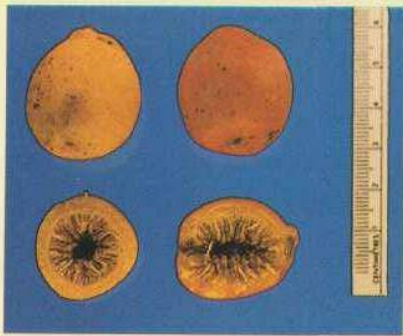


*Eurya acuminata* (see page 68)

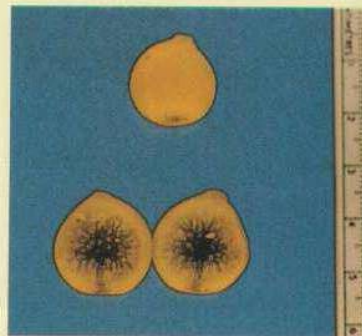


*Erythrina subumbrans* (see page 66)

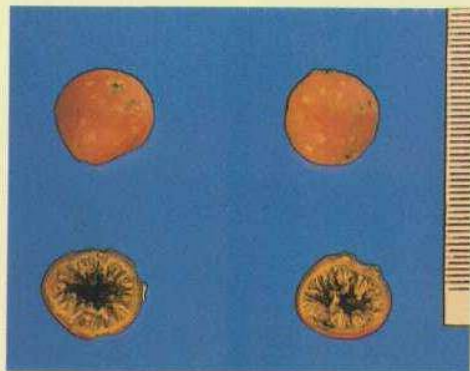




*Ficus altissima* (see page 70)



*Ficus benamina* (see page 72)



*Ficus microcarpa* (see page 74)



*Gmelina arborea* (see page 78)



*Helicia nilagirica* (see page 80)



*Heynea trijuga* (see page 82)



*Horsfieldia amygdalina* (see page 84)



*Horsfieldia thorelii* (see page 86)



*Hovenia dulcis* (see page 88)



*Litsea cubeba* (see page 90)





*Macaranga denticulata* (see page 92)



*Manglietia garrettii* (see page 94)



*Nyssa javanica* (see page 102)



*Ostodes paniculata* (see page 104)



*Markhamia stipulata* (see page 96)



*Phoebe lanceolata* (see page 106)



*Phyllanthus emblica* (see page 108)



*Melia toosendan* (see page 98)



*Morus macroura* (see page 100)



*Primus cerasoides* (see page 110)



*Pterocarpus macrocarpus* (see page 112)





*Quercus semiserrata* (see page 114)



*Rhus rhetsoides* (see page 116)



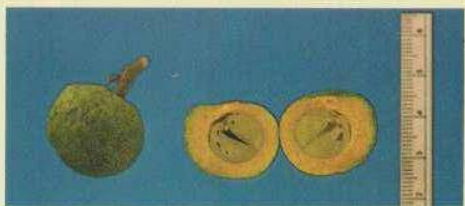
*Sapindus rarak* (see page 118)



*Schima wallichii* (see page 120)



*Spondias axillaris* (see page 122)

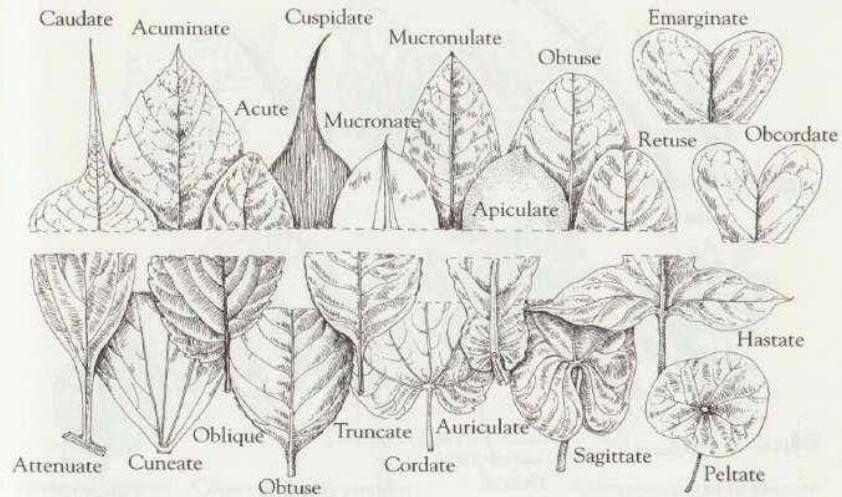


*Xanthophyllum flavescens* (see page 124)

## GLOSSARY

- Accrescent** – growing, ever increasing; enlarged and persistent.
- Achene** – a small, dry, indehiscent, one-seeded fruit with thin pericarp.
- Acorn** – fruit of oaks; a nut partly enclosed within a cup (see fig. 5).
- Acuminate** – apex with concave sides, tapering to an extended point (see fig. 1).
- Acute** – tapering to a narrow angle, less than a right angle (see fig. 1).
- Alternate** – arranged singly at each node, as leaves on a stem.
- Angiosperms** – one of the main divisions of flowering plants, containing plants that have ovules enclosed in an ovary.
- Anther** – that part of the stamen producing the pollen (see filament) (see fig. 10).
- Apex** – the tip, e.g. of a leaf (see fig. 1).
- Apiculate** – with a short sharp point on an otherwise blunt end (see fig. 1).
- Aril** – a fleshy, usually brightly coloured extra cover of a seed, arising from the seed stalk or hilum which is free from the seed (see sarcotesta).
- Attenuate** – gradually tapering to a slender point, applied to bases or apices (see fig. 1).
- Axillary** – located between a joint or angle and the main axis.
- Axis** – the main or central line of development of any plant or organ; the main stem (see lateral).

Fig 1 Leaf Apices and Bases





**Bark** – tough outer covering of woody stems or roots.

**Basifixed** – attached at the base e.g. leaf blades (see peltate).

**Berry** – a simple juicy fruit, developing from a single pistil, usually small, with several seeds within a juicy mesocarp (see fig. 6).

**Bifid** – two-cleft, as in the apices of some petals or leaves (see cleft/emarginate).

**Bifoliate** – with two-leaflets.

**Bivalved** – with two valves.

**Blade** – the expanded part of a leaf or petal (see fig. 4).

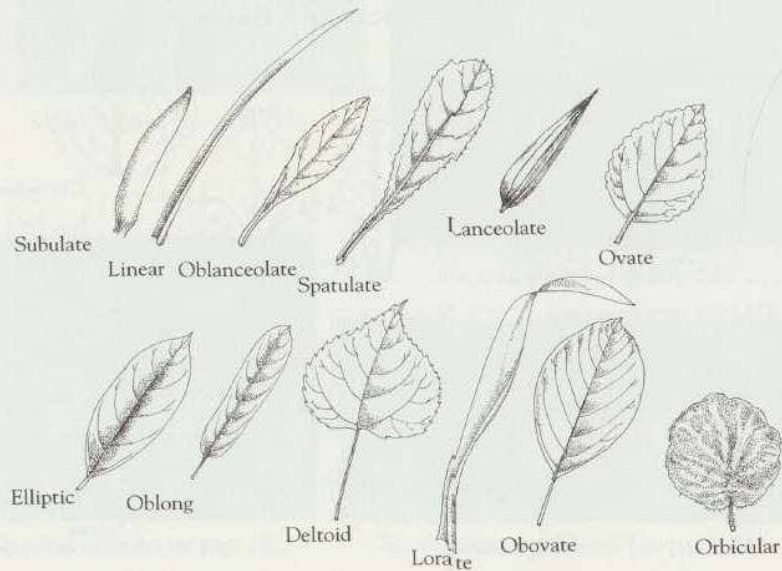
**Bole** – stem or trunk of a tree.

Figure 2a

Length/width	Widest at the:		
	Apex	Middle	Base
+/- 1		Orbicular	
1-2	Obovate	Elliptic	Ovate
2-3	Obovate-oblong	Oblong	Ovate-oblong
3-5	Obovate-lanceolate	Lanceolate	Ovate-lanceolate
5-10		Linear-lanceolate	
10+		Linear-subulate	

J. F. Maxwell

Fig 2b Leaf Form



**Bract** – a modified or rudimentary leaf subtending a flower or pedicel.

**Bractate** – with bracts.

**Bud** – an undeveloped (or dormant) leaf, flower or shoot protected by scales (sepals).

**Buttress** – a vertical projection at the base of a trunk.

**Calyx** – the sepals of a flower, considered as a group (see sepals) (see fig. 10).

**Capsule** – a one to many seeded fruit which, when ripe, either splits into valves or opens by slits or holes (see fig. 5).

**Carpel** – the structure of an ovary containing ovules and eventually seeds.

**Catkin** – a compact spike of small, unisexual flowers without petals, e.g. oaks (see raceme, spike fig. 9).

**Caudate** – bearing a tail-like appendage, as some leaf apices or bases (see fig. 1).

**Cleft** – indentation that extends about halfway to the centre, as in some leaves (see bifid).

**Compound** – with two or more similar parts in one organ e.g. leaves (see simple and fig. 3).

**Coppicing** – with many shoots growing out from tree stumps.

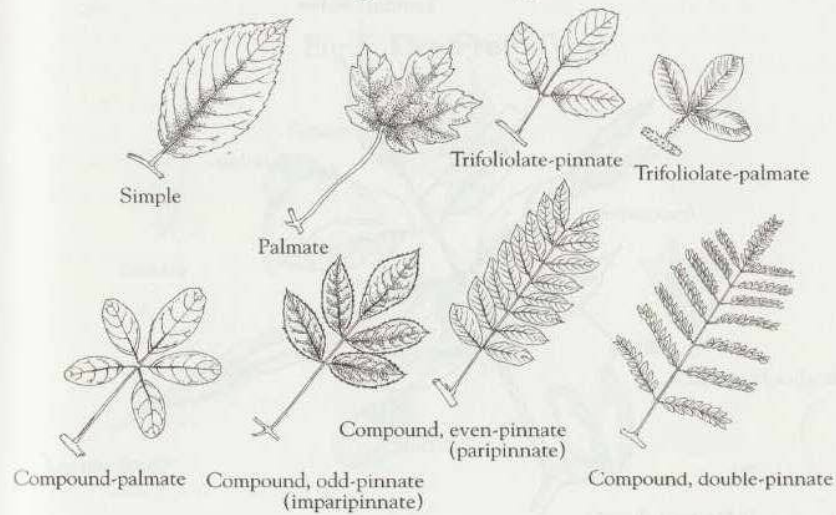
**Cordate** – heart-shaped, describing the base of e.g. a leaf (see fig. 1).

**Corolla** – the second inner whorl of a flower, (see petals) (see fig. 10).

**Cotyledon** – seed leaf; the primary leaf or leaves in the embryo; in some plants the cotyledon(s) always remains in the seed coat and in others it emerges.

**Cotyledonary leaf (paracotyledon)** – a photosynthetic leaf arising from the same node as the cotyledons (see fig. 8).

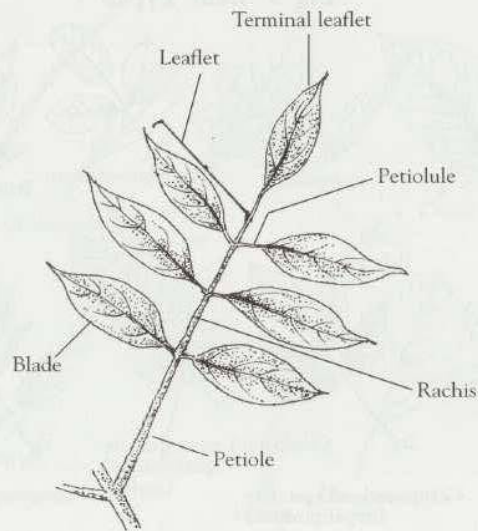
Fig 3 Leaf Types





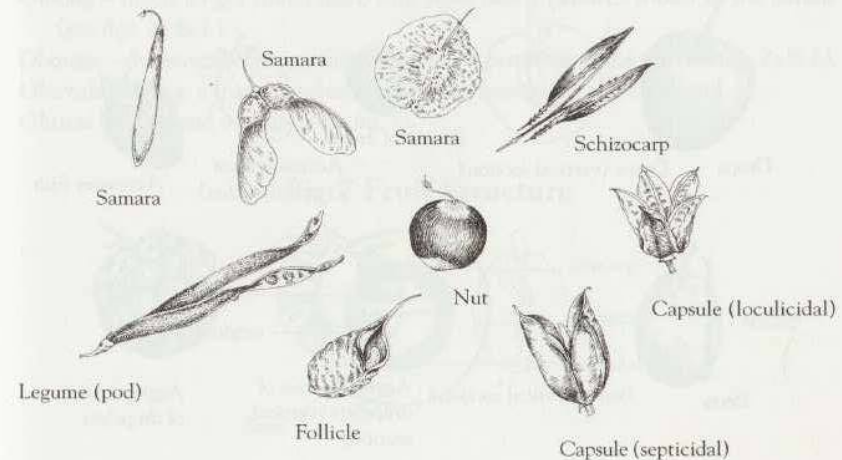
**Crenate** – shallowly round-toothed.  
**Crenulate** – finely crenate.  
**Cuneate** – wedged-shaped; triangular, with the narrow end at the point of attachment, as the bases of leaves or petals (see fig. 1).  
**Cupule** – cup-like structure at the base of some fruits formed of dry, enlarged bracts.  
**Cuspidate** – with an apex abruptly and sharply concavely constricted into an elongated, sharp-pointed tip (see fig. 1).  
**Cyme** (adjective *cymose*) – a type of branching inflorescence in which the central and terminal flower opens first (see fig. 9).  
**Deciduous** – shedding leaves annually or periodically; not evergreen.  
**Decussate** – pairs of opposite leaves arranged at right angles to each other along the stem.  
**Decurrent** – extending down and along the stem, usually referring to a petiole.  
**Dehiscence** – opening or splitting (see capsule, indehiscence).  
**Deltoid** – broadly triangular with the widest part at the base, usually referring to the shape of a leaf blade (see fig. 2b).  
**Dentate** – with spreading teeth perpendicular to the margin.  
**Denticulate** – minutely or finely dentate.  
**Dicotyledon** – one of the two great divisions of Angiosperms, having embryos with two seed leaves or cotyledons.  
**Drupe** – a fleshy fruit in which one or more seeds are enclosed in a stony layer (endocarp, pyrene) (see fig. 6).

**Fig 4 Leaf Parts**



**Elliptic** – refers to a shape (usually a leaf) that is widest in the middle and tapers towards both ends (see figs. 2a & b).  
**Emarginate** – with a shallow notch at the apex (see bifid and fig. 1).  
**Emergent** – arising above the soil, becoming visible; or describing a tree with a crown rising above the main forest canopy.  
**Endemic** – indigenous to and confined to a particular area.  
**Endocarp** – the inner layer of the pericarp or fruit wall (see drupe, pyrene, and fig. 7).  
**Endosperm** – tissue, storing nutritive material, in seeds, formed from the embryo sac.  
**Entire** – leaf margins that are not toothed or divided in any way.  
**Epicotyl** – apical end of plant embryo axis (see hypocotyl and fig. 8).  
**Epiphyte** – (adjective *epiphytic*): a plant growing upon, but not nourished by, another plant.  
**Epilithic** – growing on rocks.  
**Evergreen** – a plant that retains its leaves throughout the year.  
**Exocarp** – the outer layer of the pericarp or fruit wall (see fig. 7).  
**Filament** – the stalk of a stamen (see anther and fig. 10).  
**Fissure** – longitudinal splits or cracks in bark.  
**Flower** – the structure for sexual reproduction in the Angiosperms, usually consisting of male organs (comprising the stamens) and female organs (comprising the pistils) (see fig. 10).  
**Follicle** – dry dehiscent fruit, opening only on the front suture and the product of a simple pistil (see fig. 5).  
**Fruit** – the ripened ovary, bearing the seeds.  
**Furfuraceous** – bran-like, scaly or scurfy.  
**Genus** – a group of closely related species.

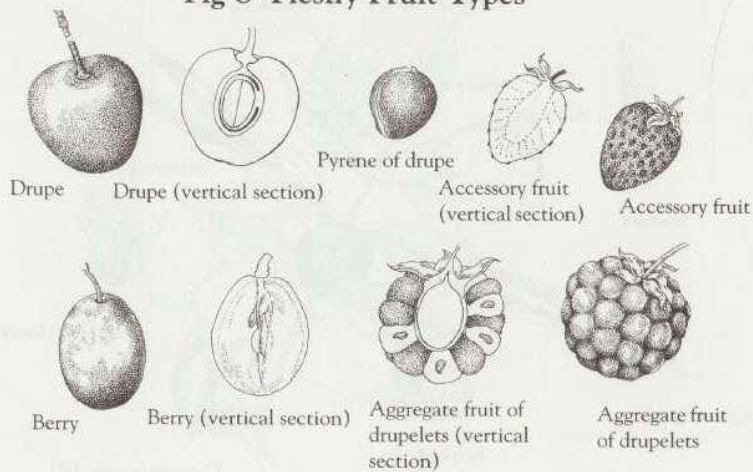
**Fig 5 Dry Fruit Types**





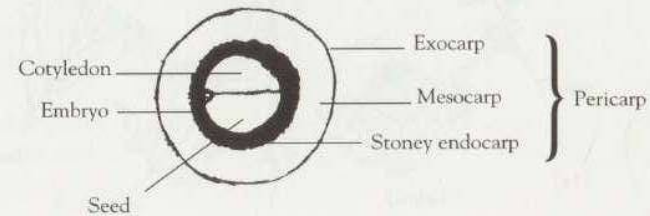
- Glabrous** – not hairy.
- Gland** – a secreting organ, often dot or wart-like, either on the surface or embedded in tissue.
- Glandular** – describing organs of secretion usually epidermal on the tips of hairs; hence glandular-hairs.
- Glaucous** – with a waxy, greyish-blue bloom.
- Globose** – spherical, round.
- Glomerule** (adjective **glomerulate**) – a dense cluster of short-stalked flowers.
- Habit** – the characteristic form of a plant.
- Hilum** – a scar on the seed, at the point of attachment to the stalk of the ovule.
- Hypocotyl** – the axis of an embryo below the cotyledons, which on seed germination produces the radicle (see epicotyl and fig. 8).
- Imparipinnate** – or odd-pinnate, with an unequal number of leaflets (see fig 3).
- Incised** – cut; slashed.
- Indehiscent** – not opening or splitting.
- Indigenous** – native to an area, not introduced: the opposite of exotic.
- Indumentum** – hairs covering a surface.
- Inflorescence** – a group of flowers having a common axis, or main stem.
- Infructescence** – a group of fruits having a common axis, or main stem.
- Integument** – the covering of an organ; the outer envelope of an ovule.
- Internode** – a length of axis between 2 nodes (see node and fig. 8).
- Involucre** – a whorl of bracts beneath an inflorescence.
- Lanceolate** – shaped like the head of a spear or lance, with the widest part at the middle (see figs. 2a & b).
- Lateral** – on or at the side (see axillary).

**Fig 6 Fleshy Fruit Types**



- Leaflet** – first sub-division of a compound leaf (see fig. 4).
- Legume** – a dry fruit of one carpel, often splitting along one or both sides (see fig. 5).
- Lenticel** – a pore in bark surrounded by a raised corky margin.
- Lignified** – becoming woody, due to thickening of cell walls by deposition of lignin.
- Ligular/ligulate** – tongue or strap-shaped.
- Lobe** – any curved or rounded part or segment of any organ; specifically a part of a petal; calyx or blade divided to approximately the middle.
- Locule** – ovary chamber, containing the ovules or anther chamber containing the pollen.
- Loculicidal** – dehiscing along the back of the carpel (see fig 5).
- Longitudinal** – along the long axis of an organ.
- Margin** – the outer edge of e.g. a leaf blade or petal.
- Mesocarp** – the middle layer of the fruit wall or pericarp (see fig. 7).
- Midrib/mid-vein** – the primary vein of e.g. of a leaf blade (see fig. 11).
- Monocotyledon** – one of the two great divisions of angiosperms, the embryos with one cotyledon.
- Monopodial** – pattern of growth in which a shoot continues to grow indefinitely and bears lateral shoots that grow similarly.
- Mucro** – a short and sharp abrupt spur or spiny tip forming an abrupt end.
- Mucronate** – having a mucro (see fig. 1).
- Mucronulate** – having a very small mucro.
- Nectar** – a sugary solution secreted by many flowers to attract animal pollinators.
- Node** – the point on an axis where leaves, flowers etc. are borne (see internode, fig. 8).
- Nut** – a simple, dry one-seeded fruit with a hard pericarp (see fig. 5).
- Oblanceolate** – of e.g. a leaf, like a lance-head reversed, about three times as long as broad, tapering more gently towards base than apex (see figs 2a & b).
- Oblique** – asymmetrical about the midrib; with unequal sides (see fig. 1).
- Oblong** – much longer than broad, with sides nearly parallel, widest in the middle (see figs. 2a & b).
- Obovate** – the inverse of ovate, with the broadest part towards the top (see figs. 2a & b).
- Obovoid** – of e.g. a fruit, egg-shaped, with the base as the narrower end.
- Obtuse** – blunt and rounded (see fig. 1).

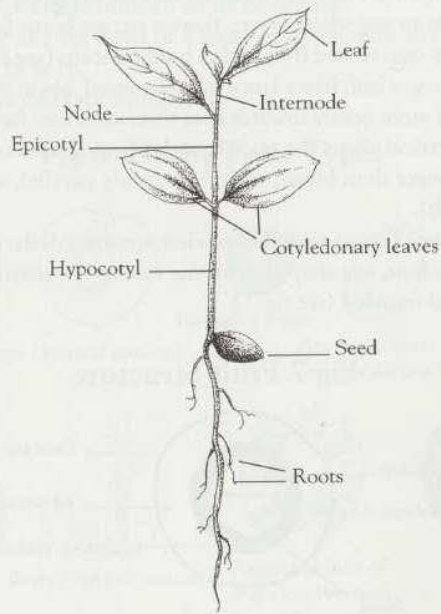
**Fig 7 Fruit Structure**





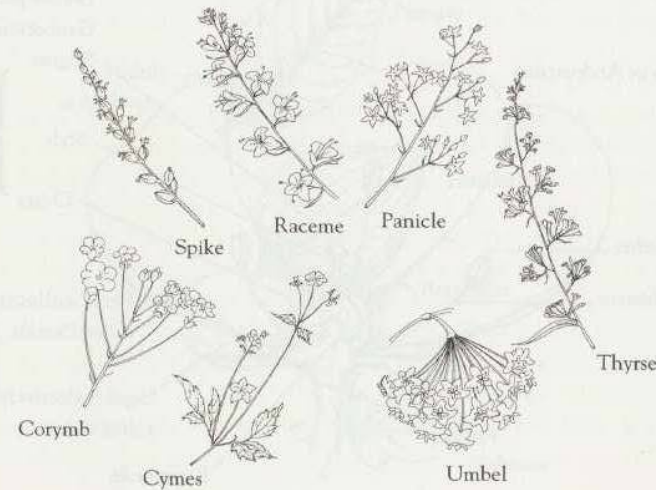
- Opaque** – with a dull surface; opposite of glossy.
- Opposite** – leaf arrangement in which the leaves arise opposite to each other at a node.
- Orbicular** – circular or disc-shaped (see fig. 2a & b).
- Ovary** – the part of the flower containing the ovules and later the seeds, usually with one or more styles and stigmas (see fig. 10).
- Ovate** – with an oval outline broader towards the base than the apex, and rounded-ended (see obovate and figs. 2a & b).
- Ovoid** – ovate in 3 dimensions, egg-shaped attached at the broad end.
- Palmate** – a leaf divided into more than 3 lobes or segments arising from a single point, as fingers on a hand (see fig. 3); can also refer to venation (see fig. 11).
- Panicle** – a type of inflorescence in which the main axis is divided into branches each bearing several flowers (see fig. 9).
- Paniculate** – arranged in a panicle.
- Paripinnate** – a compound leaf divided into pairs of leaflets, with no terminal leaflet, i.e. an even number (see imparipinnate and fig. 3).
- Pedicel** – the stalk of a single flower (see fig. 10).
- Peduncle** – the stalk of an inflorescence or of a single flower when that flower is the remaining member of an inflorescence.

**Fig 8 Seedling Parts**



- Peltate** – circular and flat with the stalk inserted in the middle (see also basifixed and fig. 1).
- Perianth** – collective term for the corolla and calyx (see fig. 10).
- Pericarp** – the wall of a fruit, developed from the ovary wall, usually with three layers: exocarp, mesocarp and endocarp (see fig. 7).
- Petal** – free parts of the second whorl of a flower, often brightly coloured (see fig. 10).
- Petiolate** – having a petiole.
- Petiole** – stalk of a leaf (see fig. 4).
- Petiolule** – stalk of a leaflet (see fig. 4).
- Pinnate** – compound leaf with leaflets in pairs along each side of a primary axis (see fig. 3), see also imparipinnate and paripinnate.
- Pistil** – the female parts of a flower, comprised of ovary; style and stigma (see fig. 10).
- Pod** – the fruit of legumes, splitting open along one valve (see fig. 5).
- Pollen** – minute spores produced by anthers.
- Prophylls** – a much-reduced, rudimentary leaf.
- Pulvinus (plural pulvini)** – swellings at the apex or base of the petiole, especially in legumes.
- Pyrene** – seed(s) enclosed in a stony endocarp in drupes (see fig. 6).
- Raceme (adjective racemose)** – an inflorescence in which stalked flowers are borne along an unbranched axis (see fig.9).
- Receptacle** – the enlarged extremity of an axis bearing the flower. The wall inside figs is a receptacle (see fig. 10).

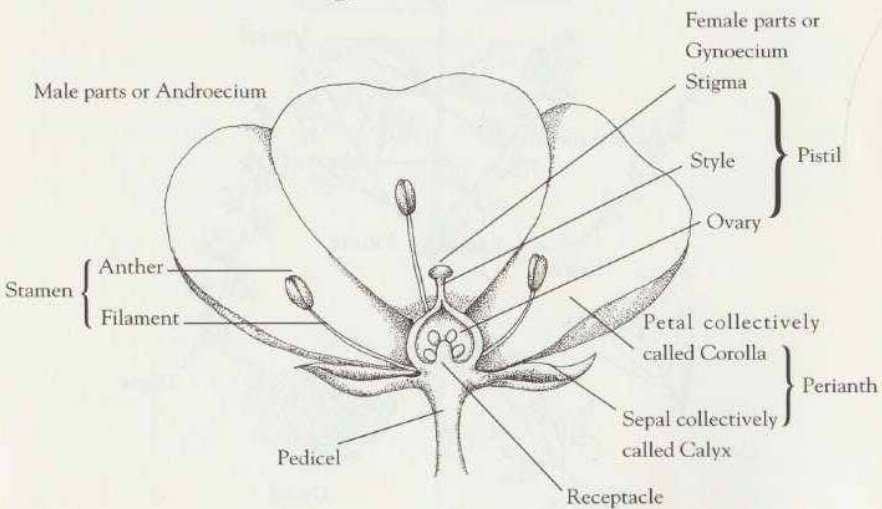
**Fig 9 Inflorescence Types**





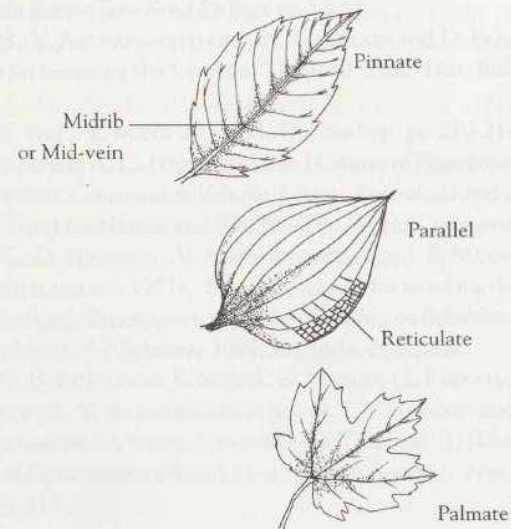
**Recurved** – curved or bent back.  
**Reticulate** – net-veined (see fig. 11).  
**Retuse** – notched slightly at an apex (see emarginate and fig. 1).  
**Sagittate** – shaped like an arrowhead; triangular, with the basal lobes pointing downward or curved towards the stalk (see fig. 1).  
**Samara** – a dry, indehiscent, winged fruit (see fig. 5).  
**Saponins** – a group of toxic soapy chemicals (glucosides) (see *Sapindus rarak*).  
**Sarcotesta** – a fleshy or juicy layer, external to and attached to the testa.  
**Scalariform** – an arrangement of venation resembling rungs of a ladder.  
**Scarious** – describing membranous, thin, dry leaf-like parts that are not green.  
**Seed** – the unit of sexual reproduction developed from a fertilised ovule, consisting of an embryo enclosed within a testa, potentially capable of germination (see fig. 7).  
**Seed coat** – outer protective covering of seed (see testa).  
**Sepal** – free part of the outer envelope of a flower (see calyx and fig. 10).  
**Septum** (plural *septa*) – the wall between two locules of an ovary.  
**Septicidal** – dehiscence longitudinally through septa so that carpels are separated (see fig. 5).  
**Serrate** – toothed like a saw with teeth pointing forward.  
**Serrulate** – minutely serrate.  
**Sheath** – the base of a leaf or leaf stalk that encases the stem.  
**Simple** – a leaf with one blade (see compound and fig. 3).  
**Sinuuous/sinuate** – (of margins) wavy.  
**Spathe** – a large bract subtending and often ensheathing an inflorescence.

**Fig 10 Flower Parts**



**Spicate** – spike-like (see fig. 9).  
**Spike** – a simple racemose (unbranched) inflorescence bearing stalk-less flowers (see fig. 9).  
**Spiral** – with parts arranged in spirals.  
**Stalk** – the 'stem' of any organ e.g. petiole, peduncle; pedicel; filament.  
**Stamen** – the male reproductive organ of a flower, composed of a filament and anther, the latter producing pollen (see fig. 10).  
**Stem** – the main axis of a plant, leaf bearing and flower bearing as distinguished from the root-bearing axis.  
**Stigma** – the receptive part of the female reproductive organs, at the top of the ovary, on which pollen grains germinate (see fig. 10).  
**Stipel** – a stipule-like appendage at the base of a leaflet.  
**Stipule** – a leaf-like or scale-like appendage at the base of leaves.  
**Striations** – parallel longitudinal lines or grooves, e.g. on bark.  
**Style** – the elongated apical part of a carpel or ovary bearing the stigma at its tip (see fig. 10).  
**Subglobose** – nearly globose.  
**Subopposite** – nearly opposite.  
**Suborbicular** – nearly orbicular.  
**Subulate** – awl-shaped, long and narrow (see fig. 2b).  
**Sympodial** – growth in which a shoot ceases to grow and one or more lateral buds, next to the apical bud, grows and repeats the pattern.

**Fig 11 Leaf Venation**





**Syconium** – a type of fleshy multiple fruit, commonly called a fig.

**Tannin** – a group of chemicals produced in the bark and leaves of some species.

**Tepal** – a perianth segment that is not clearly differentiated into a sepal or petal.

**Terminal** – at the tip or apex.

**Testa** – outer coat of a seed (developed from the integument).

**Thyrse** (adjective **thyrseoid**) – densely branched inflorescence, broadest in the middle and in which the mode of branching is cymose (see fig. 9).

**Toothed** – bearing small projections around the edge as in the margin of some leaf blades.

**Treelet** – a small tree.

**Trifoliolate** – a compound leaf, having three leaflets (see fig. 3).

**Truncate** – appearing as if squared off at the end; often referring to a leaf base or apex (see fig. 1).

**Twig** – the youngest branches, usually of the present year's growth.

**Umbel** – a flat-topped or domed inflorescence, in which the flower stalks are of equal length and all arise from the same point on an axis (see fig. 9).

**Unifoliolate** – having one leaflet.

**Vein** – tube in for example a leaf blade, along which nutrients and water are transported.

**Venation** – the arrangement or pattern of veins in a leaf blade, consisting of the main vein or midrib, basal, secondary and lateral veins and a network of minute, interconnecting veins (see fig. 11).

**Villous** – having long, soft hairs.

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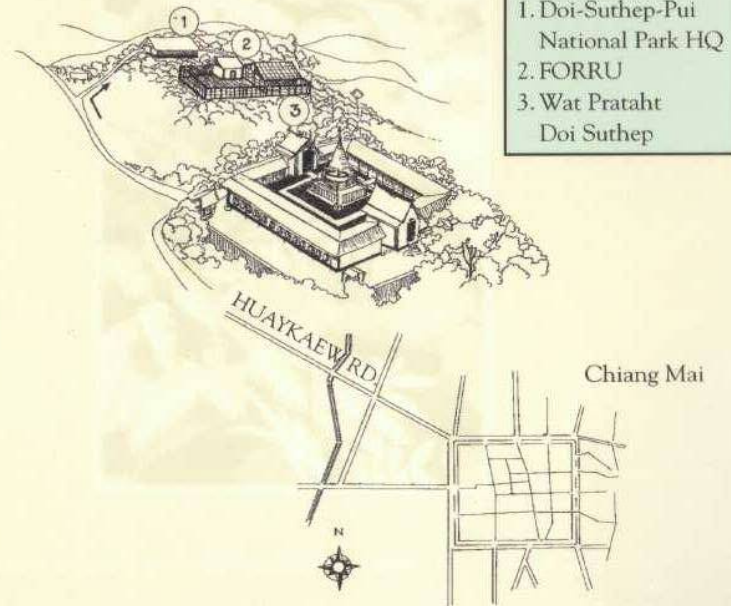
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