Annex 914

Edward Balfour, *Cyclopædia of India and of Eastern and Southern Asia* (2d Supp.) (1862)

THE SECOND

SUPPLEMENT,

WITH INDEX,

TO THE

CYCLOPÆDIA OF INDIA

AND OF

EASTERN AND SOUTHERN ASIA,

Commercial, Industrial and Scientific;

PRODUCTS OF THE

MINERAL, VEGETABLE AND ANIMAL KINGDOMS, USEFUL ARTS AND MANUFACTURES.

EDITED BY

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1862.

is also called Phanran, after a considerable town at the head of it.—*Horsburgh.*

CAPE OR BRAZIL GOOSEBERRY. Physalis Peruviana.

CAPE JASMINE. Gardenia florida.

CAPER. ENG. See Euphorbia lathyris.

CAPER OF MOUNT SINAI. Capparis sinaica.

CAPER SPURGE. Euphorbia lathyris.

CAPI-COTTAY. TAM. Coffee.

CAPILAPODI. TAM. Rottlera tinctoria.

CAPOETA MACROLEPIDATA. See Isinglass.

CAPOOR. MAL. Quick Lime.

CAPOOR CUTCHERY. HIND. Hedychium spicatum.

CAPOOR CUTCHERY ALSO KAKHUR. GUZ. HIND. Zedoary.

CAPOOR ENGREES. MALAY. Chalk.

CAPOTE. See Capers.

CAPOOROO. CYNG. Camphor.

CAPPARIDACEÆ. See Capers; Capparis divaricata. Capparis grandis. Cadaba Indica.

CAPPARIS BREVISPINA. See Vegetables of Southern India.

CAPPARIS CARANDAS. GMEL. Syn. of Carissa carandas.—*Linn.*

CAPPARIS SINAICA. See Capparis Sinaica.

CAPPARIS SPINOSA. See Capers.

CAPPED MACAQUE. See Simiadæ.

CAPPELLI. IT. Hats.

CAPPERN. GER. Capers.

CAPRA ÆGAGRUS. See Capreæ.

CAPRA CAUCASIA. See Capreæ.

CAPRA HIMALAYANA. See Capreæ.

CAPRA HIRCUS. See Capreæ

CAPRA JEMLAICA. See Capreæ.

CAPRA JHARAL. See Capreæ.

CAPRA NUBIANA. See Capreæ.

CAPERS. FR. Capers.

CAPRIFOLIACEÆ. See Caprifolium sempervirens. Cornus capitata, Lonicera Leschenaultii.

CAPRIFOLIUM. Honeysuckle.

CAPRIMULGIDÆ. See Caprimulgus.

CAPRINUM GENUS. See Capreæ.

CAPSICUM. See Cayenne pepper. Chillies. Capsicum annuum. Mirchi.

CAPSICUM ANNUUM. See Chillies.

CAPSICUM BACCATUM. LINN. Bird's eye-pepper, var. of Capsicum annuum. LINN. See Chillies.

CAPSICUM FESTIGIATUM. BLUME. Cayenne pepper, var. of Capsicum annuum.—*Linn.*

CAPSICUM FRUTESCENS. LINN. Chilly, var. of Capsicum annuum. LINN. See Capsicum. Chillies, Mirchee. Vegetables of Southern India. Capsicum minimum. Cayenne Pepper.

CAPSICUM FRUTICOSUM. See Capsicum.

CAPSICUM GROSSUM. WILLD. Bell pepper, Kafferi mirich. HIND. a var. of C. annuum. Syn. of Capsicum annuum. LINN. See Capsicum. Capsicum minimum.

CAPSICUM MINIMUM (Bird's eye pepper) See Capsicum.

CAPSICUM PURPUREUM. See Chillies, Vegetables of Southern India.

CAPSICUM NEPALENSIS. A var. of C. annuum the most acrid and pungent of the species of Capsicum. Syn. of Capsicum annuum.—*Linn.*

CAPSELLA BURSA PASTORIS. See Mullay Muntha-keeray. TAM. Vegetables of Southern India.

CAPSULES DES PAVOTS BLANCS. FR. White Poppy capsules.

CAPUCINE. See Capers

CAPULAGA, also POWAR. MALAY. Cardamom.

CARABIDÆ. See Carabus.

CARA CARNAY KALUNG. TAM. Tacca pinnatifida.

CARACAL or Indian lynx has immense speed, runs into a hare as a dog into a rat. It often catches crows as they rise from the ground, by springing five or six feet into the air after them.

CARAGANA VERSICOLOR. DAMA, TIB. a small shrub, which grows in Tibet at elevations of 14,800 feet, and is very useful for fuel.

CARA-KAIA. TEL. Myrobalan.

CARALOO. TEL. Setaria italica.

CARALLUMA ADSCENDENS. Vegetables of Southern India.

CARAMBOLA TREE. ENG. Syn. of Averrhoa carambola.

CARAMBOO. TAM. Caryophyllus aromaticus.

CARAMUNNY KEERAY. TAM. Dolichos catiany.

CARAMUNNY PYRE. TAM. Dolichos catiany.

CARANGALLY. TAM. Acacia sundra.

CARANJA OR CARRIJA ISLAND, south of Elephanta on the east side of the Bombay harbour, is 4 miles long and 2 broad, and is low and woody with two hills called after the island.—*Horsburgh.*

CARANOSI. RHEED. Vitex trifolia.

CARAPA MOLUCCENSIS. See Xylocarpus granatum.

CARAVAN. See Kafilah : Karwan.

CARAVOAS OR BUFFALOS, in about lat. 11° 53' N. in the Mindoro sea, are two small islands.—*Horsburgh.*

CARAY CHEDDI. TAM. Webera tetrandra.

CARBO-LIGNI. LAT. Charcoal.

Annex 915

"*Trema* species", *Firewood Crops: Shrub and Tree Species for Energy Production* (1980)

Firewood Crops

Shrub and Tree Species for Energy Production

NATIONAL ACADEMY OF SCIENCES

Firewood Crops

Shrub and Tree Species for Energy Production

Report of an Ad Hoc Panel of the
Advisory Committee on Technology Innovation
Board on Science and Technology for International Development
Commission on International Relations

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1980

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the federal government. The Council operates in accordance with general policies determined by the Academy under the authority of its congressional charter of 1863, which establishes the Academy as a private, nonprofit, self-governing membership corporation. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970 respectively, under the charter of the National Academy of Sciences.

The Board on Science and Technology for International Development (BOSTID) of the Commission on International Relations addresses a range of issues arising from the ways in which science and technology in developing countries can stimulate and complement the complex processes of social and economic development. It oversees a broad program of bilateral workshops with scientific organizations in developing countries and conducts special studies. BOSTID's Advisory Committee on Technology Innovation publishes topical reviews of technical processes and biological resources of potential importance to developing countries.

This report has been prepared by an ad hoc advisory panel of the Advisory Committee on Technology Innovation, Board on Science and Technology for International Development, Commission on International Relations, National Academy of Sciences–National Research Council, for the Office of Science and Technology, Bureau for Development Support, Agency for International Development, Washington, D.C., under Contract No. AID/csd-2584, Task Order No. 1.

Library of Congress Catalog Number: 80-83796

Trema species

Family Ulmaceae (or Urticaceae)

Main Attributes There are about 15 species of *Trema* distributed throughout the tropics. They are pioneer plants of eroded soils and volcanic ash and are generally among the first trees to come up on newly cleared land such as forest clearings, thickets, and roadsides. They will grow in poor soils and in barren environments. The species generally have many characteristics in common, offering like benefits and uses. The wood is soft and of only limited value as firewood. However, it probably can be produced easily in large quantities in appropriate locations.

Description *Trema* species are shrubs or small trees that reach heights of about 10 m and diameters of about 20 cm. They are found in open forests and have spreading crowns and evergreen leaves. Some examples are:

- *Trema orientalis*, an Asian species native to the moist parts of India where it is called "charcoal tree." It is also found throughout the Malay peninsula, extending into China, and has had some successful cultivation trials in the southern Philippines.
- *Trema politoria*, also an Asian species found in dry zones of subtropical India and throughout northern India from Gujarat in the west to Assam in the east.
- *Trema guineensis*, a small African tree known as the "charcoal tree" in Malawi. It is a pioneer species common to deciduous forests and is found distributed throughout tropical Africa to South Africa, extending into Arabia and Madagascar. (Some botanists consider this to be the same plant as *T. orientalis*.)
- *Trema micrantha*, native to Central and South America as well as to the West Indies.
- *Trema cannabina*, native to Southeast Asia.

Use as Firewood These and other *Trema* species are widely used as fuel, though their calorific value is not high (4,500 kcal per kg). *Trema orientalis* is used to make gunpowder in Java and as a charcoal for fireworks.

Yield *Trema* species are claimed to be exceedingly fast growing. They coppice well.

Other Uses

- Afforestation programs. These plants are pioneer species suitable for planting on poor lands, in afforestation of denuded and disturbed areas, and for use as general soil binders. All may prove to be soil improvers as well.
- Shade trees. *Trema orientalis* is often planted in Asia and Africa as a shade tree on plantations for coffee, cacao, and other crops.
- Pulp and wood. In combination with bamboo pulp the wood is employed in the manufacture of writing and printing papers. Bleached pulps in 46–50 percent yields can be prepared from *Trema orientalis*, with an average fiber length of 1 mm.
- Wood. In some areas (for example, in Gongola State, Nigeria), the wood is used for construction poles.
- Fodder. The leaves and branches of the plants are lopped for fodder. However, there has been some evidence, particularly in Australia, that they may contain a toxic glucoside.

Environmental Requirements

- Temperature. These are tropical and subtropical plants.
- Altitude. *Trema orientalis* is found extending up to about 2,000 m in the Himalayas, *Trema politoria* up to about 1,500 m.
- Rainfall. *Trema orientalis* needs a moist and humid climate, *Trema politoria* a dry climate, and *Trema guineensis* grows in both humid and dry environments.
- Soil. *Trema* species have no particular soil requirements. They are among the first woody plants to colonize denuded, fallow, or poor soils.

Establishment The plants regenerate very easily and can be propagated by stump cuttings.

- Seed treatment. Steeping seeds in giberellic acid in agar at 500 ppm or refrigerating at 2°C for 3–4 months breaks dormancy.
- Ability to compete with weeds. This species is sun loving and has the capacity to outgrow other species in newly cleared areas.

Pests and Diseases The trees harbor insect pests, which cause defoliation. These pests can spread to other plants of economic utility; therefore, caution is advised when these species are introduced outside their natural habitat. Two fungal diseases are known to attack them.

Limitations Unreported.

Trema orientalis natural regeneration, central Taiwan. (Taiwan Forestry Research Institute)

Parasponia root nodules which, like those of legumes, can fix atmospheric nitrogen (M.J. Trinick)

Related Species In the Malay Archipelago are found five species of *Parasponia* that are also pioneer trees and differ from *Trema* species only in tiny details of flower structure. These *Parasponia* species bear root nodules (containing *Rhizobium* bacteria) and can fix nitrogen as if they were legumes (despite previous literature reports, nitrogen-fixing nodules have not yet been found on *Trema* species*). Examples are:

- *Parasponia andersonii*
- *P. rugosa*
- *P. rigida*
- *P. parviflora.*

*Information supplied by M. J. Trinick. See Research Contacts.

Annex 916

Jim Croft, "An Introduction to the Structure of Ferns and their Allies", Australian National Botanic Gardens (1999), *available at* https://www.anbg.gov.au/fern/structure.html (accessed 31 May 2016)

An Introduction to the Structure of Ferns and their Allies

Prepared by Jim Croft (jim.croft@environment.gov.au)

Introduction

The ferns and their allies share a lot of commom morphlogy with the other vascular plants and in many cases the same descriptive terminology is used. However, there are some fundamental and significant differences of structure unique to the pteridophytes and a specialized terminology has evolved to descdribe these. The most obvious difference between the pteridophytes and the remainder of the vascular plants is that the ferns and their allies do not produce large floral or reproductive structures that give rise to seeds which eventually develop into the next generation of plants. Pteridophytes reproduce and disperse by means of microscopic spores, the structure and development of which is every bit as intricate and amazing as the flowers of the higher plants.

This outline covers the easily recognised features of the ferns and their alies and mentions many of the technical terms used to describe them.

Life cycle

The life cycle of pteridophytes involves two distinct and separate phases known as the gametophyte and sporophyte (these two phases also occur in the seed-plants, but because there they occur concurrently, they are less obvious). The **sporophyte**, is the most conspicuous phase, and is so-named because this is the stage that produces the spores; it is the sporophyte that most of us refer to when we describe or name a fern. Under favourable conditions, the **spores** shed from the sporophyte develop into the **gametopyhte** which is small, inconspicuous and short-lived. The purpose of the gametophyte is to produce the male and famale sex cells (**gametes**), the female of which, when fertilized, develops into a new sporophyte to continue the cycle. This regular process is known as the **alternation of generations** and involves an alternate doubling and halving of chromosome numbers at each phase.

It is interesting to compare the pteridophyte life cycle with that of another major group of spore-producing plants, the **bryophytes** or mosses and liverworts which also have alternating generations. In the bryophytes, the gametophyte is the dominant and most conspicuous stage and the sporophyte is retained as a relatively small. dependent appendage on the mature gametophyte.

A more detailed discussion of pteridophyte life cycle and reproduction is provided elsewhere.

Gametophyte

The gametophyte is the sexual or **haploid** stage of the pteridophyte life-cycle and contains a single set of chromosomes. It develops from the spore produced on the sporophyte. This spore germinates and develops into a body called the **prothallus**. At maturity, regions of the prothallus develop into small separate sexual organs. **Antheridia** produce the male sex cells and **archegonia** produce the female sex cells. The female sex cells are usually sedentary whereas the male are usually more or less coiled and motile by means of two or more **cilia** and swim or are carried by water to the archegonia where **fertilization** takes place. After fertilization a new sporophyte develops from the fertilized cell and takes over as the gametophyte withers and dies.

This is the general pattern of behaviour but there are fundamental differences in a number of genera with dimorphic spores and an number of genera that abandon the haploid phase (apogamy).

Prothallus morphology. In most cases the prothallus is green and photosynthetic, developing on the surface of the ground or on moist rocks or bark. They lack vascular tissue, mostly they are thin and more or less heart-shaped, less often ribbon-like or filamentous, the central region is somewhat thickened and bears the antheridia, archegonia and **rhizoids** (filamentous root-like structures). Useful taxonomic characters are afforded by the overall shape, the presence or absence of various hairs, the appearance of the rhizoids and the arrangement of antheridia and archegonia. However because the gametophyte generation is so small, so short-lived and must be grown from spore for reliable identification, it is rarely used in taxonomic treatments.

A more detailed discussion of gametophyte, prothallus and reproduction is provided elsehwere.

In the genera of the *Ophioglossaceae, Lycopodiaceae, Psilotaceae* and some *Schizaeaceae* the propthallus is thick, non-photosynthetic, grows and lives in the dark, underground or in the detritis in the forks of trees, and is **saprophytic**, obtaining its nutrients from decaying vegetable matter with the assistance of an **endophytic fungus**. Water is still essential for the process of fertilization.

Heterosporous pteridophytes. Certain groups of pteridophytes *(Selaginellaceae, Isoetaceae, Marsiliaceae, Azollaceae, Salviniaceae*) produce haploid meiospores of different sizes (big = **megaspores**; small = **microspores**). The microspores develop into small **microgametophytes** and the megaspores develop into larger **megagametophytes**. Apart from the separation of the gametophytes at the sexual stage, the alternation of generations is essentially the same.

Apogamous pteridophytes. In some species of ferns and their allies, the sexual process is omitted and the spores produced on the sporophyte are diploid rather than the usual haploid. The resulting prothallus is thus diploid and a few sporophyte is produced vegetatively without the usual union of gametes.

Sporophyte

The sporophyte is the asexual or **diploid** stage of the pteridophyte life-cycle. It is mostly large and conspicuous, always green and photosynthetic, long-live and produces the spores in special fruiting bodies; the spores are shed to produce the next gametophyte generation in the cycle. Because it is large, easily collected and preserved, and provides a vast array complex and distinctive characters for identification, the sporophyte generation is the foundation of all pteridophyte classification and taxonomy and the sporophyte alone is the fundamental unit of a modern pteridophyte specimen. All of the following discussion refers to the sporophyte generation or the fern plant as it is commonly known. It is convenient to consider the plant to be composed of three major parts: the stem which bears the roots, the leaves and the fertile parts with sporangia.

Habit, Lifeform

Pteridophytes exhibit a range of habits and life forms, and exist in most habitat types except the marine environment. The sporophytes range in size from a few millimetres to tens of metres tall and in mass from a few milligrams to many tens of kilograms. Pteridophyte habit reflects the enviroment and substrate in which they choose to grow and it is convenient to divide recognize three major classes: those that grow on the ground, those that grow on trees and those that grow in or on the water. However, it should be noted that a habit/habitat preference may span these classes. In particular, species that live low on trees, might be classed as epiphytes, subepiphytes or terrestrian, and plants that grow on the margins of water bodies might be considered aquatic or aquatic.

While this division of the overall structure of a plant based on where it grows might appear contrived and artificial, it should be noted that major families of pteridophytes are predominantly terrrestrial, predominantly epiphytic or predominantly aquatic, demonstrating a significant correlation of habit defined in this manner with other morphological characters.

The structure of the stem or rhizome has a particular impact on the habit type, compact or creeping stems determining the clustering or spacing of the fronds.

Terrestrial

Terrestrial pteridophytes have erect or creeping stems and the leaves are held more or less upright, either vertical or spreading and arching. Erect stems are generally unbranched, radial with a more or less terminal rosette of fronds, and may be stout and wooody (*Osmunda*, *Todea*), stout and fleshy (*Marattia*, *Angiopteris*) or arborescent (*Cyathea*, *Dicksonia*, *Leptopteris*). Creeping rhizomes have spaced or remote fronds, and the stem itself may be branched or unbranched, on the ground surface or subterranean. Such plants can be thicket-forming (Gleicheniaceae), and the fronds of some with particulaly long stems (*Lycopodium volubile*), stipes and rachises (*Lygodium*) can ascend into the crowns of small trees.

A number of species live on rocks or in rock crevise, with their roots going into bryphyte mats and trapped dirt and detritis. Their habit is often more akin to epiphytes that to other terrestrial species.

Epiphyte

Epiphytic pteridophytes have their stems attached to or rooted on trunks sor branches of trees. A distinction should be made bewteen these and species such as *Lygodium* that have terrestrial rhizomes an long fronds that climb into trees.

Epiphytes can have compact or short to long-creeping stems. The stems can start on the tree or on the ground, but in any case are attached to the tree and are not reliant on the soil for moisture and nutrients. Leaves, fronds, or stems can be erect, arching or pendulous. The fronds of some species (*Platycerium*, *Drynaria*, *Aglaomorpha* and the bird's-nest *Asplenium*) are specially adapted to trap detritis in their bases.

Subepiphytes live low on the base of tree trunks, generally generally among bryophytes and decaying detritis. They may also occur on mossy ground and mossy rocks.

Aquatic

A number of ferns are truly aquatic, a much greater number are **subaquatic** or **rheophytic** (growing beside and periodically flooded by streams). Aquatic pteridophytes can have compact or shortly creeping stems and can be free-floating on the surface fo the water (*Azolla*, *Salvinnia*), completely submerged and rooted in the bottom sediment (*Isoetes*), rooted and emergent (*Marsilia*) or a combination of all three (*Ceratopteris*).

A more detailed account of aquatic ferns is available elsewhere.

Stems, rhizomes

The stem is the main lengthwise growing axis of the fern or fern ally and bears the roots or root-like organs for attachment to the substrate and acquisition of nutrients and water, and produces leaves or fronds in a more less regular manner. Once leaves or fronds are produced, they generally do not increase in diameter at that poing. for the most part, they are not photosynthetic but in some epiphytic climbing species there is some chlorophyll; the stems of *Psilotaceae* and *Equisetaceae* are **phyllodes** and have taken over the photosynsthetic function of the leaves which are reduced to small scale-like teeth.

Growth form

Fern stems are often called **rhizomes**, but strictly speaking this term refers to those with a long-creeping or climbing habit. If the stem is short and compact and radially symmetric, either erect, prostrate or ascending, it is called a **caudex** or **rootstock** (or simply **stock**). In some cases the caudex is erect and tree-like with an apical radial tuft of leaves (*Cyathea*, *Dicksonia*, *Leptopteris*, some *Blechnum*, *Thelypteridaceae*) in which case it is often called a **trunk**. Creeping rhizomes can be either **long-creeping** with widley spaced fronds or **short-creeping** with fronds reletivley close together. The rhizomes can be **radial** or radially symmetric or **dorsiventral** with leaves or fronds produced on the dorsal or upper side and roots produced on ventral or lower side.

Branching

Overall, the rhizome or caudex may be unbranched (most compact rhizomes are unbranched) or branched in various ways. Creeping rhizomes may be unbranched or branched irregularly. Sometimes the branching is regularly **dichotomous** (or isotomous), sometimes with alternate branches reduced to a great or lesser extent (**anisotomous**. Sometimes the fork or branching is associated with the production of a leaf or frond in the axil. The rhizomes or caudices of some species that do not usually branch (e.g. tree ferns) may sometimes be induced to branch following physical damage. The branching patterns of the stem some groups of pteridophytes are quite distinctive and may be used taxonomically.

Rhizome protection

The rhizomes of ferns are very rarely naked and usually have some form of covering, especially on their growing tips, to provide protection from the extremes of temperature, dessication, predation and physical abrasion. This covering takes the form of **epidermal hairs**, **bristles** or **scales**, or a combination of any of these. The young developing fronds also bear these appendages in many cases and sometimes they are persistent on fully expanded leaves. Some rhizomes that do not produce epidermal appendages for protection achieve the same result by secreting a **mucilaginous slime** that engulfs the growing tip and the developing leaves (e.g. *Plagiogyria*). Sometimes the surface of the rhizome is **glaucous** with a bluish grey waxy sheen and sometimes with a dense white waxy covering; this often useful diagnostic character may be lost with collecting and preservation techniques involving excessive heat or solvents such as ethanol.

Hairs. Hairs may consist of a single cell (**unicellular hairs**) or single row of cells (**multiseptate** or **multicellular hairs**). Rhizome hairs are generally not glandular but those of *Monachosorum* and some other species are capable of secreting a mucilaginous slime. Hairs may be variously forked or branched but those on rhizomes generally are not. The length, density, colour, thickness and appearance of cells and the crosswalls are useful taxonomic characters. Some thick hairs can be quite stiff and bristle-like but are only composed of a single row of cells.

Bristles. Bristles are epidermal appendages resembling stiff, more or less rigid hairs. They are approximately circular in section and several to many cells thick at least at the base. Bristles may be mixed with hairs and grade into them. They are distinct from **spines** which are projection of the stem tissue and not epidermal structures.

Scales. Scales are flat plates of epidermal tissue one cell thick and several to many cells wide. Although microscopic, the details of orientation, shape, colour of the cells, and any hair-like or glandular appendages are often very important taxonomically. Mostly they are attached along their basal edge; those that are attached at their centre or at some point on the fact surface are described as **peltate**. In some families(*Cyatheaceae, Grammitidaceae*) the scales of some species are **setiferous** with short often discolourous hairs along their margins. Also in *Cyatheaceae*, the marginal cells of the scales of some species are of quite different structure, orientation and colour to the body of the scale and are described as **flabellate** or **marginate**. The scales of certain families (e.g. *Vittariaceae*, *Aspleniaceae*, some *Polypodiaceae*, *Loxogramme*, *Rheopteris*) are **clathrate** and have very dark and thickened cross walls and thin more or less transparent upper and lower walls; this is a very useful character.

Internal structure

Internal structure. The internal structure of the rhizome can provide useful diagnostic characters especially from the arrangement of the **vascular bundles**, **leaf traces** and the associated **sclerified supporting tissue** if any. Compact caudices are nearly always **radial**, so that the leaves and corresponding vascular tissure is evenly distributed around the stem. Elongate rhizomes may also be radial but are commonly **dorsiventral**, where the leaves and their traces are found on the upper surface, often in two rows, sometimes in three of more, and the roots on the lower surface.

The structure of the vascular tissue or **stele** has been used to separate certain groups of pteridophytes. The simplest form is the **protostele**, a solid vascular strand with internal xylem and an external strand of phloem; sometimes the central core of the protostele is composed of non-vascular parenchyma cells and this is termed a **medullated protostele** or equivalently an **ectophloic siphonostele**. A **siphonostele** is any uninterrupted stele with an undifferentiated centre and one with internal as well as external phloem is known as a **amphiphloic siphonostele** or a **solenostele**; this type of stele is most common in those ferns with long-creeping rhizomes and is usually dorsiventral. **Leaf-gaps** occur in such steles, usually above where the leaf traces diverge; the internal and external parenchyma are continuous through these gaps. Where the leaves are closely spaced, the leaf-gaps are so close that the vascular cylinder appears like a net-work and is called a **dictyostele**, each individual strand being called a **meristele**. This is a very common type of stem vasculature. In some families (e.g. *Davalliaceae*) the gaps in the network are not necessarily associated with leaf-gaps; such a stele has been described as a **dissected solenostele** (Holttum 1959). More complex stelar structure occur in some families (e.g. Matoniaceae) where there are several concentric series of steles. In some genera such as *Stenochlaena* there are additional vascular bundles outside the main system. In the climbing genera of the *Lomariopsidaceae* the leaf bases with their numerous vascular strands are decurrent along the rhizome for a considerable length and the resulting pattern of meristeles and leaf-traces can be very confusing. Where the stele is made up of a number of flat strands more or less parallel to each other it is known as a **plectostele**.

Internal Supporting structures. This often takes the form of dark, hard and durable, sclerified material variously distributed through the stem. In many cases the stem in encased in sclerified tissue and sometimes the entire caudex may become sclerified. Often the vascular bundles (stele, meristeles, leaf-traces) are encased in sclerified material and they are referred to as **fibrovascular bundles**. Sometimes separate dark fibrous strands are present inside and/or outside the stele. In **Cystodium** the caudex has a large, solid sclerified core. Many groups (e.g. *Ophioglossaceae, Marattiaceae*, some *Vittariaceae*) have little, if any, sclerified material and rely on tissue turgor to support the plant.

Roots

Roots. Pteridophyte roots are not produced as the downward proliferation of the stem but are mostly produced laterally, sometimes scattered along the length of the stem, and are thus **adventitious**. In some genera (e.g. *Ceratopteris*) the roots are also produced on the leaf bases. Sometimes these roots are simple, but mostly they are branched, sometimes dichotomously , mostly irregularly. In arborescent genera (*Cyathea*, *Dicksonia* etc.) the roots sometimes form a thick tangled mat that engulfs the lower trunk, becoming heavily sclerified and providing a considerable amount of physical support. Many epiphytic pteridophytes (*Lycopodiaceae*, *Vittariaceae*, many *Aspleniaceae*, *Polypodiaceae* etc.) produce a large dense mat of roots with many fine hairs that serves to trap and retain moisture and nutrients. Some reduced species of the *Hymenophyllaceae* seem to have forsaken roots for a covering of fine hairs that function as root hairs.

The root structures of *Selaginella*, known as **rhizophores** are borne along the stem, the upper ones often getting progressively longer and forming a series of supporting stilts; they branch dichotomously on contact with the ground and do not bear root hairs and there is some doubt whether they are true roots or

specialized appendages of the stem.

Stolons. The stems of some species (e.g. *Nephrolepis*, some *Blechnaceae*) produce wide ranging runners or stolons that are capable of rooting and producing new plants at regular intervals. These are of stem origin and quite different to the proliferating fronds of other species (see under Bulbils below). The stems of some species of *Selaginella* produce runners from near their bases that ascend and root, becoming new plants.

Leaves, fronds

The leaves of typical and true ferns are usually called **fronds**; those offern allies referred to as leaves. Although whole volumes of fern descriptions make no mention of "leaves", fern fronds are truly homologous with the leaves of flowering plants, being expanded vascular photosynthetic organs produced by the stem; the use of the term "leaves" or "fronds" is largely a matter of personal preference and in this work, 'frond' is used only for leaves of true ferns and not those of the fern allies.

The bewildering variety of leaf form or arrangement provide many of the most useful characters of pteridophyte taxonomy. The leaves of the **fern allies** (*Psilotaceae*, *Isoetaceae*, *Selaginellaceae*, *Lycopodiaceae*, *Equesetaceae*) are simple and undivided, not often toothed, sessile, with a single unbranched vein and are often small; they are called **microphylls**. Fern fronds are **megaphylls** and except in very reduced species, are large and complex, have many veins and are often lobed or variously divided, commonly with a distinct stalk or petiole. The microphyllous leaves of *Psilotaceae* and *Equisetaceae* are reduced to minute brown teeth and the photosynthetic function has been taken over by the green **phyllodinous stems**.

The expanded green portion of a leaf is called the **lamina**. A leaf where the lamina arises directly from the stem is described as **sessile**. The petiole or stalk of a fern frond is generally called the **stipe** (like 'leaf/frond', the use of this term in preference to stalk or petiole is a personal matter) and fronds that possess them are described as being **stipitate** or stalked.

The spore-producing organs are borne on the leaves and those that do so are called **fertile** and those without, **sterile**. The fertile fronds may be of markedly different size, shape or orientation to the sterile fronds and this is known as **dimorphism** (see later).

Phyllotaxy, Stipes and rhizome attachment. Pteridophyte leaves are nearly always **alternate**, spirally arranged or in two or more staggered rows along the stem. Often the fronds are clustered in a tuft at the end of the stem, sometimes in whorl-like clusters along the stem (some species of *Oleandra*) and in *Equisetum* the reduced leaves are in regular whorls. Leaves are generally produced ascending at an acute or obtuse angle towards the apex of the stem (whether it be vertical or pendulous) but, especially in some epiphytic ferns, they may arch and become pendulous.

The leaves may be produced one after the other in a more or less regular fashion, or a whorl leaves may develop more or less at the same time and appear to be **synchronous**. This is especially noticeable in some species of tree ferns (*Cyathea*, *Dicksonis*) and in the climbing members of *Lomariopsidaceae* (*Lomariopsis*, *Lomagramma* etc.) and the genera *Plagiogyria* and *Leptopteris*.

Stipe

Stipe bases generally bear the same type of hairs or scales that cover the stem and are similarly very important taxonomically. In groups such as the *Cyatheaceae* the structure of the stipe and caudex scales is essential for identification. These scales and/or hairs perform the same protective function as those of the rhizome. In ferns, the young fronds develop by uncurling along the main axis from the base towards the tip; this type of vernation (leaf development) is known as **circinnate vernation** and is a distinctive characteristic of ferns; the uncurling frond is known as a **fiddlehead** or **crosier**. The fern allies have straight vernation. The stipes and young fronds of some ferns secrete **mucilage** as the frond is developing, and various structures have developed to improve gas exchange while the frond is in this tightly coiled position. Elongate **areophores** extend laterally from the main axis, usually at the base of pinnae (leaflets) and these or their remnants or scars are often evident in mature fronds (*Plagiogyriaceae*, *Cyatheaceae*, some *Thelypteridaceae*). In many genera there is a raised line of pale tissue, continuous or interrupted, running the length of the stipe; this **pneumathode** is also an aerophore and involved in gas exchange. In some groups (*Angiopteris*, *Marattia*, some *Cyathea*) the aerophores may be pale depressions. Numerous **reduced pinnae** are present along the stipes of many species (some *Blechnum*, common in *Thelypteridaceae*); these serve little purpose in mature fronds but are very prominent when the frond is coiled where they are active photosynthetically and where they overlap they provide considerable support and protection for the tender crosier.

Stipes may arise fairly abruptly from the stem or it may be **decurrent** and gradually merge in. There may be an obvious mark where the stipe joins the rhizome where the frond readily falls from as it gets old; stipes with such an **articulation** are said to be **jointed** or **articulated**. Such articulations may also occur at the base of pinnae (e.g. *Nephrolepis*, *Goniophlebium*, *Drynaria*, *Aglaomorpha*). In some cases (some *Polypodiaceae*, *Elaphoglossum*, *Lomariopsis*) the stipes are articulated to specialized outgrowths from the stem called **phyllopodia**.

Stipe vasculature. The vasculature of the stipe arises from the internal vasculature of the stem. The number and arrangement of vascular strands in the stipe is a very useful and important diagnostic and taxonomic character. This can usually be seen in a crude cross section made with a sharp knife, even without staining. *Tectaria* and allied genera have many vascular strands arranged more or less in a ring, similarly *Davalliaceae* and *Lomariopsidaceae*. Two unrelated families with elongate indusiate sori, *Aspleniaceae* and *Athyriaceae* have two vascular strands in the basal part of the stipe; the former unite upwards at their middles to form an X-shaped strand, the latter at their bases to form a U-shaped strand. The complex nature of the stipe vascular of *Cystodium* recently suggested the supposed relationship with *Dicksonia* was not as close as previously thought.

Branching

Fern fronds are either **simple** or **compound** and composed of several to many leaflets which may in turn by composed of several to many leaflets, and so on until the ultimate division is a simple leaflet or lobe. A simple lamina is continuous either side of the midrib, but may be shallowly or deeply dissected or **lobed** or unlobed and **entire**.

The branching of a fern frond is nearly always in the **one plane** (exceptions include the bottle-brush fronds of some species of *Macroglena*: *Hymenophyllaceae* and the horizontal twisting of the secondary branches of scandent species). This is usually the same plane as the stipe (sometimes there is an abrupt bend where the stipe meets the lamina e.g. *Dipteris*, *Currania*, some *Tectaria*) and perpendicular to the plane of the stem.

A frond **axis** is the central supporting tissue about which the lamina and/or subsequent axes are arranged. The main axis consists of the stipe (if present) and

its continuation into the lamina of the frond; in simple fronds this is the **midrib** or **costa**, in compound fronds, the **rachis**.

Most commonly, the leaflets or secondary rachises are borne **alternately** (or at most **subopposite**) on either side of the main rachis. This is the **pinnate** condition and the leaflets are known as **pinnae**; the pinnae themselves may be similarly divided and the frond is described as being **bipinnate** and the pinna of each leaflet is known as a **pinnule**. Further division can result in **tripinnate** or even **quadripinnate** fronds; in each case the ultimate simple division is referred to as a **pinnule**. If the lamina is only partially incised towards the axis, the segment is described as being **pinnatifid** (the term **pinnatisect** describes very deep incisions, but this distinction is not often drawn). In a similar manner to pinnate division, it is possible to have **bipinnatifid** or **tripinnatifid** fronds. It is possible to have combinations of these forms of dissection and such structures as pinnate-bipinnatifid or bipinnate-pinnatifid etc. are common. Finely divided fronds are often described with the general term of **decompound**.

Fronds with **opposite branches** are not as common. *Dipteris* and *Matonia* could be considered to have fronds with two opposite branches. Usually this occurs when the growing tip of the frond remains dormant for a period as the pinnae develop and then resumes growth towards the next pair of pinnae. This can be seen in *Gleicheniaceae*, *Lygodium* and some *Dennstaedtiaceae* such as *Histiopteris*. In *Lygodium* and most *Gleicheniaceae*, the bud on the lateral branches remains dormant, resulting in a more or less equal (sometimes one side ma be suppressed) fork in the branching pattern. This is termed **pseudodichotomy** because of the presence of the central bud and should not be confused with the true **dichotomous** branch where the axis does not continue in a straight line but forks into two more or less equal parts. Examples of true dichotomy can be seen in **Dipteris**, some *Gleicheniaceae* and some *Schizaeaceae*. In some cases (e.g. *Matonia*) only the outer branch of each dichotomy forks again; this condition is known as **pedate**. It is easy to see how the pinnate condition can be derived from the dichotomous by the alternate suppression of the left and right forks. Fronds with a dormant terminal bud that are capable of indefinite growth are called **indeterminate**; most fronds are **determinate** and expand more or less at once to a limited size.

Those parts towards the **apex** or tip of the frond are described as being **apical**, whereas those parts towards the base are referred to as **basal**; similarly those parts directed towards the tip are described as **acroscopic** and those directed towards the base as **basiscopic**. The terms **upper** and **lower** can usually be applied without ambiguity to the surfaces of fern fronds, but in the case of pendulous or vertical fronds it is preferable to use equivalent but more precise terms **adaxial** (twoards the axis) and **abaxial** (away from the axis). The upper or adaxial surface develops facing the growing apex of the stem, the lower or abaxial surface faces away from the stem apex.

Anadromy, catadromy. In pinnately compound fronds the order in which the pinnules are produced has been found to be very important in the classification of some ferns (e.g *Lastreopsis*). If the basal acroscopic pinnule of a pinna is closer to the rachis than the basal basiscopic pinnule, the frond is called **anadromous** (Greek: up coursing). If the basal basiscopic pinnule is closer the frond is said to be **catadromous** (down coursing). Some groups exhibit both types of fronds but others consistently show one or the other type and it is here that this character is most useful.

Rachis

Axis junctions. The structure of the rachises and their unions with other axes offer very useful characters in fern taxonomy. In some genera (e.g. *Arthropteris*, *Nephrolepis*, *Stenochlaena*, and some *Dennstaedtia*, *Blechnum*, *Lomariopsidaceae* and *Polypodiaceae*) there are distinct **articulations** at the base of pinnae and axes. Swollen or elongate **aereophores** may be present at the bases of pinnae (see above). The pinna- and pinnule-bases of *Angiopteris* and *Marattia* are **swollen** and **turgid**. Axes are often **grooved** on the adaxial surface and the grooves and ridges of the different order branches may be confluent or the ridge along the main rachis may not open to admit the groove of the smaller axis, the lamina may be **decurrent** (gradually merging) along the side of the rachis or along the ridge of the rachis groove. These characters seem to be consistent within genera or groups of genera and are frequently used for identification. The axes may be **glabrous** (naked) on either surface or bearing **hairs** and/or **scales**, the structure and abundance of which are diagnostically very useful.

Lamina

Surface and texture of lamina and appendages. Pteridophyte leaves vary from thin and filmy and one cell thick (*Hymenophyllaceae*, *Leptopteris*) to many cells thick and fleshy (e.g. *Ophioglossum*, *Angiopteris*) or even stiff, coriaceous or leathery (e.g. *Selliguea*, *Pyrrosia*). **False veins**, also known as **pseudoveins** are present in some species. These are lines of tissue with the appearance of veins, usually not connected to true veins and not associated with any vascular tissure; they are diagnostically useful in *Davallia*, *Angiopteris*, *Trichomanes sens. lat.* and possibly other genera. The shape and arrangement of **stomata** and their supporting cells has proven to be very reliable in systematic studies and has been used taxonomically in some cases (e.g. *Schizaea*, *Isoetes*). The structure and orientation of the epidermal cells has been used in some cases (especially *Hymenophyllaceae* where they are so readily visible). In *Vittatiaceae* some **epidermal cells** are narrow and contain silica (**spicular idioblasts**); the phyllodinous (leaf analogue) stems of *Equisetum* also contain large crystals of silica. Either surface of the lamina may be glossy or dull, naked of with various type or hairs; if hairs are present, they are generally more abundant on the lower surface than on the upper surface. The **hairs** may be **simple**, **binate** (forked) or **branched** in a more complex manner, sometimes with **glandular tips**. **Stellate hairs** are particularly important taxonomically, consisting on numerous elongate cells radiating from a central point of attachment (e.g. *Pyrrosia*, *Platycerium*). Hairs may completely cover the lower surface of the lamina giving the frond a silky appearance beneath. The veins and constules of some species may bear **scales** beneath that are diagnostically important (e.g. *Cyathea, Elaphoglossum*). Like the rhizome scales they may be **concolorous** or **clathrate**; pale, deeply concave and blistered-looking scales are called **bullate**, those bearing hairs, **ciliate**, those with **setae** (stiff marginal bristle-like scales), **setiferous** or **setose**, and those with divergent free cells along the margin, **fimbriate**.

Glaucescence. A pale bluish grey waxy covering may be present on the lower surface of some species ans ins described as **glaucous** (e.g. *Dipeteris*). Other species may have a thick white waxy covering or **farina** and are called **farinose** (e.g. *Pityrogramme*, some species of *Cheilanthes*). Glaucescence and farina are immediately obvious on live plants but the was may have melted in specimens dried with too much heat, or dissolved in specimens field-preserved in ethanol before drying, and may not be visible in herbarium material.

Venation

The vascular traces of the stipe and axes eventually end up in the venation of the lamina and the manner and pattern in which this is achieved is particularly important in fern classification. **Veins** are the ultimate vascular strands (and their supporting structure) running through the leaf, and are for the most part clearly visible on either surface of the lamina, being raised or impressed with cells of different colour, shape and orientation the rest of the lamina.

Veins with no branches or unions are called **simple**. Veins that do not reunite with other veins are called **free** and free veins may be **simple** or **forked** one of

more times oftn in a more or less **dichotomous** manner. These veins may terminate at the margin or short of it, often in lobes or teeth, sometimes in the sinus between the lobes, or the margin may be entire. In many cases, the veins (forked or simple) are pinnately arranged around a main vein or **costule**, usually with a single costule in each lobe of the ultimate segment; the costules are in turn pinnately arranged about the midrib or costa of the leaflet. This is the common pattern in many *Athyriaceae*, *Cyatheaceae*, *Thelypteridaceae*. It is also common for the veins of adjacent groups to **anastomose** or reunite, sometimes forming another **excurrent vein** (= outward running) between the costules; this pattern is common in *Thelypteridaceae*. The area of lamina enclosed by veins is called an **areole** and a venation pattern involving few free veins is termed **areolate**. Anastomosing patterns are not restricted to between adjacent costules and may occur between adjacent veins forming a single series of areoles along the cost or costule (e.g. *Stenochlaena*, *Pleocnemia*, some *Pteris*) or at vein extremities to form a continuous **intramarginal vein** (e.g. "bird's nest" *Asplenium*, *Vittaria*, some *Hymenophyllaceae*) or even a marginal series of areoles (*Coniogramme*, some *Syngramma*). In some species there are no obvious costules, the veins forming a more or less even network or **reticulum** (e.g. *Acrostichum*); this form of areolate venation is often described as **reticulate**. In some species of *Ophioglossum* and *Antrophyum* there is no costa and the entire frond is reticulate. Sometimes the areoles themselves contain free veins that may be simple or forked; the number, position and orientation of the **included veins** (or veinlets) is often diagnostically important.

Supplimentary veins. In fertile fronds additional vascular networks or **commissures** may be present to serve the sporangia and soral tissue and may overlay or replace the venation of sterile fronds.

Hydathodes. The ends of veins some that terminate short of the margin may be swollen and are often involved in water and salt secretion. In some species (some *Grammitis*, *Selliguea*, *Pyrrosia*, *Coniogramme*) the secreted water evaporates leaving a persistent deposit of white salts visible in rows on the upper surface of the lamina. The presence of these deposits is a taxonomically useful character.

False veins. Also known as **pseudoveins**, these are strands of structural tissue running through the frond, often with the superficial appearance of true veins. However they are not involved with the translocation of water or nutrients and they are not connected to or continuous with the vascular network. They are sometimes hyaline or translucent, running between and parallel to the true veins, or outside the veins and parallel to the leaf margin. The presence and disposition of false veins is constant within a species and forms a useful taxonomic character.

Polymorphism

Frond dimorphism. In addition to differences that may exist between sterile and fertile leaves, juvenile leaves are sometimes different to the adult leaves. The first fronds produced by pinnately divided species are often simple and differences in the shape of this juvenile foliage is sometimes diagnostic (e.g. *Acrostichum*). A particular case involves the high climbing epiphytes of the *Lomariopsidaceae*; the lower juvenile fronds near the ground (**bathyphylls**) are often finely divided and of quite different appearance to the adult fronds high on the trunk (**acrophylls**). In some bipinnate species some juvenile at the pinnate stage may be fertile and bear sporangia; examples of this **precocious fertility** are known in *Cyathea* and *Lindsaea*.

Bulbils

Bulbils. Bulbils are **vegetative buds** usually towards the apex of the frond (some species of *Asplenium*, *Bolbitis*, *Diplazium*, *Ceratopteris*) but sometimes along the rachis (*Ampelopteris*) or at the base of pinnae (some *Diplazium*). These may remain dormant and die with the frond, but under suitable conditions they are capable of producing roots and juvenile fronds and eventually developing into a new plant. By repeated propagation in this manner clonal populations may be produced in much the same manner as stolons. The presence of bulbils, whether dormant or active, is important taxonomically.

Sporpohyte fertility

Fertile Leaves. The leaves that bear the sporangia are termed **fertile** as opposed to **sterile** for those without sporangia. In the fern allies sporangia bearing leaves are called **sporophylls**. Fertile leaves or fronds may or may not be different to the sterile. The sporangia of the fern allies are generally borne on the acroscopic or upper side of the sporophylls, at the base near the axil of the leaf. In true ferns they are generally produced in various ways on the abaxial or lower side of the leaf, remote from the base.

Sori

Sori. In the *Osmundaceae* the sporangia are more or less scattered along veins on the lower surface of the lamina, but the situation in the remainder of the ferns is for the sporangia to be aggregated in various ways into a **sorus** attached to a common **receptacle** which supplies nutrients from the veins. All sori and sporangia are associated with veins. The structure and distribution of these sori is very important diagnostically. Developing sori are protected in various ways such as thin, dry outgrowths of the lamina called **indusia** or by a reflexed fold of the lamina margin (a **false-** or **pseudo-indusium**). Sori with an indusium are called **indusiate**, those without are **exindusiate**. Sori may also be protected by **paraphyses**: simple, branched or stellate, glandular or eglandular hairs or scales mixed with the sporangia, the possible origin of which may be aborted sporangia or included hairs. The structure of the sorus and indusium, if present, is extremely diverse and very important taxonomically.

Commonly, sori are small and more or less circular. Their receptacles may be at the end of a free vein, at the margin or remote from it, or at the junctions of veins, or on the back of a vein, or on a free vein within an areole. The indusium, if present, can be **circular, reniform** (kidney-shaped), **peltate** or attached at the base, pocket-shaped (attached at the base and sides), **cyathiform** (cup-shaped) or variations of these (e.g. **hemitelioid** or half-cup-shaped). Sometimes a submarginal sorus may be protected by both a cupped inner indusium and a cupped reflexed lobe of the lamina (e.g. *Dicksoniaceae*) or the inner and outer parts may be more or less united into a tube or cup (*Hymenophyllaceae*, *Dennstaedtia*).

Sori may be **elongate** along free (e.g. *Asplenium*, *Diplazium* or anastomosing veins (e.g. *Taeintis*), or intramarginal veins (e.g. *Vittaria*), or elongate submarginal sori may link several free veins that would otherwise terminate at the margin (see coenosori below). The indusia of such elongate sori usually open acroscopically if along veins divergent from the costa (downward facing linear indusia are known in *Diplora* and some *Athyriaceae*) and outwardly if submarginal or parallel to the costa. Marginal linear sori may be sunk in a groove of the lamina (e.g. *Vittaria*, *Scleroglossum*), protected by an inner indusium only (e.g. *Lindsaea*), protected by an inner indusium and outer pseudo-indusium (e.g. *Pteridium*), or protected only by an outer pseudoindusium (e.g. *Pteris*).

Coenosori and acrostichoid sporangia. Sori that link veins that are normally free in the sterile condition or result from the spread of one sorus into another distorting the normal venation pattern are known as **coenosori** (or **fusion-sori**). They are often supplied by a supplimentary vascular system overlaying the

usual veins of the sterile fronds. *Lindsaea*, *Pteridium* and Pteris are examples already mentioned; in *Blechnum* and *Stenochlaena* the coenosorus runs adjacent to the costa, and the remaining lamina is often very much reduced. The extreme case of the coalescing of sori is the **acrostichoid condition** (from the genus *Acrostichum*). Sporangia spread along all of veins of the lower surface of the fertile frond (or fertile region) and even between the veins; this fertile area may be slightly or greatly contracted when compared with the sterile. Examples of acrostichoid sori are common in the *Polypodiaceae*, *Blechnaceae* and to a lesser extent, *Hypoderriaceae*; all *Plagiogyriaceae* and most of the *Lomariopsidaceae* are acrostichoid.

Sporangia

Sporangia. The sporangia are the bodies in which the spores are produced. They are generally small and superficial but may be large and immersed in the sporophyll (*Isoetes*). The mostly minute spores are shed when the sporangium **dehisces** or splits although sometimes the spores are released by decay of the sporangial wall (*Isoetes*). In most cases the sporangia burst under dry conditions and dispersal is by wind.

The ferns are divided into two main groups on the basis of their basic sporangia type. Those with thick walled (several cell layers thick) sporangia that develop from several cells are known as **eusporangiate** and are considered to be more primative. The bulk of the ferns have thin-walled sporangia developed from a single cell and are termed **leptosporangiate**; these are the advanced ferns.

In the *Psilotaceae*, perhaps the most primative group of pteridophytes, the sporangia are large and united into twos or threes (**synangia**) each splitting when mature.

In the *Ophiglossaceae*, a primative group of ferns, the sporangia are relatively large and borne on erect or pendulous fertile **spikes** or branched structures produced near the base of the fronds. This is the most aberrant method of sporangia production in the ferns. The sporangia or *Marattia, Angiopteris* and *Christensenia* (also primitive ferns) are large, sessile and thick-walled and more or less united in groups (**synangia**) on the lower surface of the lamina. The synangia or *Marattia* and *Angiopteris* are composed of two rows of sporangia along a vein; in *Christensenia* the sporangia are arranged in a circle at vein junctions. Like the *Ophioglossaceae*, these genera do not possess an annulus (see later).

The sporangia of the remainder of the true ferns are all remarkably similar. They are thin-walled and dehiscence is caused by a region of cells with thick inner walls and thin outer walls, usually in a ring, called the **annulus**. The dehiscence occurs in a specialized region called the **stomium**. In *Osmundaceae* the annulus is a region of cells to the side of the sporangium; in *Schizaeaceae* it is a tight ring of cells at one end of the sporangium; in *Gleicheniaceae*, *Hymenophyllaceae*, *Cyatheaceae*, *Plagiogyriaceae* it is **oblique** and a **complete** ring; in the remainder of families it is more or less **vertical** over the top of the sporangium and **interrupted** by the stalk or **pedical**.

The microscopic structure of the sporangia yields many useful taxonomic characters. There may be **hairs**, which may be **glandular** or **eglandular**, on the pedicel or on the body of the sporangium near the annulus. There may also be **sessile glands** or stiff **setae**. Such characters have been used extensively in the *Thelypteridaceae* and also in the *Grammitidaceae* and may be useful in other families as well.

Spores

There are two basic types of spores in the pteridophytes: **monolete** (or **bilateral**) and **trilete** (or **tetrahedral**). Spores are always produced in **tetrads** (groups of four) and the spore shape results from the two possible cleavage patterns of the initial cell. If the second cleavages are in the same plane the result is a bilateral spore with a monolete spore; each spore as it develops has two neighbours, the two contact faces meet in a single ridge of scar and the free spore is more or less bean-shaped. If the second cleavages are in planes perpendicular to each other, the result is a tetrahedral spore with a trilete scar; each spore as it develops has three neighbours, the three contract faces meet at a three-armed ridge or scar, the four spores are positioned at the four corners of a tetrahedron and the resulting spore is more or less globular or tetrahedral with a rounded base. Generally, all genera have one or the other type of spore, but a few (e.g. *Loxogramme*, *Dicranopteris*) have both types, sometimes in the same species.

During development, the spores are nourished by an inner layer of the sporangial wall (the **tapetum**). In some species, a residue of this tapetal material may be deposited around the spore and is known as a **perispore**. The perisore is usually folded into ridges, wings or spines and its presence and structure are very important characters. Species that lack a perispore often have intricate ornamentation of the spore wall in the form of tubercules, depressions, ridges, valleys, warts etc. The morphology of the spore wall and perispore has been widely used in many groups and indeed in some genera (e.g. *Isoetes*) it is often the only reliable taxonomic character. Much of the spore detail can be seen with appropriate light microscopy techniques, but the use of **scanning electron microscopes** (**SEMs**) reveals much more detail and shows the previously know structure more clearly.

Photosysthetic spores. The spores of *Equisetum* and *Grammitidaceae* are dark green when alive and are capable of photosynthesis. This presumably confers some survival advantage on the germinating prothallus. In addition to photosynthetic pigments, *Equisetum* spores are provided with special coiled structures called **elaters** that extend and contract with changes in humidity, aiding dispersal.

Heterospory

Heterosporous pteridophytes are those that produce spores of markendly different sizes (e.g. *Selaginellaceae*, *Isoetaceae*, *Marsiliaceae*, *Azollaceae*, *Salviniaceae*). They produce both large**megaspores** and minute **microspores** in much the same manner as the **homosporous pteridopytes**, the main difference being the greatly increased size of the megaspores. (See under Gametopyte above.)

In *Platyzoma*, spores are produced in two distinct. but not vastly diferent, sizes and are described as **anisosporus**. This condition is known as **anisospory**.

Dimorphism

Sterile/fertile dimorphism. The sporophylls of some *Selaginellaceae* and *Lycopodiaceae* are contracted and much smaller than the foliage leaves and may be aggregated into a tight or lax radial **cone** or **strobilus**. The sporophylls of *Equisetum*, usually called **sporangiophores**, are also aggregated into tight strobili; the sporangiophores are peltate structures bearing sporangia on the lower surface.

In the true ferns, fertile fronds may be of different size, shape and orientation to the sterile, the difference being slight or very marked. Commonly, in species with dimorphic fronds, the **fertile frond** is held **more erect**, has **a longer stipe**, is **narrower** and often **elongate** compared with the sterile; this is widespread in many families. In the extreme case the fertile pinnae can be so contracted that there is hardly any green lamina visible beneath the sporangia (e.g

Lomariopsidaceae, *Stenochlaena*, some *Blechnaceae*, *Stenosemia*, *Plagiogyria*, *Leptochilus*). When the difference between fertile and sterile regions occur within the same frond (e.g. *Aglaomorpha*, *Belvisia*) the frond is sometimes called **internally dimorphic**; more often the whole frond is modified and thus **externally dimorphic.**

Sporocarps

A special case of spore production is involved in the aquatic heterosporuos families *Azollaceae*, *Salviniaceae* and *Marsiliaceae* (the last family is quite unrelated to the former two which are considerd closely related to each other and are in fact combined by many authors). In these families, the **megaspores** and **microspores** are produced in separate **megasporangia** and **microsporangia** which are produced in enclosed bodies called **sporocarps**. The stems of *Marsiliaceae* root in the mud and the sporocarps are borne near the base of the long-stalked leaves; the capsular fruit-like sporocarps are often called **conceptacles**. *Azolla* and *Salvinia* are floating herbs with short-stalked leaves below which the sporocarps are produced.

Cytology

[To be prepared]

Chromosome numbers

[To be prepared]

Polyploidy

[To be prepared]

Updated November 1999 by Jim Croft (jim.croft@environment.gov.au)

Annex 917

J. C. Dagar, et al., "Agroforestry rejuvenates saline soils using saline irrigation", *Asia-Pacific Agroforestry Newsletter*, No. 26 (July 2005), a*vailable at* http://www.fao.org/docrep/008/af338e/af338e04.htm#bm04

Agroforestry rejuvenates saline soils using saline irrigation

J.C. Dagar (jcdagar@cssri.ren.nic.in), O. S. Tomar and P. S. Minhas

There seems to be little hope for bringing fertile arable lands under forestry, particularly in developing countries where food production for the ever-increasing population is a primary concern. Yet, afforestation is not only a necessity for reducing pressure on natural forests, but also a most desired land use, especially for reclaiming and rehabilitating degraded lands, and particularly saline soils.

According to the Food and Agriculture Organization (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), the world has 397 million ha of saline soils and 434 million ha of sodic soils. About 12.6 million ha are considered to be under acid-sulphate soils distributed along coastal regions. Of the current 230 million ha of irrigated land, 45 million ha are salt-affected. Of the almost 1 500 million ha of dry land agriculture, 32 million ha are salt-affected in varying degrees by human-induced processes.

Be that as it may, it is possible to increase wasteland productivity in terms of food, fuelwood, forage, medicinal drugs and biodiversity if it is planted with trees. In particular, salt-affected wastelands hold promise for agroforestry. However, without adequate fresh water for irrigation, the dry areas are not arable enough for forest and horticultural crops. But there is plenty of water beneath many of the world's deserts with saline water reserves.

Studies conducted at the Central Soil Salinity Research Institute (CSSRI) in Karnal, India, showed that salt-affected soils and saline waters can be satisfactorily utilized in raising some forest and fruit tree species, forage grasses, conventional and nonconventional crops, oil-yielding crops, aromatic and medicinal plants of high economic value, petro-crops and flower-yielding plants using appropriate techniques.

Salt-affected soils and saline waters

At least five groups of salt-affected soils are influenced by different chemical types of electrolytes, which not only represent different salts, but also have different effects on soil formation. For practical use, salt-affected lands in the Indian subcontinent are identified as saline, alkali/sodic and saline-alkali. CSSRI groups salt-affected soils as either saline or alkaline.

Planting methods and techniques for saline lands

Alkali soil is characterized by a *kankar*, a hard pan of calcium carbonate forming a layer, which hinders root development. It can be broken up by a tractor-mounted auger pit which digs holes, 15-20 cm in diameter, through the hard *kankar* layer up to 150-180 cm deep (Fig. 1). These holes are refilled with original soil, 3-5 kg of gypsum (50 percent of the gypsum required for reclamation), 8 kg of farm yard manure, 10 g of zinc sulfate and a small quantity of aldrin to prevent termites. Sodic-tolerant tree saplings, 6-9 months old, are planted in the refilled pit-auger holes, and then irrigated two to three times. This method enables the plant roots to grow at a faster rate toward deeper soil layers where sufficient moisture and nutrients are available.

Many forest and fruit tree species can be raised on highly alkaline soil (pH > 10), but some of them, such as pomegranate (*Punica granatum*), are unable to tolerate water stagnation. To solve this problem during the monsoon, the raised and sunken-bed technique was found

to be quite suitable for agroforestry. The tree species can be successfully grown on raised bunds, and rice-wheat and berseem (*Trifolium alexandrium*)-kallar grass (*Leptochloa fusca*) can be grown in rotation on the sunken bed.

Table 1. Relative tolerance of tree species to soil sodicity.

Average soil pH	Fuelwood/fodder/timber species	Fruit tree species
> 9.8	*Prosopis juliflora, Acacia nilotica,Tamarix articulata*	Not recommended
9.1-9.8	*Pithecellobium dulce, Casuarinaequisetifolia, Salvadora oleoides, Salvadora persica, Capparis deciduas, Terminalia arjuna, Cordia rothii, Albizzia lebbeck, Pongamia pinnata, Eucalyptus tereticornis, Sesbania sesban, Parkinsonia aculeata*	*Carissa carandus, Psidium guajava, Aegle marmelos, Zizyphus mauritiana, Emblica officinalis, Punica granatum, Achrus japota Syzygium cuminii, Tamarindus indica*
8.2-9.0	*Butea monosperma, Kijellea pinnata, Grevillea robusta, Azadirachta indica, Melia azedirach, Acacia leucocephala*	*Grewia asiatica, Prunus persica, Sapindus laurifolius, Litchi chinensis*

Fig. 1. Auger-hole technique for planting trees in alkali soil.

Planting on saline lands and raising trees with saline irrigation

For the afforestation of saline waterlogged soils, the subsurface planting and furrow irrigation method (SPFIM) was found to be the most appropriate. It improved tree survival and growth. Six-month-old tree saplings were planted in the auger holes in furrows during the rainy season. The V-shaped furrows (20-cm-deep and 60-cm-wide at the top) were made using a tractor-driven furrow maker. Saplings were irrigated with saline water during the early establishment stage. Besides reducing the water application costs, the furrows helped in creating a favorable zone of low salinity through the downward and lateral water fluxes, making salts move away from the root zone, especially when low-saline water was used.

Suitable tree species

Results of long-term field experiments showed that tree species such as *Acacia nilotica, Prosopis juliflora* and *Tamarix articulata* were the ideal species for highly alkaline soil (pH >10). Relative performances of the forest and fruit tree species at different pH are shown in Table 1. The biomass of seven-year-old plantations of *T. articulata, Acacia nilotica* and *Prosopis juliflora* were 97.3 t/ha, 69.8 t/ha and 51.3 t/ha, respectively. Among the fruit tree species, *Zizyphus mauritiana, Syzygium cuminii, Psidium guajava, Emblica officinalis* and *Carissa carandus* grew well in these soils.

For saline waterlogged lands, 40 tree species of arid and semi-arid areas were evaluated. Based on periodical observations of survival, height, girth and biomass, woody species such as *Acacia farnesiana*, *Parkinsonia aculeata* and *Prosopis juliflora* were rated the most tolerant of waterlogged salinity and could be grown satisfactorily on soils with salinity levels

of up to 50 dS/m in their root transmission zone. Tree species like *Acacia nilotica*, *Acacia tortilis*, *Casuarina glauca*, *Casuarina obesa* and *Casuarina equisetifolia* could grow on sites with ECs varying from 10-25 dS/m.

The experiments concluded that the waterlogged saline conditions affected the survival and growth of trees used for afforestation because salt accumulation near the rooting zone was directly attributed to ground water fluctuations and the saline underground water.

Table 2. Tolerant species for saline soils.

Range of tolerance	Tree species
Highly tolerant (EC 25-35 dS/m)	**For inland saline soils** *Prosopis juliflora, Salvadora persica, S.oleoides, Tamarix articulata, Tamarix troupii, Tamarix ericoides, Acacia farnesiana, Parkinsonia aculeate, Salsola baryosma, Atriplex* spp.*, Suaeda* spp.*, Kochia indica* **For coastal regions** Mangrove species (*Avicennia, Rhizophora, Ceriops, Aegiceras, Cynometra, Excoecaria, Heritiera, Lumnitzera, Nypa, Phoenix, Scyphiphora, Sonneratia, Xylocarpus), Barringtonia asiatica, Cordia subcordata Clerodendruminerme, Dolichandrone spathacea, Hernandia peltata, Hibiscus tiliaceous, Pandanus* spp.*, Pongamia pinnata, Terminalia catappa, Thespesia populnea, Ochrosia oppositipholia, Scaevola taccada, Cerbera manghas, Calophyllum inophyllum, Ficus retusa, Syzygium samarangense, Manilkara littoralis, Arthrocnemum indicum, Salicornia brachiata*
Tolerant (EC 15-25 dS/m)	*Casuarina equisetifolia, Casuarina glauca, Casuarina obesa, Acacia nilotica, Acacia tortilis, Callistemon lanceoleta, Eucalyptus camaldulensis, Albizzia lebbeck, Pongamia pinnata, Crescentia alata, Capparis deciduas*
Moderately tolerant (EC 10-15 dS/m)	*Casuarina cunninghamia, Eucalyptus tereticornis, Acaciacatechu, Acacia eburnean, Terminalia arjuna, Samaneasaman, Albizzia procera, Borassus flabellifera, Prosopiscineraria, Azadirachta indica, Dendrocalamus strictus, Buteamonosperma, Feronia limonia, Leucaena leucocephala, Tamarindus indica, Guazuma ulmifolia, Ailanthus excelsa, Dichrostachys cinerea, Balanites roxburghii, Maytenus emerginatus, Dalbergia sissoo, Carissa carandus, Melia azedirach, Acacia leucocephala*

As the most suitable species for saline waterlogged soils, *Prosopis juliflora* and *Casuarina glauca*, when planted with subsurface or furrow techniques, had the highest biomass, followed by *Acacia nilotica* and *Acacia tortilis* (Table 2). More than 30 species were evaluated in low rainfall areas (annual rainfall about 350 mm) growing in furrows and irrigated with saline water of EC 8-10 dS/m. For three years, the trees were irrigated four to six times. The results showed that various species could be raised on degraded sandy calcareous soil in arid and semi-arid regions.

Fig. 2. Tree species established with saline irrigation.

Ameliorative effect of plantation

The established trees improved the physical, chemical and biological properties of salt-affected soils. The roots of salt-tolerant trees penetrated into the soil and improved permeability, which facilitated salt leaching. Through absorption, the trees were able to exclude salts. However, it was observed that tree plantations could only ameliorate salt-affected soils depending on the soil type. In alkali soils, the ameliorative effects of 20-year-old plantations appeared in the order of *Prosopis juliflora* > *Acacia nilotica* > *Terminalia arjuna* > *Albizzia lebbeck* > *Eucalyptus tereticornis*. The results from seven-year-old plantations also indicated that the maximum reduction in ESP and pH was observed under *Tamarix articulate*, followed by *Prosopis juliflora* and *Acacia nilotica*. When raised with saline irrigation, *Tamarix articulata* had a 0.23% increase in organic carbon in its soil surface layer; *Prosopis juliflora*, 0.26%; and *A. nilotica*, 0.10%.

A major benefit that was noticed was that tree plantations lowered the water table in saline waterlogged areas. Based on the seven-year study, it was found that the water table became deeper, an average of 5 cm under the tree canopy, than that in barren lands. Surface-level salts were considerably reduced in soils under tree canopies compared with bare fallow lands. When the trees were raised with saline irrigation, the soil was enriched with organic carbon (>0.4%) in the upper 30 cm and there was no salinity buildup in the profile.

These results showed that the salt-affected soils and poor-quality saline waters could be judiciously utilized for tree plantations. *(The authors work at the Central Soil Salinity Research Institute, Karnal, India.)*

Annex 918

F. Göltenboth, et al., eds., Ecology of Insular Southeast Asia: The Indonesian Archipelago (2006)

Ecology of Insular Southeast Asia

THE INDONESIAN ARCHIPELAGO

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species only occupying narrow areas (Tsuchy and Lirwitayapasit, 1986). In most of the Indonesian islands, distinct zones within the eulittoral and infralittoral could be identified which show a typical distribution of tidal organisms.

It is possible and important to distinguish the three major types of shorelines:

- Rocky shorelines.
- Sandy shorelines of volcanic or other terrestrial origin.
- Sandy shorelines exclusively built from the biogenetic materials of reefs, the so-called coral cays.

The vast majority of the 17,508 islands of the Indonesian archipelago are most likely coral cays or low islands (Tomascik et al., 1997). Among the best known examples of this kind of islands with splendid white shores are the about 120 islands of Kepulauan Seribu Thousand Islands off the Jakarta Bay in the Java Sea. Coral cay sediments are biogenic, originating mainly from the skeletal material of numerous calcifying plants and animals which built and live in the reef. During the early stages of development, most sand cays are rather unstable systems. Once sand cays reach a certain mass, the movements become much less pronounced. Stabilization is greatly enhanced by the colonization of plants whose seeds arrrive by atmospheric transport, water currents or on floatsam, or carried by birds.

In addition to the reef sediments, some cays located close to the mainland of large islands (e.g. Java) or active volcanoes (e.g. Banda Neira in the Moluccas) may have non-carbonate sediments incorporated into the cays (Tomascik et al., 1997).

The sandy shorelines of the majority of the larger islands are mostly of pure terrestrial origin with often volcanic or jurassic sediments and sands or a mixture of carbonic and non-carbonic sediments.

Rocky shores occur along the coastlines of many Indonesian islands:

- The west coast of Sumatra is lined by rocky beaches.
- Most of the Lesser Sunda Islands and the Moluccas consist of volcanic or limestone shorelines with little or no beach formation.

ECOSYSTEM FUNCTIONS

Shorelines absorb the energy of wave action and hence, prevent erosion in coastal areas.

Depending on tidal regime, tidal zones can be sinks or sources of nutrients. Like mangroves, they can hold among the most productive soils in the tropics.

Shorelines are habitats of a specialized community of organisms, some of them being useful to man like different species of algae, sea cucumbers, and molluscs. Thousands of shorebirds coming from temperate and arctic zones of both hemispheres greatly depend on different types of shorelines as feeding grounds. Species of endangered sea turtles use sandy beaches as nesting ground. Sand bars or rocky shores are breeding grounds for an array of shorebirds.

Abiosis

The composition of communities of organisms along shorelines is strongly dependent on the type of substrate. Shoreline habitats can range from steep cliffs, over rocky, boulder and gravel shores, sandy beaches, to silty and muddy flats. The different sizes of particles do not only influence the water content of the substrate and the interstitial space between the particles, but also the stability of the surface as a whole. Mud bottoms consist of very fine particles. Space between particles is small so that these substrates usually contain only small amount of water. Silty and clayey bottoms are more stable than most other substrates. Hence, it is possible for the infauna or such animals of the sediment beaches which rarely emerge onto the surface, in contrast to

the epifauna or animals that spend at least some time on the surface, to build permanent burrows. Sandy substrates consist of mineral and calcareous components of larger size. The latter usually are of organic origin.

Sand surfaces are highly influenced by water movement and sometimes form characteristic ripple patterns. Interstitial spaces are inhabited by a unique microfauna. Like in the clayey or silty substrates, the infauna is dominant. However, permanent burrrows are rare, because of the instability of the substrate. The type of substrate strongly depends on the current regime of the respective area. Hard-bottom substrates occur in areas with strong erosive forces, soft-bottoms only can form in situations where deposition is stronger than erosion. Low waves with a long wavelength are carrying material to the shore, whereas high waves with short wavelength have erosive effects (Morton and Morton, 1983). Also wind can have a major impact in the forming of seashore landscapes. Sand dunes are a restricted feature in Indonesia. They only occur near Pangumbahan along the south coast of West Java and the north coast of Irian Jaya. The dunes form parallel to the coastline with the younger more mobile ones closer to the beach. As initial stage of the forming of a dune, drifting sand is caught on the leeward of small obstacles, like vegetation or debris. Sand is blown over the ridge off this small obstacle. Subsequently, the sand bakes together and vegetation establishes. Consequently, the older dunes in the hinterlands are less, but still are growing (Siringan and Pataray, 1996).

Shorelines are strongly influenced by the tides. The latter are caused by the rising and falling of the world's ocean's water body due to the gravitational influence of the moon and the sun upon the earth (Fig. 9.3). Two tidal protrusions of water permanently exist, one facing the moon and one on the opposite site of the globe. These bulges result in two high tides with two low tides in-between during one lunar day lasting 24 hours and 50 minutes. Together with the rotation time of the earth, a cycle of 24 hours and 21 minutes duration results. The impact of the sun on tidal forces is lower than that of the moon. However, it has a modifying influence. Spring tides occur, with considerable differences in water level during low

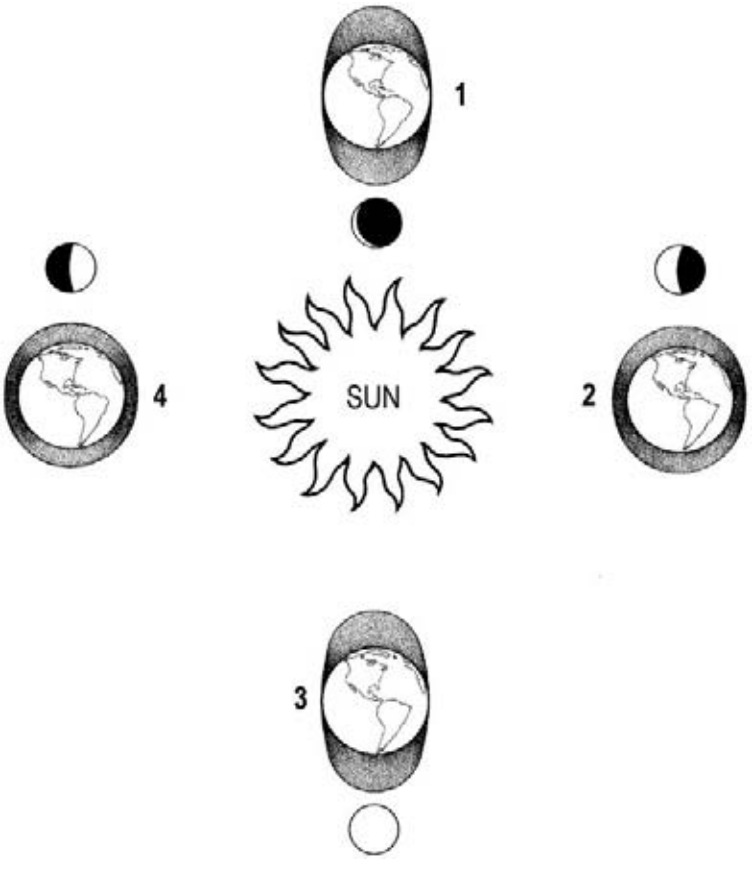

FIGURE 9.3. Forming of hypothetical tidal bulges under the influence of the moon and the sun during: 1 New moon, 2 Last quarter, 3 Full moon, 4 First quarter.

and high tide, when the moon, the earth and the sun are situated in line (during full or new moon). The sun's gravity pull diminishes that of the moon, when the position of the sun is on a right angle to that of the moon. Subsequently, neap tides, with only minor changes of water levels between the tides become prevalent. Each constellation occurs twice during a lunar month. In reality, tidal regimes follow a much more complicated pattern, since the world oceans are disrupted by land masses which influence the tidal bulges considerably. This change between marine and terrestrial conditions is the single most important factor that limits the diversity of the community of organisms in this ecosystem. Tidal cycles do not only influence the diurnal activity patterns of virtually all organisms of the tidal zones, but also sometimes function as triggers for their longer term life cycles, for example through determining time of mating or migrating.

Like most ecotones, shorelines are subjected to extremely variable abiotic factors. Especially the water bodies in tidal pools can vary considerably regarding temperature and oxygen content. When exposed to the sun, evaporation increases the salinity, while when exposed to rain, it decreases. In the zone where the surf breaks, organisms are exposed to strong physical forces. Action of waves is influenced by the speed of the wind and the distance over which the wind operates (Morton and Morton, 1983). Algae occurring in tidal zones have developed thick cuticulas to avoid desiccation and structures to stand the physical forces of wave action like strong rhizoids and flexible thalloids. Animals adapt to these factors by evolving hard shells like molluscs. Others hide in crevices or the substrate where they can endure when conditions get unfavorable like some echinoderms or annelids. These organisms are usually referred to as 'cryptofauna' (Evans, 1949). Other mobile organisms search actively for their fitting surrounding like crustaceans or some blenniid or gobiid fish, which can move over dry land for some distance.

Biodiversity

Littorial communities can be divided into two categories:

- Free living species including fish, molluscs, crabs, sea urchins, sea stars, and polychaetes.
- Sessil species including algae, barnacles, sea anemones, and corals.

Producers

Main producers in tidal zones are different forms of algae. On soft bottoms diatoms (Fam. Chrysophyceae) form a yellow to green cover during low tide which partly is removed during high tide. Those microalgae are those producers contributing most to the food chain. Some varieties of seagrasses are also able to dwell on tidal zones. On hard bottoms, the pinkish to red calcareous algae *Corallina* sp. form encrusting covers. Euryoecious macro algae like *Padina* sp. are capable of growing on hard bottoms in tidal pools.

Higher plants are able to establish on beaches.Pioneering species have different tolerance to saltwater exposure following germination, which results in a loose, but discernable zonation (Tomascik et al.,1997). On coral cay and other limestone beaches, the most tolerant species to salt water exposure is *Sporobolus fertilis* . Just above the highest inundation line, the creeping *Vigna marina* and the fast growing *Spinifex litoreus* can be found. Parts of the shoreline only affected by sea spray are frequently dominated by the grasses *Thaurea involuta* and *Lepturus repens*. A typical pioneering species is the Goat's foot vine *Ipomoea pes-caprae* that can form dense vegetation mats on sandy substrates. It does not only prevent erosion but also acts as trap for nutrients with its root system. The bright pink flowers are very conspicuous and the common name is derived from the characteristically shape of the leaves which resembles the hoof of a goat (Fig. 9.4). It is often pollinated by *Xylocopa* sp.(Hymenoptera).They produce , like many others of the beach plants, floating seeds. The

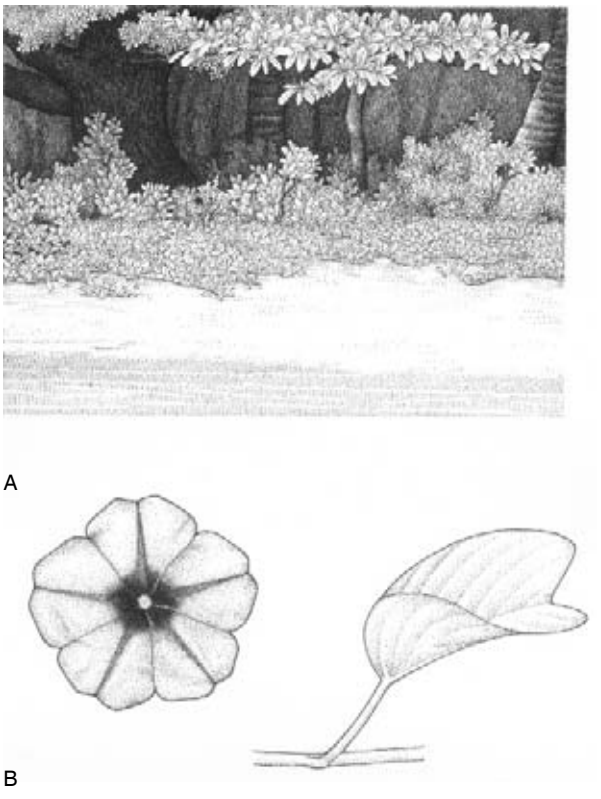

FIGURE 9.4. A) Pes-caprae formation on a sandy beach. B) Goat's foot vine *Ipomoea pes-caprae* (Fam. Convolvulaceae).

whole plant community with this habit is named after this species as Pes-caprae-formation. This formation is an open community of low, sand-binding herbs, grasses and sedges behind the drift line. Endemics are absent and many species have a pantropical distribution.

Often associated with the former species is *Canavalia maritima* (Fam. Fabaceae). Superficially the vegetative parts resemble that of the goat's foot vine with fleshy shoots that form a tangle of vegetation. Other associated plants are *Wedelia biflora* (Fam. Compositae), *Sessuvium portulacustrum* (Fam. Aizoaceae), *Euphorbia chaissonis* (Fam. Euphorbiaceae), *Vigna marina* (Fam. Fabaceae), *Triumfetta repens* (Fam.Tiliaceae), and *Vitex trifolia* (Fam. Verbenaceae). Different species of grasses and sedges can also settle on barren sand. Common are the sedge *Cyperus pedunculatum* (Fam. Cyperaceae) and the grass *Spinifex littoreus var. longifolius* (Fam. Poaceae) which further enhance the stability of the substrate. Eventually this vegetation can be replaced by woody species which may develop into beach forest. On very sandy stretches, pure stands of *Casuarina equisetifolia* can develop followed by a full *Barringtonia* community.

Consumers

The community of animals inhabiting tidal zones and beaches is dominated by the following guilds:

- Sessile or hemisessile planctivores.
- Grazing herbivores which feed on the algal turf growing on the rocks and the layer of diatoms on the soft bottoms.
- 'Grazing' carnivores which feed on benthic invertebrates.
- Detritivores which feed on the dead organic matter brought by high tide.
- Carnivores and scavengers are particularly abundant in supralittoral beaches.

The majority of animals belong to three groups concerning their feeding habit:

- They filter plankton from the seawater and are therefore filter feeders.
- They suck organic deposits and microorganisms off the sediment surface.
- They sort edible particles of sediments and are therefore deposit feeder.

In addition, beach organisms are frequently divided into three sediment-size related groups (Carter, 1988):

- Attached microfauna
- Interstitial meiofauna

Annex 919

W.A. Whistler & C. Elevitch, "*Erythrina variegate* (coral tree)", *Species Profiles for Pacific Island Agroforestry* (Apr. 2006), *available at* http://priede.bf.lu.lv/ftp/.vg_Daba/201101/Erythrinacoraltree.pdf

Species Profiles for Pacific Island Agroforestry
www.traditionaltree.org

April 2006
ver. 3.1

Erythrina variegata (coral tree)

Fabaceae (legume family)

'*atae* (Tahiti); coral tree, Indian coral tree, tiger's-claw (English); *drala* (Fiji); *gatae* (Samoa, Horne Islands, 'Uvea, Cook Islands); *gate* (Niue); *natae*, *netae* (Marquesas); *ngatae* (Tonga); *paar, weeku* (Chuuk); *paar, raar* (Yap); *parepein* (Pohnpei); *wiliwili haole* (Hawai'i)

W. Arthur Whistler and Craig R. Elevitch

IN BRIEF

Distribution Found throughout the tropics in cultivation.

Size Typically 10–15 m (33–50 ft), with a spreading crown, except for the commonly used cultivar 'Tropic Coral', which has a narrow, columnar form.

Habitat Grows best in the tropical lowlands with moderate rainfall 1000–1500 mm (40–60 in).

Vegetation Found with a wide variety of cultivated plants in farming and landscaping.

Soils Prefers sandy loams but does well in a wide range of soil textures and pH; it is a nitrogen-fixing tree so it can tolerate poor soils.

Growth rate Fast growing in favorable conditions with observed growth rates greater than 1.5 m (5 ft) per year.

Main agroforestry uses 'Tropic Coral': windbreak, living fence, trellis support. Regular form: ornamental, overstory shade.

Main products Fodder, medicinal.

Yields Primarily used for the services it provides, as commercial products are minimal.

Intercropping Interplanted as a shade tree in coffee and cacao plantations and as a trellis plant with betel nut (*Piper betel*), black pepper, vanilla, and yam (*Dioscorea* spp.).

Invasive potential Not considered an aggressive invasive, although it can naturalize along streams.

PHOTO: C. ELEVITCH

The columnar form of coral tree known as 'Tropic Coral', is often used for hedges, windbreaks, and living fence posts.

INTRODUCTION

The coral tree is cultivated throughout the tropics, particularly as an ornamental tree and as a shade and soil improvement tree (it fixes nitrogen) for other tree crops such as coffee and cacao. The large, spreading tree is tolerant of a wide range of soil textures and soil pH. It is also relatively tolerant of salty conditions, waterlogging, and seasonal drought. The most attractive type, var. *variegata*, is grown for its variegated leaves, as well as its seasonal showy red flowers. Another type that has ascending branches, cultivar 'Tropic Coral', is currently very popular as a boundary plant, living fence post, and windbreak. The tree is also often used as a shade tree planted among coffee or cacao trees (although *Erythrina subumbrans* is more commonly used for this purpose). The spiny stems can be a drawback in certain situations, and it cannot be planted too close to sidewalks, which will be lifted by its lateral root growth. In some places the tree is used for fuelwood and cattle fodder, especially when interplanted with other tree crops as a shade plant. It can easily be grown from either seed or cuttings. It has a low potential to be invasive, because the seeds are dispersed by dropping to the ground under the mother tree, but the tree can naturalize along stream courses below where it is planted.

DISTRIBUTION

Native range

Coral tree is indigenous to the Old World tropics, possibly originally from India to Malaysia, but is native or of ancient introduction westward to Zanzibar and eastward to eastern Polynesia (the Marquesas). It is typically found on sandy soil in littoral forest, and sometimes in coastal forest up to 250 m (800 ft) in elevation.

Current distribution

The tree is found throughout the tropics, in cultivation.

BOTANICAL DESCRIPTION

Preferred scientific name and author

Erythrina variegata L.

Family

Fabaceae (legume family)

Subfamily

Papilionoideae

Non-preferred scientific names

Erythrina corallodendrum var. *orientalis* L.
Erythrina indica Lam.
Erythrina orientalis (L.) Merrill
Tetradapa javanorum Osbeck

Common names

Pacific islands

'*atae* (Tahiti)
coral tree, Indian coral tree, tiger's-claw (English)
drala (Fiji)
gatae (Samoa, Horne Islands, 'Uvea, Cook Islands)
gate (Niue)
natae, *netae* (Marquesas)
ngatae (Tonga)
paar, weeku (Chuuk)
paar, raar (Yap)
parepein (Pohnpei)
wiliwili haole (Hawai'i)

Other regions

arbre au corail, *arbre immortel* (French)
dadap aykam (Java, Indonesia)
dadap blendung (Sunda, Indonesia)
galala itam (Moluccas, Indonesia)
chengkering (Malaysia)
andorogat (Bikol, Philippines)
bagbag (Ilocos, Philippines)
penglay-kathit (Burma)
rolouohs bay (Cambodia)
dok 'kho, *thong ban* (Laos)
thong lang lai, *thong phueak* (Thailand)

Size

The tree grows up to 20 m (66 ft in height) in height, but 10–15 m (33–48 ft) is more typical, with a spreading crown (except in the cultivar 'Tropic Coral'). The dense, oblong to rounded crown is low-branching with many ascending branches.

Flowers

Inflorescence of many-flowered fascicles occurs in terminal or axillary racemes up to 20 cm (8 in) or more long. Calyx is top-shaped, deeply split along one side, 1–1.8 cm (0.4–0.7 in) long, on a pedicel 2–5 mm (0.1–0.2 in) long. Corolla is papilionaceous; standard is short-clawed, ovate to subelliptic, 3–4 cm (1.2–1.6 in) long, red-orange with longitudinal white lines; wings are about half as long as the standard, greenish to pale red; keel is as long as the wings, greenish to pale red. Ovary is superior, stamens 10, diadelphous, with 9 fused together at the base, enclosed within the


Left: Coral tree inflorescence. Right: Seed pods can usually be found on trees nearly year-round. PHOTO: C. ELEVITCH

keel. Flowering is reported from July to November in the Southern Hemisphere and 6 months later in the Northern Hemisphere.

Leaves

Leaves are trifoliate, alternate; rachis is mostly 10–20 cm (4–8 in) long; blades are ovate to rhomboid, 8–18 cm (3.2–7.2 in) long; lateral ones are smaller than the terminal one, petiolules 6–13 mm long, with vegetative parts finely pubescent. They are deciduous just before and during the flowering season, except for 'Tropic Coral', which has been reported by some authors to not drop its leaves, while other sources have noted its deciduous habit. *E. variegata* retains its leaves better than other *Erythrina* species in Hawai'i. Low temperatures, powdery mildew, and/or drought combined with very windy conditions will accelerate leaf drop and retard the development of new leaves.

Fruit

Fruit a compressed, narrowly oblong pod 10–14 cm (4–5.6 in) long, sterile in the basal portion, and not constricted between the 5–10 dark brown seeds. The fruits are ripe from October to November in the Southern Hemisphere and March to April in the Northern Hemisphere, but they often remain on the tree for several months longer.

Seeds

Seeds are kidney-shaped, dark purple to red, and 1–1.5 cm (0.4–0.6 in) in length. These simply fall to the ground and may be washed away (they have been seawater-dispersed over their native range). There are 1450–5000 seeds/kg (660–2270 seeds/lb).

Similar species

The genus includes 110 species, many of which are cultivated as ornamentals. The only other related species common in the Pacific islands are *Erythrina crista-galli*, *E. fusca*, and *E. subumbrans*. Another species, *E. sandwicensis*, is endemic to Hawai'i and is uncommon in cultivation. These can be distinguished from *E. variegata* and each other as follows:

E. crista-galli—Easily distinguished from the other three by its flowering much of the year. Its leaves are leathery, dark green, and elliptic (widest toward the middle), and the flowers are rich, dark red.

E. fusca—This tree, unlike the others, occurs naturally in swampy areas. The leaves are oblong to oval in shape, like *E. crista-galli*, but the flowers are seasonal and dull purple-red.

E. subumbrans—The most distinguishable characteristic of this species is its seed pod, which is constricted at the base (the seeds are formed only in the upper part of the pod), unlike the other four species noted here, and the flowers are greenish to pale red.

E. variegata—This is the most commonly cultivated member of the genus. Its young stems and other parts are finely hairy, its leaves are mostly ovate (widest toward the base) and sometimes variegated with yellow (var. *variegata*). Its crimson to orange flowers are 5–8 cm (2–3.2 in) long, and its pod is 5–10 seeded.

E. sandwicensis—This is similar to *E. variegata* but has smaller flowers that are 3.5–4 cm (1.4–1.6 in) long and fewer seeds. one to three per pod. *E. sandwicensis* trunks and main branches have a characteristic orange hue, while *E. variegata* trunks and branches are whitish gray.

GENETICS

Variability of species

Variable because of its large range, and some varieties have been selected for propagation.

Known varieties

var. *variegata* (possibly the same as cv. 'Parcellii')—This one is easily recognized by its yellow and green variegated leaves and is favored as an ornamental throughout the Pacific.

var. *orientalis* (L.) Merr.—This is the "wild type."

var. *alba* (with white flowers)—This looks like the wild type, but has white flowers.

cv. 'Tropic Coral'—This is the cultivar used as fence posts and windbreaks because of its unique growth form (columnar, with branches all erect). 'Tropic Coral' probably originated under cultivation in New Caledonia, as a sport or mutant of the more typical open-branched form of *Erythrina variegata*. In cultivation it has spread to other tropical and warm-temperate areas, including Australia and southern Florida. This cultivar is not known to occur naturally anywhere in the wild.

Culturally important related species in the genus

The genus comprises 110 species, and many of these are cultivated for their showy flowers and/or variegated variation. Perhaps the most attractive of the species is *Erythrina variegata* var. *variegata*, with its variegated leaves. The other species of the genus most commonly cultivated are *Erythrina crista-galli* and *Erythrina fusca*.

Genetic resources where collections exist

Seed collections are stored in Costa Rica (the Centre for Tropical Agricultural Research and Training [CATIE]), and the seeds or the plants are often obtainable at local nurseries.

ASSOCIATED PLANT SPECIES

Its native habitat is littoral forest and coastal forest. In the former, it is associated with trees such as fish-poison tree (*Barringtonia asiatica*), tropical almond (*Terminalia catappa*), and many other littoral species. It also occurs inland in coastal forest, where it is mixed with numerous native lowland forest species.

Commonly associated in modern times

It is commonly associated with ornamental plants, and where it is a windbreak, often with crop plants such as vegetables, sugarcane, coffee, macadamia nuts, and many others.

Top: The variegated variety, var. *variegata*, is a favored ornamental in many parts of the Pacific. Bottom: *Erythrina crista-galli* is a popular ornamental, but is used little in agriculture. PHOTO: C. ELEVITCH

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

The tree is found in the humid tropics and subtropics and can tolerate a wide variety of climates within this zone. It does particularly well in monsoonal climates that have a wet summer and a dry winter, and it requires little water during the winter dry season, because it drops its leaves at that time. The rainfall in its natural environment ranges from 800 mm (32 in) to 1500 mm (60 in). It is usually found in the lowlands from near sea level to 250 m (800 ft), but it can be planted up to 1500 m (5000 ft) elevation.

The bark of coral tree is mostly smooth, with a small number of short thorns. PHOTO: C. ELEVITCH

Elevation range

lower: near sea level

upper: 250 m (800 ft) or more in nature, but can be grown at up to 1500 m (5000 ft) near the equator

Mean annual rainfall

lower: 800 mm (32 in), should be at least 1000 mm (40 in) for optimum growth

upper: 1500 mm (60 in) in native range, tolerates up to 3800 mm (150 in)

Rainfall pattern

In its native habitat the climate is monsoonal with a rainy summer and a dry winter of 5–6 months, but it can be cultivated in practically any rainfall pattern. The tree performs better in moderate than in heavy rainfall areas.

Dry season duration (consecutive months with <40 mm [1.6 in] rainfall)

5–6 months of dry season in its native range

Mean annual temperature

20–32°C (66–90°F)

Mean maximum temperature of hottest month

28–35°C (82–95°F)

Mean minimum temperature of coldest month

16–24°C (61–75°F)

Minimum temperature tolerated

0°C (it is intolerant of freezing)

Soils

It can be grown in a wide range of soil types. Although it prefers sandy loams, it will do well in clay and loam soils. It also is tolerant of a wide range of soil pH, ranging from 4.5 to 8.0. It can do well in nutrient-poor soil, as it fixes nitrogen.

Soil texture

Tolerates light to heavy texture soils (sands, sandy loams, loams, and sandy clay loams, sandy clays, clay loams, and clays).

Soil drainage

Grows in soils with free or impeded drainage and even tolerates seasonally waterlogged soils.

Soil acidity

pH 4.5–8.0

Special soil tolerances

It can grow in moderately saline and infertile soils.

Tolerances

Drought

It is drought tolerant, as it is native to monsoonal areas that have several months of dry season. It needs almost no water when it is leafless in the winter.

Left: Coral tree (cultivar 'Tropic Coral') and banana, both tolerant of salt spray, growing as a hedge along the coast of 'Upolu, Samoa. Right: Coral tree can be pollarded (pruned back severely to the branch in order to promote dense regrowth) on an annual basis. PHOTOS: C. ELEVITCH

Full sun

It prefers full sun.

Shade

It does not tolerate shade very well.

Fire

It is somewhat fire resistant.

Frost

It is intolerant of frost, which limits its natural distribution to the tropics.

Waterlogging

It is resistant to periodic waterlogging for up to 2 weeks, but it prefers well drained sandy loams.

Salt spray

It is moderately tolerant of salt spray, as it is a littoral tree.

Wind

It does well in windy situations and is often used as a windbreak.

Abilities

Fix nitrogen

It fixes nitrogen and thus can grow in and enrich areas of nutrient-poor soil.

Regenerate rapidly

It can regenerate rapidly, and saplings have been known to grow up to 3 m (10 ft) in height in a year.

Coppice

Coral tree responds well to pruning. Regrowth appears to be significantly faster when at least 15% of the foliage is left after cutting.

Pollard

The trees are regularly pollarded where they are used as shade trees and in landscaping.

GROWTH AND DEVELOPMENT

The tree is grown from cuttings or seed. Sapling growth is rapid, and a 1-year-old sapling can reach 3 m (10 ft) in height. Growth continues to be rapid during its young years. Trees as young as 3 or 4 years old can start flowering.

Growth rate

It typically reaches 3 m (10 ft) in height in a year, and 15–20 m (50–66 ft) in 20 to 25 years. On favorable sites, the stem can reach a diameter at breast height (dbh) of 50–60 cm (20–24 in) in 15 to 20 years.

Flowering and fruiting

Flowering and fruiting are seasonal. Flowering occurs when the tree is leafless in the summer, and fruiting soon follows. Its flowering time was used as a seasonal indicator in some places (e.g., in Samoa its flowering indicated that whales would soon be running in the adjacent ocean).

Yields

It is not usually used for fodder in the Pacific, but yields of 15–50 kg (33–110 lb) of fodder per tree per year have been recorded.

Rooting habit

It forms extensive vertical roots, but these may spread horizontally from the base of the trunk to make large surface roots, making the tree unsuitable for planting next to sidewalks.

Reaction to competition

The tree does not tolerate shade well, and the seedlings grow poorly in the shade of competition. For optimum growth, new plantings should be kept weed-free. Mature trees are tolerant of a grass cover, but it should be mowed to reduce competition.

PROPAGATION

Propagation is by two common methods, cuttings and seeds. Large branch cuttings can easily be planted to form new trees, as described below. Cuttings are the only way to propagate clonal varieties, as seeds are not true to type.

Propagation from cuttings

(after Wilkinson and Elevitch 2003a)

Cutting collection

This tree is most commonly propagated vegetatively for live fences, windbreaks, and establishment in areas where livestock is present (which could eat shoots from small seedlings). Large-size branch cuttings are used, usually 2–3 m (6.6–10 ft) in length and 5–10 cm (2–4 in) in diameter. Smaller cuttings may be used, a minimum of 30 cm (1 ft) in length and a diameter of 4–5 cm (1.8–2 in). However, larger cuttings at least 1.5 m (5 ft) long will establish more quickly, survive better against competition from weeds, and be less susceptible to damage or destruction from grazing animals. It is best to retain the terminal bud of branch cuttings to ensure fast new top growth. However, in many cases growers cut one long branch into several cuttings, and therefore this is not always feasible.

Cuttings can be taken any time of year, although the ideal time is when the new growth is appearing, usually at the onset of the rainy season. Growers traditionally favor taking cuttings with the waning moon and planting them in the ground with the waxing moon.

Storage of cuttings

Cuttings are stood upright in shady, dry, and cool conditions for a minimum of 24 hours and a maximum of 2 weeks. This standing time allows the cuttings to dry slightly and helps prevent rotting and fungal problems.

Outplanting

Whether planted directly in the field or in nursery containers, the cuttings should be grown in sunny conditions. After planting, soil moisture should be maintained, although overwatering can easily cause the buried part of the cutting to rot. For larger stakes 2–2.5 m (6.6–8.3 ft) tall, the lower portion of the cutting is buried 20–40 cm (8–16 in) deep. For smaller cuttings, generally about 20% of the cutting's length should be underground. Planters should make sure to plant cuttings correct side down! Some recommend dipping the top portion of the cutting in pruning wax to help keep moisture from rotting the wood. Another strategy for avoiding rot on the top portion of the cutting is to make sure the top is cut at an angle so that rainwater is shed. The planting holes may be sprinkled with VAM mycorrhizal fungi inoculant (an aid to establishment and growth in P-deficient soils) and rhizobia bacteria inoculant. The soil should be firmed around the base of the cutting. Incisions should be made in the bark of the part of the cutting that will be underground in order to improve rooting. It takes about a month for axillary shoots to appear.

Media

Usually cuttings are started directly in the ground. However, if using containers, any standard well drained potting media may be used.

Time to outplanting

Cuttings establish quickly, producing axillary shoots in 3–4 weeks, followed by rooting. Generally, 3–4 months in the nursery will yield a well rooted plant ready for outplanting.

Success rate

Under optimal conditions of soil moisture, 90–100% of coral tree cuttings will survive. Very wet conditions in the early stages of establishment can lead to rot in the underground portion of the cutting.

Propagation from seed

(after Wilkinson and Elevitch 2003b)

Seed collection

The seeds can be collected after the pods mature, which is usually late winter. In Hawai'i, it flowers in January and February and sets seed in February–April. The fruits are pods about 15–30 cm (6–12 in) long. Seeds are mature when the pod dries and turns brown and the seeds become hard with a shiny seed coat. Mature pods can be collected from the tree or from the ground.

Seed processing and storage

Seeds are easily cleaned by hand from dried pods. Seeds should be well dried in the sun. Prior to storage, seeds should be frozen for a minimum of 48 hours to kill any insect larvae harbored inside. Germination is commonly 90% or greater for recently harvested seed. Seeds maintain viability for several years when stored in an airtight container with desiccant in a cool location or in the refrigerator.

Pre-planting seed treatments

For best germination, scarification of the hard seed coat is recommended. Mechanical scarification (nicking with a large nail clippers) works very well; be sure not to damage the germ or the inner part of the seed. Soak the scarified seeds overnight in room-temperature water. If any seeds do not imbibe water, they may be nicked and soaked again. Hot-water scarification is an alternative to mechanical scarification and is appropriate for large seed lots. Seeds are soaked in hot water (80°C [176°F]) for 10 minutes and then in tepid water overnight.

Growing area

Seedlings should be grown in full sun in an uncovered growing area. Humidity and overwatering can lead to fungal diseases, so a hot and dry growing environment is ideal.

Germination

Scarified seeds will begin germinating in 5–10 days. Scarified seeds may be planted in containers or direct-seeded. Cover seeds shallowly with potting mix (about 0.6 cm [0.25 in] deep), followed by a thin mulch layer such as coarse poultry grit or sand. Water the seeds with a fine-headed sprayer. Keep moist but not overwatered. Overwatering can easily lead to damping off. After 1–2 weeks of growth, seedlings should be inoculated with rhizobia bacteria selected for this species.

Media

Any standard potting soil is suitable. As with other nitrogen-fixing plants, the medium should have low available N, which encourages active nodulation for nitrogen fixation, assuming rhizobia bacteria are present.

Time to outplanting

Well watered seedlings are normally ready for planting 10–16 weeks after germination. The size expected for outplanting is 30 cm (1 ft) tall, with a based diameter of 6 mm (0.25 in).

Other comments on propagation

Coral tree is not true to seed. Projects desiring the columnar variety 'Tropic Coral' (mainly for windbreaks and live fence posts) should propagate the tree from cuttings, not seed, to ensure the column-shaped form. Projects desiring thorny trees or more branching form (commonly desired for shade) should propagate vegetatively from trees with the desired form or from their seeds.

DISADVANTAGES

The tree is ideally planted by itself as a specimen or in rows; it needs to be kept away from sidewalks and lawn areas because large lateral roots can lift sidewalks and interfere with mowing. It is leafless during part of the year and so tends to produce a lot of leaf litter. The flowers, although spectacular, are seasonal and last on the tree only 1–2 months.

Potential for invasiveness

It is not very invasive, because it has an ineffective dispersal mechanism for its seeds (they just fall from the tree).

A serious pest identified in Hawai'i in 2005, the erythrina gall wasp causes severe defoliation and eventual death of trees. The presence of this pest effectively halts the planting of coral tree in Hawai'i until the problem is resolved. Left: New leaves with stems swollen by gall formation. PHOTO: C. ELEVITCH **Right: Completely defoliated hedge, Mānoa, Hawai'i.** PHOTO: D. EVANS

However, it can naturalize along streams where there are trees planted upstream.

Diseases and pests

The species is a host to the fruit-piercing moth *Othreis fullonia*, a serious pest in the Pacific islands. The tree itself is not particularly susceptible to diseases, but borers may infest weakened trees and some species of caterpillars can damage foliage. In Hawai'i, the leaves are susceptible to attack by powdery mildew (*Oidium* sp.), especially during the winter rainy season.

In 2005, a serious new pest was identified in Hawai'i, the erythrina gall wasp (*Quadrastichus erythrinae*) (Heu et. al 2006). This pest has also been reported in American Samoa and Guam, as well as parts of Southeast Asia. The wasp larvae develop inside the young leaf petioles and stems, and cause galls to form. Severe infestations have been reported throughout Hawai'i. These infestations can cause complete defoliation and death of trees. Treatments with certain pesticides have been effective at reducing infestations, although such treatments are impractical for most people. Until this problem is resolved, planting of coral tree in Hawai'i is not recommended.

Host to crop pests/pathogens

The species is a host to the fruit-piercing moth *Othreis fullonia*, a serious pest in the Pacific islands.

Other disadvantages

The wood is not very suitable for much other than light (and temporary) construction and for making light boxes.

AGROFORESTRY/ENVIRONMENTAL PRACTICES

Mulch/organic matter

Although not as prolific as some other nitrogen- fixing

Coral tree is deciduous in many environments. The loss of foliage could be a disadvantage if shade or wind protection is required during the dry season. PHOTO: C. ELEVITCH

trees such as *Gliricidia sepium*, coral tree is often pruned annually when used for crop shade or living fence posts. The prunings make excellent mulch for crops.

Crop shade/overstory

The tree is sometimes used as a shade for coffee and cacao. For this purpose they are planted with a spacing of 8 x 10 m (27 x 33 ft). The trees are pollarded once a year to a height of 2–3 m (6.6–10 ft) to produce a spreading crown.

Alley cropping

Because of its relatively moderate growth rate after pruning, coral tree is usually not the best choice for a fast-growing nitrogen-fixing tree for organic matter production in alley cropping.

Homegardens

The tree is very well suited for homegardens as an ornamental.

Improved fallows

Since they fix nitrogen they are potentially useful trees for enriching the soil, as well as being a shade tree.

Living fences

Coral tree is excellent for living fences, as it can easily be grown from large cuttings. The type most suitable for this is 'Tropic Coral', which has a columnar shape and is evergreen. Farmers commonly establish fence posts from 3-year-old upright branches about 15 cm (6 in) in diameter and 2.5 m (8 ft) long. These are normally stacked in the shade in an upright position and left to cure for a week before planting.

Fence posts

The wood is not good for this, because it is not particularly resistant to rot. But if a living fence post is desired, it is excellent for this purpose.

Top: This densely planted row of 'Tropic Coral' is used to support hog wire, making a very strong enclosure for pigs. Bottom: A boundary hedge without attached fencing. PHOTOS: C. ELEVITCH

Boundary markers

It is commonly used for a boundary marker as a living fence.

Windbreaks

Commonly used as a windbreak, particularly the columnar variety ('Tropic Coral') and for soil and water conservation. The trees have a strong, vertical root system that does not seem to compete too severely with adjacent crops. Windbreaks are normally established from large cuttings planted in lines at a spacing of about 1 m (3.3 ft).

Silvopasture

Living fence posts can be used as support for fencing suitable for containing cattle or horses. The periodic pruning of these fence posts yields excellent fodder. Trees are also grown inside paddocks to provide some shade, wind pro-

tection, and as a potential source of off-season fodder.

Animal fodder

The foliage makes an excellent feed for most livestock, as the leaves normally contain 16–18% crude protein. A tree of average size, pruned three or four times a year, produces from 15 to 50 kg (33–110 lb) of green fodder annually depending on growing conditions. Trees maintained in coffee plantations benefit from associated cultivation practices and can produce up to 100 kg (220 lb) of fodder from one annual harvest. The leaves have no known toxicity to cattle.

Woodlot

The wood is not very suitable for use as timber, as it is soft, light, and not durable, but it can be used for fuelwood, especially when gathered in areas where it is used as a shade tree among other tree crops.

Native animal/bird food

Nectar-feeding birds are attracted to the copious nectar produced during the short flowering season.

Host plant trellising

Farmers in India use it to support climbing plants such as betel nut (*Piper betel*), black pepper (*Piper nigrum*), vanilla (*Vanilla planifolia*), and yam (*Dioscorea* spp.). Trees established to support vines are usually planted at a spacing of 2 x 2 m (6.6 x 6.6 ft) to 2 x 3 m (6.6 x 8 ft). Vines are planted 3–4 months after establishment of the tree seedlings or during the following rainy season. During the hottest months, foliage from the closely spaced trees shades the vines, and in the winter, the leaves fall to allow them to more receive more direct sunlight.

Coastal protection

The tree can be used in coastal areas, as it improves the soil and is native to littoral habitats.

Ornamental

It makes an attractive ornamental tree because of its large, showy red, seasonal flowers.

USES AND PRODUCTS

The coral tree is important for several reasons, but its distribution may be natural (seawater drift) rather than being carried through the islands as a useful tree. Although the light wood is of little use as timber, it was and still is commonly used to make the outrigger on traditional canoes and for floats on fishing nets. The flowering was used as a seasonal indicator on some islands (e.g., Samoa). The bark and leaves have been widely used to make traditional medicines, although there seems to be little commonality of usage in the Pacific islands. The nectar is an important seasonal food source for lories, honeyeaters, and flying foxes. Nowadays the tree is mainly used as an ornamental, especially the variety with variegated leaves (var. *variegata*), and as a living fence post, especially 'Tropic Coral'.

SAMOAN LORE

When the coral tree fruits are ripe, it is an indicator that whales are running and yams are in season in Samoa.

Medicinal

In Pohnpei the leaves are reportedly used to make a drink to cure curses, and the smoke from smoldering leaves, bark, or roots is inhaled for the same purpose. In Yap the leaves and bark are reportedly used as a potion to treat stomachache. In Tonga the bark is mixed with others and used to treat stomachache. In Samoa the leaves are occasionally used to treat eye ailments, and the bark is applied to swellings. In India, China, and Southeast Asia, the bark and leaves are used in many traditional medicines, including one said to destroy pathogenic parasites and relieve joint pain; the juice from the leaves is mixed with honey and ingested to treat tapeworm, roundworm, and threadworm in India; women take this juice to stimulate lactation and menstruation; it is commonly mixed with castor oil to treat dysentery; a warm poultice of the leaves is applied externally to relieve rheumatic joints; and the bark is used as a laxative, diuretic, and expectorant.

Coral trees in flower attract many nectar-feeding birds. PHOTO: C. ELEVITCH

Leaf vegetable

Boiled leaves can be eaten as a potherb.

Beautiful/fragrant flowers

These are sometimes used as decoration in vases, or in leis, but are seasonal.

Timber

The wood is not very suitable for use as timber since it requires careful seasoning, preferably kiln drying. It does not split on nailing, but holds nails poorly.

Fuelwood

It is a useful fuelwood tree. An average shade tree in a coffee plantation can yield 25–40 kg (55–88 lb) of wood from annual pollarding.

Craft wood/tools

The wood is used to construct outriggers and fishnet floats, packing boxes, picture frames, and toys, but other timbers are much for suitable for this purpose.

Canoe/boat/raft making

The light wood is favored for making outrigger floats.

Body ornamentation/garlands

Seeds and flowers may be used for making leis, but the seeds are prone to beetle infestation on the tree and the flowers are highly seasonal.

Top: 'Tropic Coral' makes a very good component in a hedge, visual barrier, or windbreak, and can be repeatedly pruned to maintain its size. Upolu, Samoa. Bottom: Hedge in commercial landscaping. Kaloko, island of Hawai'i, before arrival of the erythrina gall wasp. PHOTOS: C. ELEVITCH

URBAN AND COMMUNITY FORESTRY

Coral tree is an easy-to-grow, medium size tree with attractive foliage and flowers. It is well suited for coastal environments, where many people live, and can grow at elevations up to 1500 m (5000 ft) near the equator. It can be pruned to size and shape for many landscaping applications.

Size in an urban environment

The tree typically grows to 10–15 m (33–50 ft) in height, with a crown diameter of about half the height of the tree, except for the columnar cultivar 'Tropic Coral', which has a narrow crown diameter of 2–3 m (6.6–10 ft). However, in urban environments trees can be pruned periodically to maintain a desirable size and form.

Rate of growth in a landscape

As a nitrogen-fixing tree, it can grow rapidly, especially in cultivated landscapes with ample moisture. A tree can grow to 10 m (33 ft) in height in 8 years. After pruning, regrowth is also rapid, up to 3 m (10 ft) within the first year.

Root system

In younger trees, most roots are in the upper 30 cm (12 in) of soil. Older trees have deeper root systems. The extensive surface rooting may interfere to a limited degree with pavement, sidewalks, and other surface objects.

Products commonly used in a Pacific island household

Many parts of the tree have various uses, such as medicine, fodder, utility wood, and lei making, but the tree is probably best known as a shade, hedge, and living-fence tree.

Light requirements

Coral tree grows best in full sun. Seedlings as well as larger trees perform poorly if heavily shaded.

Water/soil requirements

It grows in a wide range of soil types. Because it is a nitrogen fixer, it tolerates infertile soils better than many landscaping plants.

Life span

Coral tree can live to be about 100 years old.

Varieties favored for use in homegardens or public areas

The yellow and green variegated var. *variegata* is a popular ornamental in the Pacific. 'Tropic Coral' has a narrow, columnar form and is also favored as an ornamental. Its compact canopy makes it suitable for tight landscapes and for narrow hedges and living fences. 'Tropic Coral' has only tiny prickles on the stems, which makes it easier to work with in a homegarden.

Seasonality of leaf flush, flowering, fruiting

Flowering takes place once a year (July–November in the Southern Hemisphere, and January–May in the Northern Hemisphere). Trees are deciduous just prior to and during flowering (except possibly for 'Tropic Coral', which may hold its leaves).

Exceptional ornamental values

The bright red, showy flowers last for several weeks. Flowering is particularly attractive because it occurs during a deciduous period when the grayish bark and framework of the tree are visible. The flowers have no scent.

Use as living fence, hedge or visual/noise barrier

When pruned to encourage leafy regrowth from the lower trunk, trees make an excellent hedge, particularly 'Tropic Coral'. This cultivar is also used very successfully as a living fence post on which to mount wire fencing. Thornier types may be used for a hedge or living fence where the added deterrent is desired.

Birds/wildlife

The flowers produce copious nectar and attract many small nectar-feeding birds that hop around and poke at the flowers.

Maintenance requirements

Small seedlings can usually hold their own with weed competition, but vines and tall grasses should be controlled for the first 2–3 years. Once established, the tree requires little maintenance. Fertilizer is rarely required, except in very infertile soils. Irrigation is also often unnecessary, as the tree handles drought well.

To control the size and form, pruning is required. Regrowth is rapid after pruning, so landscape hedges are typically

Recently rooted cuttings used for trellis to support bitter melon, vanilla, and beans. PHOTO: S. SKIPPER

trimmed once or twice per year, depending on how much regrowth is visually acceptable. The prunings make excellent nutrient-rich mulch for other plants in the landscape, or are valuable fodder for most livestock.

The tree can also be pollarded to control the height and canopy diameter. In pollarding, a framework of several stems is formed at a desired height by pruning the tree during its early development. These stems are then pruned back heavily every 1–3 years, depending on the rate of regrowth.

Special considerations regarding leaf, branch, and fruit drop

Generally, regrowth after pruning is more susceptible to breakage in high winds than are branches on a tree that has never been pruned. Once pruned, regular follow-up pruning will reduce the risk of storm damage.

When using prunings for mulch, branches of any size may set root in wet environments. To avoid new plants emerging from mulch, newly rooted plants can be periodically pulled up using a hoe or other hand tool. Another option is to compost the prunings before using them as mulch.

Nuisance issues

None.

Hazards

Some trees are thornier than others. Thornier trees can present a hazard, especially in public places where people could be injured by stepping bare-footed on small fallen branches or even bumping up against the trunk of the tree. The seeds are poisonous if eaten without cooking.

Common pest problems

Powdery mildew (*Oidium* sp.), Chinese rose beetle (*Adoretus sinicus*), mealybugs (*Phenacoccus* spp.), and mites (*Tetranychus cinnabarinus* and *Polyphagotarsonemus latus*) are common pests that effect coral tree in the landscape. These are passing pest problems, however, and rarely require any treatment.

COMMERCIAL PRODUCTS

Coral tree is valued for its use as livestock fodder, windbreak, live fence, crop shade, organic matter production, ornamental uses, and uses in traditional handicrafts and medicines. The tree has little commercial use, although it is used commercially for paper pulp production in India.

INTERPLANTING/FARM APPLICATIONS

Some interplanting systems include:

Example system 1

Location

Throughout the Pacific, and other tropical regions.

Description

The tree is used for shade and soil enrichment in crops such as cacao or coffee. This is a new practice, as these crops were not traditionally cultivated in plantations (and are not native to the Pacific). In the Pacific, *Erythrina subumbrans* is probably more commonly used for this purpose.

Crop/tree interactions

It produces soil nitrogen from the roots, and a green mulch from the falling leaves. The tree can also be planted along the edges of the plantation as a living fence post and as a windbreak.

Spacing

When planted among other tree crops for shade, a spacing of 8 x 10 m (27 x 33 ft) is common. The trees can be planted very close together when making a living fence or hedge.

Example system 2

Location

India

Description

Farmers in India use it to support climbing plants such as betel nut (*Piper betle*), black pepper, vanilla, and yam (*Dioscorea* spp.). Vines are planted 3–4 months after establishment of the tree seedlings or during the following rainy season. During the hottest months, foliage from the closely spaced trees shades the vines, and in the winter, the leaves fall to allow more direct sunlight.

Crop/tree interactions

In this case, the young trees are used as trellises and for shade.

Spacing

The trees used to support vines are usually planted at a spacing of 2 x 2 m (6.6 x 6.6 ft) to 2 x 3 m (6.6 x 8 ft).

PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

Extension offices for agroforestry and forestry in the Pacific: http://www.traditionaltree.org/extension.html

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Species Profiles for Pacific Island Agroforestry (www.traditionaltree.org)

Erythrina variegata (coral tree)

Authors: W. Arthur Whistler[1] and Craig Elevitch[2]

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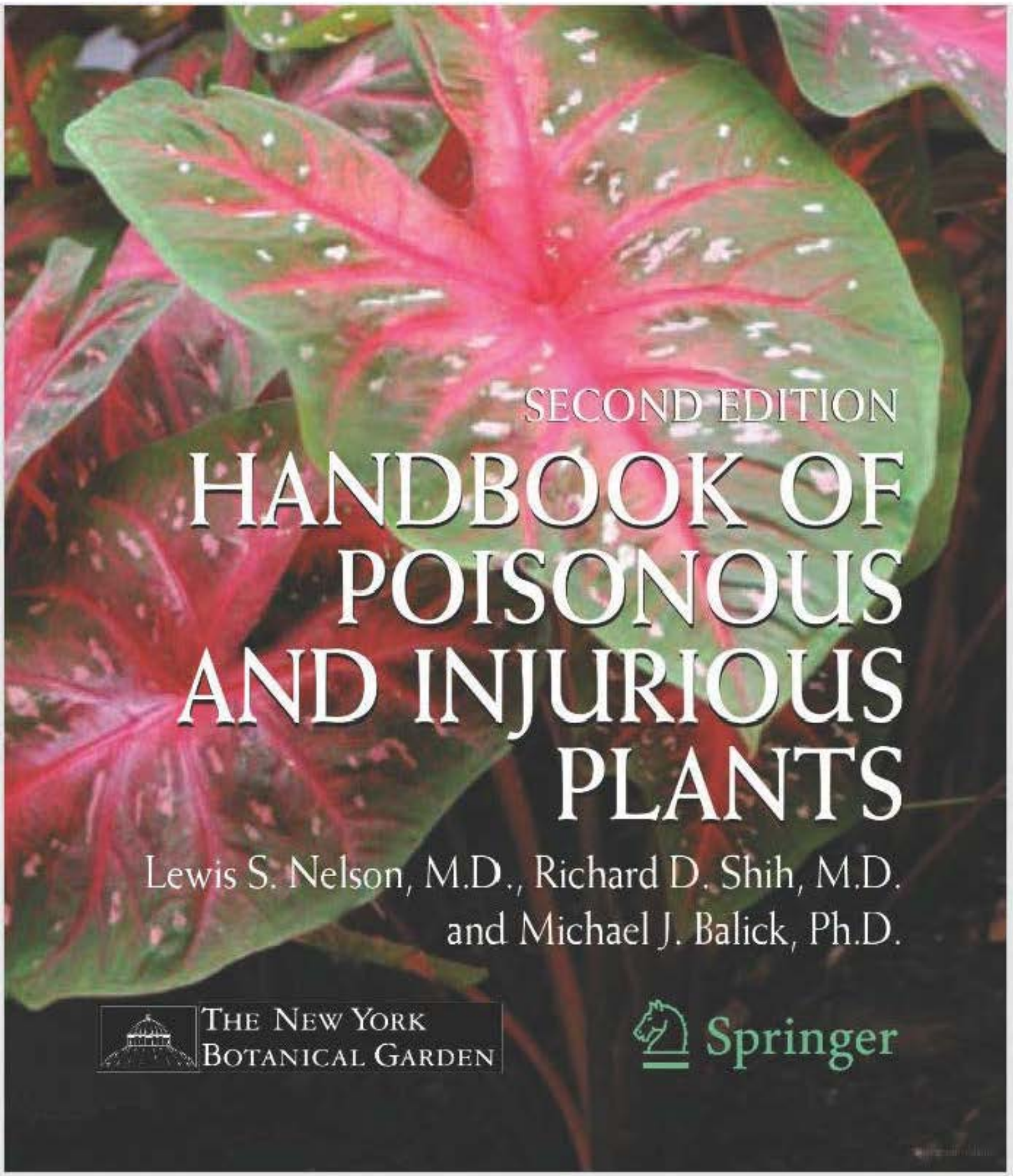
Muriel
& Kent
Lighter

Annex 920

L.S. Nelson, et al., "*Calophyllum inophyllum* L.", in *Handbook of Poisonous and Injurious Plants* (2d ed., 2007)



SECOND EDITION

HANDBOOK OF POISONOUS AND INJURIOUS PLANTS

Lewis S. Nelson, M.D., Richard D. Shih, M.D.
and Michael J. Balick, Ph.D.

THE NEW YORK BOTANICAL GARDEN

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Toxin: Raphides of water-insoluble calcium oxalate and unverified proteinaceous toxins.

Clinical Findings: A painful burning sensation of the lips and oral cavity results from ingestion. There is an inflammatory reaction, often with edema and blistering. Hoarseness, dysphonia, and dysphagia may result.

Management: The pain and edema recede slowly without therapy. Cool liquids or demulcents held in the mouth may bring some relief. Analgesics may be indicated. The insoluble oxalate in these plants does not cause systemic oxalate poisoning. Consultation with a Poison Control Center should be considered. See "Poisoning by Plants with Calcium Oxalate Crystals," p. 23.

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Calophyllum inophyllum L.
Family: Guttiferae (Clusiaceae)

Common Names: Alexandrian Laurel, Beautyleaf, Indian Laurel, Kamani, Laurelwood, María Grande, **Mastwood**, Poonay Oil Plant

Description: This low-branched tree grows to 40 feet or more. The trunk is covered by light gray bark with a pink inner bark. The paired leaves are shiny green and leathery with a prominent midrib, 3 to 8 inches long and elliptical with a slight notch at the tip. The flowers form small clusters resembling orange blossoms and are fragrant. The fruit is globose, 1.25 to 1.5 inches in diameter, and becomes yellowish-brown at maturity. It contains one large seed with a bony shell. The plant has a cream-colored, resinous latex.

Calophyllum inophyllum, fruiting branch

Distribution: This tree is native to India and the Malay Peninsula. It is a commonly planted ornamental in the West Indies, south Florida, Hawaii, and Guam.

Toxic Part: The seed kernel is poisonous.

Calophyllum inophyllum, leaf and fruit (above)

Calophyllum inophyllum, flowers (left)

Toxin: Inophyllum A-E, calophyllolide, calophynic acid.

Clinical Findings: Ingestion can cause nausea, vomiting, abdominal cramping, diarrhea, and dehydration. The latex is used as a home remedy in the West Indies and the Pacific and appears to be nontoxic, although it may cause keratoconjunctivitis on contact with the cornea.

Management: Most exposures do not lead to significant toxicity. Intravenous hydration, antiemetics, and electrolyte replacement may be necessary in severe cases, particularly in children. Consultation with a Poison Control Center should be considered. See "Poisoning by Plants with Gastrointestinal Toxins," p. 28.

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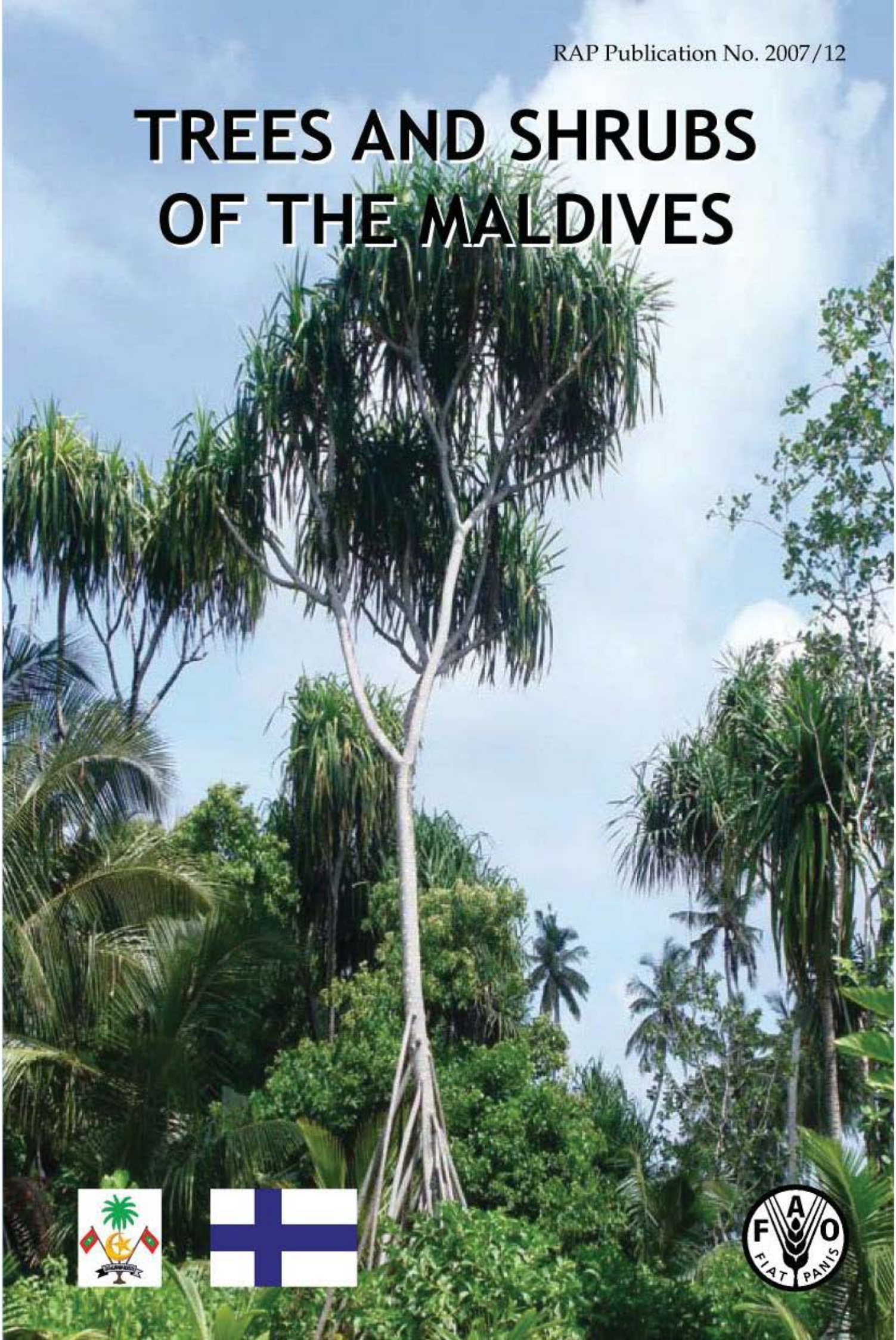
Annex 921

V. Selvam, *Trees and shrubs of the Maldives*, FAO Regional Office for Asia and the Pacific Publication No. 2007/12 (2007)

RAP Publication No. 2007/12

TREES AND SHRUBS OF THE MALDIVES



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Trees and shrubs of the Maldives

V.Selvam

Ministry of Fisheries, Agriculture and Marine Resources
Maldives

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Guettarda speciosa - Uni

Guettarda speciosa L. RUBIACEAE

Common name: Nit pitcha

Dhivehi name: Uni

Status: Abundant in forested areas; present in all islands.

Description: An evergreen, small- to medium- sized size tree that grows normally about 5 to 10 m in height but is capable of reaching more than 20 m. Crown is round and spreading. Leaves are large, 15 to 25 cm long, 7.5 to 20 cm wide, dark green in colour and ovate in shape. Tip of the leaves is blunt or sometimes acute and the base is rounded or heart-shaped; midrib of the leaf and seven to ten pairs of lateral nerves are prominent. Flowers are fragrant, tubular and white in colour. Corolla tube is light yellow in colour and 2.5 to 5 cm long and corolla is about 3 cm across. Flowers are sensitive to sun and hence, open in the evening and fall before dawn. During cloudy days or in shaded places, opened flowers can be occasionally seen during daytime. Fruits are round and slightly flattened, faintly ribbed, 2.5 to 3 cm in diameter and without stalk; green in colour when unripe, turns to brown at maturity. Each fruit has four to six cells and each cell has one very small white seed. Matured fruits are cork like and dispersed by ocean currents.

Uses: Wood is white in colour, dense, heavy, hard and durable. Wood is mainly used as poles for house construction and boat building. According to some Maldivian elders, wood is heated before using to increase its strength. It is said that nails once fixed in heated wood cannot be easily removed. Wood is also buried in the sand near the sea to keep its freshness for future use. Branches are excellent firewood. It is also grown as ornamental tree and small poles are used for growing passion fruits. In the Maldives, the latex is used to treat cut wounds and the flowers are mixed with an ayurvedic medicine namely, *huvandhu byes*, to treat polio and paralysis. It can be a candidate species for developing multispecies coastal bioshield and can be planted along with lettuce tree (*Scaevola taccada*) and beach heliotrope (*Tournefortia argentea*)

Ecology, propagation and management: It grows in light to heavy soils but prefers well-drained medium-textured soil for better growth. It also grows well in poor soil. Its tolerance to drought, aerosol salt spray and soil salinity is high. Propagation is mainly by seeds. In the Maldives, it is not cultivated. But according to the elders, wildlings can be used to raise this plant in desired locations. Cuttings are also used for propagation. Both seedlings and cuttings require proper shading and watering in the initial stage to establish and grow.

Morinda citrifolia - Ahi

Morinda citrifolia L. RUBIACEAE

Synonyms: *Morinda bracteata, Morinda litoralis*

Common names: Indian mulberry, cheesefruit, noni

Dhivehi name: Ahi

Status: Common; found mostly in the forested areas.

Description: An erect, evergreen, smooth shrub or small tree 3 to 10 m tall. Bark is greyish or yellow-brown, shallowly fissured and somewhat shiny. Young branches are light green in colour and four-angled. Leaves are simple, opposite in arrangement along the branches, elliptic to elliptic-ovate in shape, 20 to 45 cm long and 7 to 25 cm wide. Leaves are dark green in colour, shiny and deeply veined. Flowers are small, white, numerous and about 70 to 90 flowers can be seen in a ovoid to round flower head, which has 1 to 4 cm long peduncle. Inflorescence is axillary and normally opposite to leaves in position. Flowers are bisexual and fragrant; corolla is five lobed on a short greenish yellow coloured tube. Fruit is yellowish-white in colour, fleshy, roughly cone like in shape, 3 to 10 cm long and 2 to 3 cm wide. It is soft, somewhat gelatinous when ripe, and strong smelling. Each fruit has many seeds and each seed is enclosed in a distinct air chamber.

Uses: Indian mulberry was previously cultivated for a reddish-purple and brown dye from the bark and roots to colour cloths. Now it is widely cultivated for medicinal purpose. Fruit juice is used in alternative medicine for a host of illness such as diabetes, high blood pressure, arthritis, and muscle aches, menstrual difficulties etc. Fruit juice is considered as an excellent adaptogen (can keep body systems in homeostasis). In the Maldives, fruit is normally given to old people to alleviate illnesses resulting from senility. Leaf juice, obtained by crushing leaves or cooked leaves are applied on the swollen body parts to reduce swelling and pain.

Ecology, propagation and management: It grows on a wide range of soils and harsh environmental conditions, such as brackish tide pools, limestone soils or outcroppings on coral atolls. It also tolerates seasonal water logging but prefers free, well-drained soils for better performance. It grows well both in acidic and alkaline soils. Its tolerance to drought, aerosol salt spray and water and soil salinity is very high. Its growth and fruit production is somewhat reduced in windy areas. Indian mulberry can be easily propagated by seeds and stem cuttings. Seeds float in water due to presence of air bubbles inside and such floating seeds from mature fruits can be collected and scarified to improve germination rate and time. Seeds may be directly sown or seedlings of about 2 to 12 months can be outplanted. Stem cuttings 20 to 40 cm long can be grown in containers and used for outplanting after six to nine weeks.

Annex 922

Burdekin Dry Tropics NRM, *Coastal Plants of the Burdekin Dry Tropics* (2008), *available at* http://wiki.bdtnrm.org.au/index.php?title=Coastal_Plants_ of_the_Burdekin_Dry_Tropics

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Screw Palm

Pandanus tectorius
Pandanaceae

The Pandanus species are palms with one or more trunks to 15 metres. Leaves of the Screw Palm are long, to 1.5 metres. They are rigid and tapering, with prickly spines along the edges that can easily cut bare hands. They are light green and arranged spirally at the end of each branch. The lower leaves can be pruned to improve appearance in gardens.

The trunk is slender and light coloured with a tough exterior. The flowers are very tiny on separate male and female plants. The fruit is orange. These are wedge shaped, woody and clustered together. The clumps can grow to be over 30 cm.

This plant likes well-drained soils and is tender to frosts. Seeds propagate and grow easily. This tall tree is attractive to numerous wetland birds and particularly Red-tailed Black Cockatoos and Crimson Finches.

Thuarea involuta
Poaceae

Birds Beak Grass

This plant is a hardy, pioneer grass with long runners that help to bind the sand. It has bright green leaf blades that are short but broad and densely coated with short hairs, giving the grass a velvet look and feel.

Flowers are white and protrude from the sheath as they begin to bloom. The flowers are bisexual and have multiple male and female parts. These appear along the grass sheath in groups of 5 – 9. When the grass is in flower it has the appearance of a bird's beak. Fruits are formed as a grass spike that has a water-tight covering. The spike is light and buoyant to aid water dispersal.

Birds Beak Grass is hardy, being found on fore dunes. It will grow in gardens with well-drained soils or sand and is being trialled for beachfront revegetation. It is considered an attractive ground cover or alternative to conventional lawn.

Table of Growth Parameters

Plant	Common Name	Typical Height	Soils
Acacia crassicarpa	Beach Wattle	- 10m	Mo
Acacia flavescens	Toothed Wattle	- 10m	Mo
Alphitonia excelsa	Soap Tree	10 – 15m	Mo
Avicennia marina	Grey Mangrove	- 10m	M, s
Bauhinia hookeri	Hooker's Bauhinia	5 – 10m	Mo
Canarium australianum	Melville Island White Beach	15+m	Wd
Casuarina equisitefolia	Beach She Oak	10 – 15m	Wd
Ceriops tagal	Yellow Mangrove	- 10m	M, s
Corymbia tessellaris	Moreton Bay Ash	15+m	Mo
Cupaniopsis anacardioides	Beach Tamarind	- 12m	Wd
Ficus opposita	Sandpaper Fig	4 – 8m	Mo
Hibiscus tiliaceus	Cottonwood	10+m	Mo
Livistona drudeii	Drude's Cabbage Palm	- 20m	Wd
Macaranga tanarius	Heart Leaf	- 10 m	Mo
Melaleuca dealbata	Swamp Tea Tree	- 20m	Mo
Millettia pinnata	Pongamia	5 – 10m	Wd
Mimusops elengi	Red Coondoo	- 15m	Mo
Morinda citrifolia	Rotten Cheese Fruit	3 – 10m	Mo
Pandanus tectorius	Screw Palm	- 15m	Wd
Planchonia careya	Cocky Apple	- 10m	Mo
Pleiyogynum timorense	Burdekin Plum	- 20 m	Mo
Polyalthia nitidissma	Canary Beech	6 – 18 m	Wd
Premna serratifolia	Creek Premna	2 – 5 m	Mo
Sterculia quadrifida	Peanut Tree	- 10m	Mo
Terminalia cattapa	Sea Almond	10 – 15m	Wd
Thespesia populnoides	Portia Tree	- 8m	Mo
SHRUBS			
Caesalpinia bonduc	Nicker Nut	- 4m	Wd
Clerodendrum floribundum	Lollybush	- 4m	Mo
Clerodendrum inerme	Coastal Lollybush	- 4m	Mo
Crotalaria medicagenia	Trefoil Rattlepod	0.8m	Wd
Eugenia reinwardtiana	Cedar Bay Cherry	2+m	Mo Wd
Exocarpus latifolius	Beach Cherry	4 – 8 m	Mo Wd
Flueggia virosa	White Currant	- 4 m	Mo
Sophora tormentosa	Silver Bush	- 4m	Wd
Tabernaemontana orientalis	Banana Bush	- 4 m	Mo
Vitex trifolia	Beach Vitex	0.5 – 3m	Mo
CREEPERS			
Canavalia rosea	Beach Bean	Creeper	Wd
Cassytha filiformis	Dodder Laurel	Vine	
Enchylaena tomentosa	Ruby Salt Bush	0.5m	Wd
Ipomea-pes-caprae	Goat's Foot Morning Glory	Creeper	Wd
Jasminium simplicifolium	Beach Jasmine	Vine	Mo
Sesuvium portulacastrum	Sea Purslane	Creeper	S, M
Setaria surgens	Pigeon Grass	60cm	Mo, S
Spinifex sericeus	Beach Spinifex	Creeper	Wd
Sporobolus virginicus	Saltwater Couch	Creeper	Mo
Sueada australis	Saltbush	-1m	Wd
Tecticornia indica	Beadweed	Creeper	S, M
Tecticornia pergranulata	Glassworts	Creeper	Wd
Thurea involuta	Birds Beak Grass	Creeper	Wd
Vitex rotundifolia	Creeping Vitex	0.5m	Mo

	Amount of sun	Amount of water	Salt Tolerance	Pg
	F P	D M	M	8
	F P	D M	M	9
	F P	D M	M	10
	F P	A	E	11
	F P S	D M	M	12
	F	D M	M	13
	F	D M	E	14
	F P	A	E	15
	F	D M	M	16
	F	D M	M	17
	F P S	D M	M	18
	F P	D – A	E	19
	F	D – A	M	20
	F P S	D M	M	21
	F P	D – A	E	22
	F P	M – A	M	23
	F	D M	E	24
	F P S	D – A	M	25
	F	D – A	E	26
	F P	D M	M	27
	F P	D M	M	28
	F P	M	L	29
	F P	D M	M	30
	F P	D M	M	31
	F	D M	E	32
	F P	D – A	E	33
	F P	D – M	E	34
	F P	M	M	35
	F P	M – A	M	36
	F	M	M	37
	P S	D – A	M	38
	F P	M – A	M	39
	F P	D – M	M	40
	F	M	M	41
	F P	M	L	42
	F	D – M	E	43
	F	D – M	E	44
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	F P	D – M	M	48
	F P	M – A	E	49
	F, P	M – D	L – M	50
	F	D – A	E	51
	F P	D – A	E	52
	F	D – A	E	53
	F P	M – A	E	54
	F	M – A	E	55
	F S	D – M	E	56
	F	D – M	E	57

Key

Typical Height

This is the height most commonly seen. Growth and habit can vary depending on environmental conditions.

Soils

Mo = tolerates most soils
Wd = needs well drained soils
S = sand
M = mud

Amount of Sun

F = full sun
P = partial sun
S = shade

Amount of Water

D = drier areas
M = moderately wet areas
A = likes to be wet and tolerates tidal inundation

Salt Tolerance

L = little to no tolerance
M = moderately tolerant
E = extremely tolerant, usually has special adaptations for salt

Index of Common Names

Annex 923

Forest Biodiversity Division, Royal Forest Department, Government of Thailand, *Sufficient convention of Tahsida people in Phukambok forest* (Sept. 2008), *available at* http://fbd.forest.go.th/en/wp-content/uploads/2010/07/roiet.pdf

Sufficient convention of Tahsida people in Phukambok forest

Tahsida district, Amphur Nongpok, Roi Et Province

"Somehow, we managed to live"

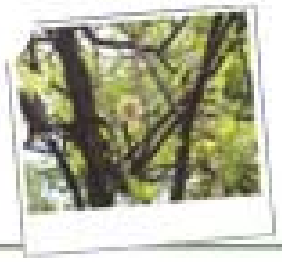
Exploration and Database Preparation on the Forest Biodiversity
Roi Et provincial area
Forest Biodiversity Division, Royal Forest Department

Stories inside...

Background of the Project

In 2008, Forest Biodiversity Division, Royal Forest Department did an exploration and database preparation on the forest biodiversity of Chi basin which we select a sample area at Phukambok forest, Tahsida district, Amphur Nongpok, Roi Et province because it's a small mountain forest that remained from the advancing of industrial crops and its characteristic as a headwater forest known as Young headwater forest, a sub branch of Chi basin. There are also villages who have skills in conservation and teamed up as an organization called " Forest Conservation People Volunteer "

The dimension of this project is to let the villagers engage in the work, from defining research manner, study, sustaining utilization and generational inheritance. The government service will be supporting the exploration process divided into 4 fields, namely plant, animal ,microbe and traditional knowledge diversity. One part of the exploration result had offered 3 key issues, which are community capital, conservation and development of biodiversity and utilization of forest biodiversity.



Khi Non

Prevent maggots from the preserved pickled fish jar.

Pickled fish is an important flavor enhancer for the Northeast people. Clean pickled fish must be without maggots and worms. In the preservation of pickled fish, Tahsida people will use leaves and stems from Khi non as the preventive for maggots that will come into the jar.

Ingredients

1. Pickled fish
2. Leaves and stems from Khi non

Tools

1. jar
2. knife and chopping block

Procedures

1. ferment the pickle fish in the jar
2. chop all the leaves and stems
3. put the chopped leaves and stems in the jar

Botanic appearances

Common name: “Khi non” or “Kong khao yen / Mak paep phi”, “Ham pa yao”, “Anchan pa”, “Ueangchan pa”. Scientific name: Clitoria macrophylla, LEGUMINOSAE (GABACEAE) PAPILIONOIDEAE family. Characteristics: Apart from the ability to prevent maggots in the preserved fish far, it also has other properties such as the ability to stop the bleeding and wound healing.

...Kloi... the fantastic food of Tahsida people

Botanic characteristics :

Common name : Kloi, Scientific name : Dioscorea hispida, DIOSCOREACEAE family, has the character of a creeping plant. More than 32 types can be found in Thailand which 3 of them are edibles, namely

1. Kloi khao niao or Kloi Lueang, Kloi hua kiao, Kloi nok, Kloi khai
2. Kloi khao or Kloi khao
3. Kloi chuet

Important substance :

Tryptophan is a beneficial substance that can mostly be found in sticky rice and helps healing depression. On the other hand, we found Dioscorine which is a toxic substance that has the power of a sedative. Those who take in the toxin will have an irritation at the mouth or tongue, slightly intoxicated, feel nauseated or sick, palpitate or astigmatism. The preparation of kloi will be in april to may because its size is big and can be easily cropped. There's a belief that the toxicity will be at its lowest at this time as well. Kloi cropped in august will have the highest possible toxicity. Tahsida villagers mostly cropped large size kloi and left small ones behind and cover up the area to further propagation which is considered a wise utilization of the villagers.

Benefits of Kloi

dietetics : Its blossom contains large amount of starch so it can be use to process various kinds of food, such as steamed sticky rice, kloi, Kloi phla , fried kloi, crisp rice, etc.

handicraft : solvent made from kloi's blossom will help the silk shine and harden to traction

herbal : used as an ingredient to make a medicine, melt to make oils or apply to cure blemishes

Annex 924

"*Ochrosia borbonica*", in *Plant Resources of Tropical Afric*a, Vol. 11, No. 1 (2008)

PROTA

Medicinal plants 1

Plant Resources of Tropical Africa 11(1)

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- M. Domis, Tobias Asserlaan 104, 5056VD Berkel-Enschot, Netherlands (*Piper umbellatum*)
- E. Dounias, Centre d'Ecologie Fonctionnelle et Evolutive, Center for Evolutionary and Functional Ecology (CEFE-CNRS), 1919, route de Mende, 34293 Montpellier cedex 5, France (*Gloriosa superba*, *Microdesmis puberula*, *Pentadiplandra brazzeana*, *Sacoglottis gabonensis*)
- J. Elia, National Herbarium of Tanzania (TPRI), P.O. Box 3024, Arusha, Tanzania (*Tabernaemontana pachysiphon*)
- V.E. Emongor, Department of Crop Science and Production, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana (*Euphorbia hypericifolia*, *Harrisonia abyssinica*)
- D.G. Fowler, Flat 4 Abbotsrood, 1 Milnethorpe Road, Eastbourne BN20 7NR, Sussex, United Kingdom (*Adenia cissampeloides*, *Brucea antidysenterica*, *Euphorbia grantii*, *Stephania abyssinica*)
- H.S. Foyet, Faculty of Science, Laboratory of Animal Physiology, University of Yaoundé I, P.O. Box 812, Yaoundé, Cameroon (*Synclisia scabrida*)
- P.E. Gasson, Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3DS, United Kingdom (wood anatomy)
- O.M. Grace, PROTA Country Office United Kingdom, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AB, United Kingdom (*Adenia cissampeloides*, *Andrachne ovalis*, *Brucea antidysenterica*, *Euphorbia convolvuloides*, *Euphorbia grantii*, *Euphorbia tirucalli*, *Stephania abyssinica*, *Stephania dinklagei*)
- A. Gurib-Fakim, Faculty of Science, University of Mauritius, Réduit, Mauritius (*Heliotropium indicum*, *Heliotropium ovalifolium*, *Ochrosia borbonica*, *Plantago lanceolata*, *Plantago major*, *Withania somnifera*, editor)
- R.K. Henning, Rothkreuz 11, D-88138 Weissensberg, Germany (*Jatropha curcas*)
- P.C.M. Jansen, PROTA Network Office Europe, Wageningen University, P.O. Box 341, 6700 AH Wageningen, Netherlands (*Cannabis sativa*, *Solanum nigrum*)
- R.B. Jiofack Tafokou, Ecologic Museum of Cameroon, P.O. Box 8038, Yaoundé, Cameroon (*Erythrococca anomala*)
- V. Kawanga, Zambian Branch, Commonwealth Forestry Association, Private Bag RW 359X, Ridgeway, 15102 Lusaka, Zambia (*Cassia abbreviata*, *Erythrophleum africanum*, *Jatropha gossypiifolia*, *Senna singueana*)
- M.M. Kitambala, Département de Chimie de la Faculté des Sciences, Université de Lubumbashi, Lubumbashi, DR Congo (*Uapaca guineensis*)
- A.M. Kouyaté, Institut d'Economie Rurale, B.P. 16, Sikasso, Mali (*Detarium microcarpum*)
- D.O. Ladipo, Centre for Environment, Renewable Natural Resources Management, Research and Development (CENRAD), 5 Akinola Maja Avenue, P.M.B. 5052, Jericho Hills, Ibadan, Nigeria (*Bridelia atroviridis*, *Okoubaka aubrevillei*)
- J. Lejoly, Laboratoire de Botanique systématique et de Phytosociologie, Université Libre de Bruxelles, Avenue F. Roosevelt 50, C.P. 169, B-1050 Bruxelles, Belgium (*Alchornea cordifolia*)
- R.H.M.J. Lemmens, PROTA Network Office Europe, Wageningen University, P.O. Box 341, 6700 AH Wageningen, Netherlands (*Cerbera manghas*, *Fumaria*

1–2 mm from the base, lobes narrowly ovate to narrowly obovate, 2.5–7 mm long; stamens inserted at base of the corolla tube, apex of anthers with tuft of hairs; ovary half-inferior, 2-celled, style very short, pistil head with long appendages. Fruit composed of 2 spreading follicles, 4–18 cm × 1–3.5 cm, tapering to the tip, opening by longitudinal slits, dark green with dense rusty brown hairs, longitudinally winged, many-seeded. Seeds c. 18 mm × 9 mm, with tuft of hairs 30–80 mm long at apex; cotyledons broadly ovate, leafy.

Motandra comprises 3 species, which all occur in continental tropical Africa. It is related to *Baissea* and *Oncinotis*. *Motandra guineensis* is the most widely distributed species whereas *Motandra lujaei* De Wild. & T.Durand and *Motandra poecilophylla* Wernham are restricted to the more humid rainforest of western Central Africa. In DR Congo the bark sap of *Motandra lujaei* is taken to treat cough. The long stem is used for making snares and as binding material.

Motandra guineensis flowers towards the end of the dry and the beginning of the rainy season. Fruits mature during the dry season.

Ecology *Motandra guineensis* occurs in open or secondary deciduous forest, gallery forest and in secondary regrowth. It grows on sand, clay and rocky outcrops, from sea-level up to 1200 m altitude.

Genetic resources and breeding *Motandra guineensis* is widespread, also in more or less disturbed habitats, and does not appear to be threatened.

Prospects Because of the varying medicinal uses of the leaf sap, *Motandra guineensis* deserves research attention.

Major references Bouquet & Debray, 1974; Burkill, 1985; de Kruif, 1984; Kerharo & Bouquet, 1950.

Other references Atindehou et al., 2002; Omino, 2002; Terashima & Ichikawa, 2003.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M.J. Boone

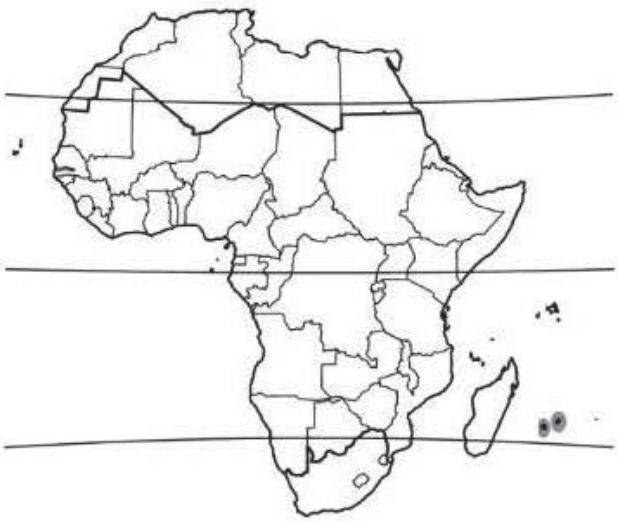
OCHROSIA BORBONICA J.F.Gmel.

Protologue Syst. nat. 2: 439 (1791).

Family Apocynaceae

Vernacular names Bois jaune, quinquina du pays (Fr).

Origin and geographic distribution *Ochrosia borbonica* is endemic to the Mascarene Islands (Réunion and Mauritius).



Ochrosia borbonica – wild

Uses In Réunion a small piece of the bark is boiled and the decoction is sweetened with honey and is drunk to treat loss of appetite, hypotension and constipation, and to reduce fever, e.g. in case of malaria. The bark soaked in wine is taken daily to purify the blood; the bark soaked in rum or water is taken before meals to reduce stomach cramps. In Mauritius the bark boiled with leaves is taken to treat fever. It is also widely taken as a tonic and stomachic and is applied against stomach cramps, as a bath or drink. It is also used against childhood eczema, locally known as 'tambave'.

The wood was formerly used as timber for making household utensils.

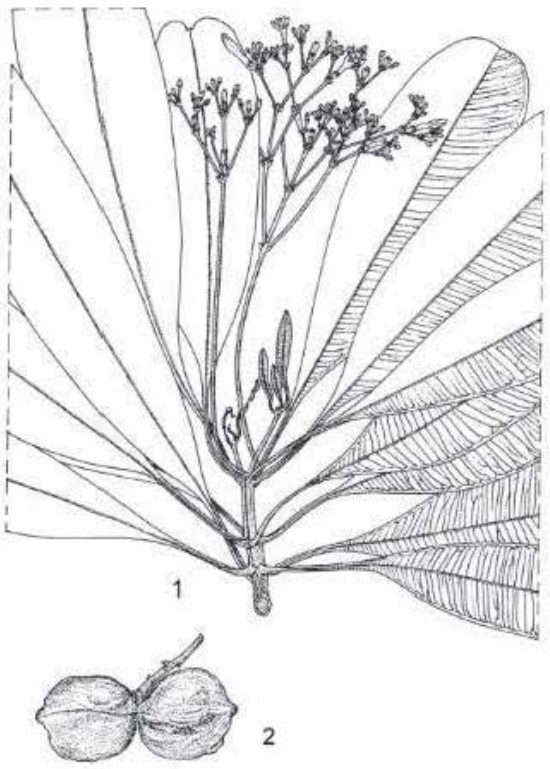
Production and international trade *Ochrosia borbonica* is used at a local scale only, and because it has become rare, it is no longer traded much.

Properties Research on active constituents in *Ochrosia* has focused on anticancer compounds following the isolation of the indole alkaloids ellipticine, elliptinine, 9-methoxy-ellipticine and isoreserpiline from the Asian *Ochrosia elliptica* Labill. Many *Ochrosia* spp. have since been subject to investigation of their alkaloid content, and the production of ellipticine in in-vitro grown callus from *Ochrosia elliptica* has been successful.

The bark of *Ochrosia borbonica* is rich in indole alkaloids and contains mainly ellipticine, 9-methoxy-ellipticine, reserpiline and isoreserpiline. Ellipticine and 9-methoxy-ellipticine show antitumour properties, but also disturb biological membranes, which makes their utili-

zation in medicines impossible.
Semisynthetic derivatives show higher activities against cancer cells and are less toxic. So far, only one ellipticine derivative, celiptium© (N-methyl-9-hydroxy-ellipticine, as acetate salt) has been introduced onto the market for treatment of metastatic breast cancer. This drug also shows significant activity against several leukaemia and melanoma cell lines. Ellipticine derivatives and analogues are also reversible non-competitive inhibitors of cholinesterases and interact with muscarine receptors. The ellipticine derivative hydroxy-methyl-ellipticine shows strong antiviral activities and is being extensively screened in clinical anti-Aids treatments.

Description Small tree up to 15 m tall, glabrous, except for the fringed sepals, with white latex; bole up to 40 cm in diameter; bark dark grey, fissured; branches with ring-shaped leaf scars. Leaves in whorls of 4, simple and entire; petiole 1–3.5 cm long, widened into a stipule at base; blade obovate to elliptical, 3–25 cm × 1.5–5 cm, base decurrent into the petiole, apex rounded, retuse, obtuse or acute, pinnately veined with numerous lateral veins at right angles to the midrib. Inflorescence a terminal cyme, but often seemingly axillary, many-flowered; peduncle 2–12 cm long; bracts scale-like. Flowers bisexual, regular, 5-merous, fragrant, sessile; sepals free, ovate, 2.5–3 mm long, thick, subtended by a sepal-like bracteole; corolla tube 7.5–10 mm long, cylindrical, slightly widened around the stamens, white with pink or red throat, lobes elliptical, 6–13 mm × 3–7 mm, apex rounded, spreading; stamens inserted 5–7 mm from the base of the corolla tube, included, filaments short; ovary superior, consisting of 2 carpels fused at base, style 2.5–4 mm long, split at base, ending in a conical pistil head. Fruit consisting of (1–)2 free ellipsoid drupes, 3.5–4.5 cm × 2–3 cm, apex rounded or apiculate, indehiscent, smooth, with 2 lateral ridges, mesocarp fibrous, each drupe 1–2-seeded. Seeds elliptical, flattened, 1.5–2.5 cm long, winged.



Ochrosia borbonica – 1, flowering branch; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Ochrosia* comprises about 30 species from the Mascarene Islands and Seychelles to South-East Asia, the Pacific and northern Australia. New Caledonia is particularly rich in endemic species. *Ochrosia* belongs to the tribe *Rauvolfieae*, together with the well-known genus *Rauvolfia*.

Growth and development *Ochrosia borbonica* flowers almost throughout the year, with a peak in January and February. Fruits are mainly observed from November to February. The fruits float with their thick fibrous mesocarp and are dispersed by sea currents. Likewise, the seeds float because of cavities in the endocarp. The seeds germinate readily when washed ashore. Natural regeneration of *Ochrosia borbonica* is very slow. It is also often not more than a shrub in the semi-arid vegetation.

Ecology *Ochrosia borbonica* occurs in forest, up to 1250 m altitude.

Propagation and planting *Ochrosia borbonica* can be propagated by seed or by cuttings. In Mauritius attempts are being made at propagating *Ochrosia borbonica* by ripe-wood cuttings, and plantlets are present in nurseries of the Ministry of Agriculture.

Genetic resources In Mauritius and Réunion, *Ochrosia borbonica* has become rare because of habitat loss and destructive harvesting of the bark. It is now confined to remnants of forest and the risk of genetic erosion and extinction is very real for this species. It is classified as endangered on the IUCN Red List. Although *Ochrosia borbonica* is officially protected, pieces of bark collected from the wild can still be found on markets in Réunion.

Prospects The indole alkaloids isolated from *Ochrosia borbonica* possess interesting anti-cancer and anti-viral activities. This potential can only be realized if the future of the species is secured.

Major references Bruneton, 1995; Gurib-Fakim & Brendler, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1995; Lavergne, 2001; Leeuwenberg, 1988a; Leeuwenberg & Rudjiman, 2005; Matte et al., 2002; van Valkenburg & Hendrian, 2001.

Other references Aubert & Picot, 2005; Bisset, 1988b; Chénieux, Ramawat & Rideau, 1988; Lavergne & Véra, 1989; Loupy, 1987; Moinet-Hedin et al., 2000; Rouillard & Guého, 2000; Svoboda, Poore & Montfort, 1968.

Sources of illustration Leeuwenberg, 1988a.

Authors A. Gurib-Fakim

OCHROSIA OPPOSITIFOLIA (Lam.) K.Schum.

Protologue Engl. & Prantl, Nat. Pflanzenfam. 4(2): 156 (1895).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Ochrosia parviflora* (Forst.f.) G.Don (1837).

Vernacular names Bois chauve-souris (Fr).

Origin and geographic distribution *Ochrosia oppositifolia* is widely distributed on the coasts of the islands throughout South-East Asia and the Pacific. In Africa it is restricted to the Seychelles.

Uses In the Seychelles a bitter bark decoction is taken to purify the blood, as an appetizer, purgative and carminative, and in high doses as an abortifacient. A leaf decoction is used to wash the abdomen of women after childbirth. *Ochrosia oppositifolia* has similar uses in South-East Asia. The wood was formerly used for construction.

Properties Research on active constituents in *Ochrosia* has focused on anticancer compounds following the isolation of the indole alkaloids ellipticine, elliptinine, 9-methoxy-ellipticine and isoreserpiline from the Asian *Ochrosia elliptica* Labill. Many *Ochrosia* spp. have since been subject to investigation of their alkaloid content.

The main compounds present in the bark of *Ochrosia oppositifolia* are reserpiline, isoreserpiline and ochropposine. Numerous other indole alkaloids have been recorded in the bark, including epi-rauvanine, bleekerine, ochropposinine, reserpinine and isoreserpinine, but no ellipticine or derivatives. The principal constituent of the leaves is isoreserpiline, with 10-hydroxy-apparicine and 10-methoxy-apparicine as minor compounds.

The wood is yellowish white and hard.

Botany Small to medium-sized tree up to 25 m tall, glabrous except for the corolla tube inside, with white latex; bole up to 50 cm in diameter; bark pale grey, rough; branches with ring-shaped leaf scars. Leaves in whorls of 4, sometimes opposite near the inflorescence, simple and entire; petiole 1–6.5 cm long, not widened into a stipule at base; blade obovate to elliptical, 8–35 cm × 3–15 cm, base decurrent into the petiole, apex rounded, retuse or obtuse, pinnately veined with numerous lateral veins at right angles to the midrib. Inflorescence a terminal cyme, but often seemingly axillary, many-flowered; peduncle 2–14 cm long; lower bracts leafy, broadly ovate, others scale- or sepal-like. Flowers bisexual, regular, 5-merous, almost sessile; sepals connate at base, ovate, 1–2 mm long, thick; corolla creamy to white, tube 4–10 mm long, cylindrical, slightly widened around the stamens, lobes elliptical, 5–9 mm × 2–3 mm, apex rounded, spreading; stamens inserted c. 2 mm below the mouth of the corolla tube, included, sessile; ovary superior, consisting of 2 free carpels, style 1–4.5 mm long, ending in an ovoid pistil head, with a basal ring and a 2-lobed apex. Fruit consisting of 2 free ovoid to ellipsoid drupes 5–8 cm × 3–5.5 cm, apex rounded or apiculate, indehiscent, smooth, mesocarp fibrous, each drupe 1–2-seeded. Seeds elliptical, flattened, 1.5–2.5 cm long, winged.

Ochrosia comprises about 30 species and occurs from the Mascarene Islands and Seychelles to South-East Asia, the Pacific and northern Australia. New Caledonia is particularly rich in endemic species. *Ochrosia* belongs to the tribe *Rauvolfieae*, together with the well-known genus *Rauvolfia*.

The fruits float with their thick fibrous mesocarp and are dispersed by sea currents. *Ochrosia oppositifolia* fruits planted without removal of the pulp germinate poorly and only after about 8 months.

Ecology *Ochrosia oppositifolia* occurs in coastal forest, bush or open localities, only occasionally far inland, often on limestone, up to 100 m altitude.

Genetic resources and breeding The widespread natural distribution of *Ochrosia oppositifolia* and its tolerance of disturbed habitats limit the risk of genetic erosion. In the

Annex 925

"*Cyperus javanicus*", *Native Plants Hawai'i*, University of Hawaii, *available at* http://nativeplants.hawaii.edu/plant/view/Cyperus_javanicus (accessed 31 May 2016)

Native Plants Hawaii - Viewing Plant : Cyperus javanicus

Common Names

Synonyms

Plant Characteristics

Distribution Status

Indigenous

Endangered Species Status

No Status

Plant Form / Growth Habit

- Non-Woody, Clumping

Mature Size, Height (in feet)

- Grass-like, Medium, 1 to 2.5
- Grass-like, Tall, Greater than or equal to 2.5

Mature Size, Width

‘Ahu‘awa has a spread of 2 feet or more.

Life Span

Short lived (Less than 5 years)

Landscape Uses

Additional Landscape Use Information

‘Ahu‘awa is flood tolerant and can be used along water banks to control erosion. It is an excellent natural feature for restoration projects and used as food, nesting material and shelter by native waterfowl. This sedge tolerates salty water and soils. [2] The plants will naturally reseed themselves for regeneration without becoming invasive.

An alternate to using umbrella sedge.

Source of Fragrance

- No Fragrance

Plant Produces Flowers

Yes

Flower Characteristics

Flower Type

Not Showy

Flower Colors

Additional Flower Color Information

Though ‘ahu‘awa flowers are diminutive, the golden brown seed heads combined with the beautiful bluish green foliage are attractive features of this native sedge.

Blooming Period

- Year Round

Leaf Characteristics

Plant texture

- Coarse

Additional Plant Texture Information

‘Ahu‘awa leaves range from 16 to more than 45 inches long.

Leaf Colors

Additional Leaf Color Information

Leaves are green to bluish or gray green and often have a powdery white cast.

Pests and Diseases

Additional Pest & Disease Information

‘Ahu‘awa is prone to ants, scale, mealy bugs and aphids.

Growth Requirements

Fertilizer

Fertilize ‘ahu‘awa with small amounts of 8-8-8, and foliar feed at one-third to one-quarter of recommended strength. Do not over fertilize.

Pruning Information

The beautiful leaves are enhanced by the golden seed heads. When these seed heads turn brown they may be trimmed off. If ‘ahu‘awa is being grown for the foliage itself, the seed stalks can be pruned to prolong the life of this sedge. The seed heads and stalks may have potential for flower arrangements. Cut plants back and divide them to keep this sedge looking their best. [Native Nursery, LLC]

Water Requirements

- Dry

Additional Water Information

‘Ahu‘awa can grow in dry, moist and wet conditions, and in standing water to about 8 inches.

Soil must be well drained

No

Light Conditions

Additional Lighting Information

If grown in too much shade ‘ahu‘awa tends grow leggy. The plants perform best in full sun. [David Eickhoff, Native Plants Hawai‘i]

Spacing Information

Space 2 to 4 feet apart.

Tolerances

Soils

Limitations

‘Ahu‘awa leaf blades are very sharp and so do not plant near high traffic walk ways. The saying "sedges have edges" is most apropos for this plant.

Environmental Information

Natural Range

Natural Zones (Elevation in feet, Rainfall in inches)

- Less than 150, 0 to 50 (Dry)
- 150 to 1000, 0 to 50 (Dry)

Additional Habitat Information

‘Ahu‘awa is found in a variety of habitats such as along coastal sites, cliffs and stream banks. In the Northwest Islands this sedge is found on Midway Atoll (Pihemanu) and is known to occur in marshes, taro paddies, along streams and ditches. ‘Ahu‘awa has even been found in mangroves exposed to brackish and salt water. [1]

Special Features and Information

General Information

There are fourteen species in the genus *Cyperus* that are native to the Hawaiian Archipelago, with eight that are endemic, or found exclusively, here. *Cyperus* belong to the Sedge Family (Cyperaceae) consisting of some 4,000 species in about 70 genera.

Famous, or infamous, non-native relatives include papyrus (*Cyperus papyrus*), the source of the Egyptian writing material and the origin of the English word paper; piripiri or cañita (*Cyperus giganteus*) used in parts of Mexico for plaiting sleeping mats and sambreros; and the ever-present noxtious lawn weed nutsedge or "nutgrass" (*Cyperus rotundus*) that keep homeowners busy and gardeners employed, but also used in Kampō (traditional Japanese/Chinese medicine). [3]

Etymology

The generic name Cyperus comes from the *kyperos*, the Greek word for sedge.

The specific epithet *javanicus* is Latin for "belonging to Java." This species is indigenous to Java, Indonesia, and other parts of the world.

Hawaiian Names:
The name ‘Ehu‘awa for this species should not be confused with Ehu‘awa (*Cyperus laevigatus*), which lacks the first ‘okina.

Early Hawaiian Use

Agriculture:
One of the few indigenous plants cultivated by early Hawaiians.

Cordage:
The stems of of ‘ahu‘awa were pounded until there were only fibers. The fibers were soaked for a few hours to free pulp, dried in the sun for a day or two, and then could be used. [7] The material was very durable, lasting two years or more. Two- or three-ply cordage was used for cords (hāwele) or nets (kōkō pu‘upu‘u) designed to carry ‘umeke (food or water containers). Due to its strength, it was good for deep water fishing line and canoe rigging. They were also used as strainers for ‘awa or niu

(coconut) drink and medicine. [4,6,7]

Lei:
The leaves and seed/fruit were used in lei. [5]

Medicinal:
‘Ahu‘awa was used to treat ‘ea (thrush) in children. The stems and flowers were used with green kukui (*Aleurites moluccana*) fruit sap. ‘Ahu‘awa was also used with ‘alaea clay, ‘awa root (*Piper methysticum*), and kō kea (white sugar cane) for ule hilo (gonorrhea) and waikī (gonorrhea in males). The fine sediment of ahu‘awa was mixed with lama kuahiwi (*Diospyros* spp.) for use on deep cuts, bruises, boils, cold sores. A runny nose is treated by inhaling powdered ‘ahu‘awa. [8]

Other Uses:
The stringy fibers were also made into brushes to paint color onto tapa (kapa). [4]

Additional References

[1] "A Guide to Pacific Wetlands Plants" by Lani Stemmermann, page 38.

[2] "Amy Greenwell Garden Ethnobotanical Guide to Native Hawaiian Plants & Polynesian Introduced Plants" by Noa Kekuewa Lincoln, page 9.

[3] http://en.wikipedia.org/wiki/Cyperus [accessed 10/12/09]

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[6] "Resource Units in Hawaiian Culture" by Donald D. Kilolani Mitchell, page 136.

[7] "Lā‘au Hawai‘i: Traditional Hawaiian Uses of Plants" by Isabella Aiona Abbott, page 59, 62, 63.

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More Links

Plant Gallery

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Other Nursery Profiles for *Cyperus javanicus*

Annex 926

"*Cordia subcordata*", *Native Plants Hawai'i*, University of Hawaii, *available at* http://nativeplants.hawaii.edu/plant/view/Cordia_subcordata (accessed 31 May 2016)

Native Plants Hawaii - Viewing Plant : Cordia subcordata

Cordia subcordata

Main Plant Information

Genus

Cordia

Species

subcordata

Hawaiian Names with Diacritics

- Kou

Hawaiian Names

- Kou

Did You Know…?

Kou was thought to be exclusively a Polynesian introduction. Indeed the early Hawaiians did bring the useful kou with them on their journey to the islands. However, recently eveidence of kou was found on Kaua‘i that pre-dates human arrival. Kou is now catagorized as an indigneous to the Hawaiian Islands.

Plant Characteristics

Distribution Status

Indigenous

Endangered Species Status

No Status

Plant Form / Growth Habit

- Tree

Mature Size, Height (in feet)

- Tree, Small, 15 to 30
- Tree, Medium, 30 to 50

Mature Size, Width

Canopy may spread to 25 feet across, often as wide as tall. In the 19th century, kou grew as tall as 50 feet in Hawai‘i, but defoliation by kou leaf worm as reduced the heights. Such giants may remain in remote areas in the Marshall Islands and the elsewhere in the Pacific, and perhaps over a century old. [7]

Life Span

Long lived (Greater than 5 years)

Landscape Uses

Additional Landscape Use Information

Kou is an excellent tree for a roomy landscape. They can get to be medium-large trees and may not be suitable for small urban yards that cannot accommodate a height and canopy spread of 25-35 feet. [7] Good to keep in mind that they have a shallow root system and can be damaged by too much surface disturbance. Once established they require little maintenance.

However, the slippery fruits along with exceptionally hard seeds may present a hazzard if planted too close to driveways or along sidewalks where they can a present a real threat for slipping or going an unintentional "skating trip." [7]

In many urban plantings kou is being replaced by kou haole or the Geiger tree, a similar species with red-orange flowers and rough leaves. This is unfortunate because the Geiger tree is a native of the West Indies and has no cultural value in the Hawaiian Islands. [7]

Plant Produces Flowers

Yes

Flower Characteristics

Flower Type

Showy

Flower Colors

Additional Flower Color Information

Flower color ranges from light to bright orange.

Blooming Period

Additional Blooming Period and Fruiting Information

Generally, kou fruit all year long, but maybe sporadic. [7] The green fruits soon become brown and then dry to a blackish color when ripe. Inside are four white seeds.

Leaf Characteristics

Plant texture

- Coarse

Additional Plant Texture Information

Leaves are smooth and somewhat glossy.

Leaf Colors

- Medium Green

Additional Leaf Color Information

Kou trees with varigated green and white leaves are known. [7]

Pests and Diseases

Additional Pest & Disease Information

The Kou leaf worm (*Ethmia nigroapicella*), from a moth, can defoliate and can be killed kou trees. The wood is very termite reistant. Large trees can develop heartwood rot. [7]

Growth Requirements

Pruning Information

Kou trees will often grow crooked and pruning is necessary to keep a nice shape. [7]

Water Requirements

- Dry

Soil must be well drained

Yes

Light Conditions

Additional Lighting Information

Prefers full sun but tolerates some shading. [7]

Tolerances

Soils

Limitations

Moderately drought tolerant trees. Kou will not grow at higher altitudes and cannot withstand frost. Kou can grow in saline soils and tolerate some salt spray, but heavy spray can severley damage leaves. [7]

Environmental Information

Natural Range

Natural Zones (Elevation in feet, Rainfall in inches)

- Less than 150, 0 to 50 (Dry)
- 150 to 1000, 0 to 50 (Dry)

Habitat

- Terrestrial

Additional Habitat Information

Kou is found throughout most of the Main Islands today, but is only known to have occurred for a certainty as an indigenous plant on Kaua‘i in the past. [3]

Special Features and Information

General Information

Kou (*Cordia subcordata*) is in the Borage or Foget-me-not family (Boraginaceae). Other native members include nama or hinahina kahakai (*Nama sandwicensis*), hinahina (*Heliotropium anomalum* var. *argenteum*), and kīpūkai (*H. curassavicum*).

Well known non-native kin include the tree heliotrope (*Tournefortia argentea*) commonly seen along the salty Hawaiian coasts; borage (*Borago officinalis*), used in European cuisine; comfrey (*Symphytum* spp.); and kou haole or Geiger tree (*Cordia sebestena*), a commonly used landscape tree in the islands in urban areas along streets, business districts, public parks, housing common areas, and private yards.

Etymology

The generic name *Cordia*, is named for Euricius Cordus (1485-1535) and his son Valerius (1515-1544), both German botanists and pharmacists.

The specific epithet is from the Latin *sub*-, almost or not completely, and *cordatus*, cordate (with two

equal rounded lobes at base) in reference to the leaf shape, literally meaning "almost heart-shaped."

Background Information

Formerly thought to be exclusively a Polynesian introduction, a recent fossil site at Māhāʻulepū, Kauaʻi predates Polynesian arrival where kou samples were found and thus proving that kou is also an indigenous plant. [3,6] The seeds are salt-water tolerate and disperse along coastal areas even on atolls where few other timber trees for wood can grow. [5]

In Papua New Guinea this indigenous tree is known as the Kerosene tree because it burns so easily.

Cordia subcordata is known by a number of local names outside of the Hawaiian Islands, such as Bird lime tree, Glueberry, Kerosene wood, Manjak, Mareer, Marer, Narrow-leafed bird lime tree, Snottygobbles, and Tou.

Early Hawaiian Use

Early Hawaiians certainly brought kou with them as one of the canoe plants since it is such a highly esteemed wood. [5,12]

They were planted as a favorite shade tree around houses and by the seashore. [9] Women would beat their kapa under kou trees. [12]

Kou was considered as one of the best woods for carvings along with the native koa (*Acacia koa*) and milo (*Thespesia populnea*), and the Polynesian introduced kamani (*Calophyllum inophyllum*). [7,8,12] Kou was prized because of the beauty of the grain and ease of cutting and carving. [12]

Dye:
The leaves were used to stain fishing lines a light tan. [5,10,12] The aged leaves were used for a warm brown to red dye for kapa. [1]

Fishing:
Wood was made into fishing hook containers. [12]

Food:
The tasteless seeds were eaten in times of famine or occasionally by hungry children.

Household Furnishings:

Wooden food bowls (ʻumeke kou), meat dishes, cups, platters (pā kou), and calabashes were highly prized as the best of all woods because it did not impart a resinous flavor to the food such as koa and most other native woods. [2,4,8,10]

Lei:
The flowers were used for lei and young girls especially were fond of lei kou. [4,9,12] They were always strung kui style (one behind the other). [10]

Medicinal:
Use to treat ʻea (thrush), a disease of young children. [12]

Religion:
Kou wood was fashioned into images of gods. [12]

Modern Use

The wood is used to carve artifacts such as calabashes, dishes, cups, bowls, paddles, furniture, and drums. [5,11]

Uses Outside of Hawaiʻi:
In Tahiti, fruit of banyan (*Ficus* sp.) is added to kou leaves to make a beutiful red dye. [12]

Additional References

[1] "Plants in Hawaiian Culture" by Beatrice H. Krauss, page 65.
[2] "Arts and Crafts of Hawaii" by Te Rangi Hiroa (Sir Peter H. Buck), pages 37-38, 187.

[3] "Fossil Evidence for a Diverse Biota From Kauaʻi and Its Transformation Since Human Arrival" by David Burney et al., Ecological Monographs, 71(4), 2001, Ecological Society of America, pages 631, 632, 633.

[4] "Nā Lei Makamae--The Treasured Lei" by Marie A. McDonald & Paul R. Weissich, page 53-54.

[5] "Plants of the Canoe People" by W. Arthur Whistler, pages 83-84.

[6] "Back to the Future in Caves of Kauaʻi--A Scientist's Adventures in the Dark" by David A. Burney, page 106.

[7] "Traditonal Trees of the Pacific Islands: Their Culture, Environment, and Use," pages 305, 307, 309, 312, 313.

[8] "Resource Units in Hawaiian Culture" by Donald D. Kilolani Mitchell, pages 79-80, 120, 130-131.

[9] "In Gardens of Hawaii" by Marie C. Neal, pages 714-715.

[10] "Lāʻau Hawaiʻi: Traditional Hawaiian Uses of Plants" by Isabella Aiona Abbott, pages 57, 87, 127.

[11] "Contemporary Woodworkers" by Tiffany DeEtte Shafto & Lynda McDaniel, page 182.

[12] "Ethnobotany of Hawaii" by Beatrice H. Krauss, page 133.

More Links

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Other Nursery Profiles for *Cordia subcordata*

Annex 927

Betsy R. Jackes, *Plants of Magnetic Island* (3d ed., 2010), *available at* https://issuu.com/jamescookuniversity/docs/maggie-complete

PLANTS OF MAGNETIC ISLAND

3rd EDITION

BETSY R. JACKES

SCHOOL OF MARINE and TROPICAL BIOLOGY
JAMES COOK UNIVERSITY
TOWNSVILLE
QUEENSLAND

Jackes Betsy R (Betsy Rivers)
Plants of Magnetic Island

ISBN: 978-0-9808183-8-3

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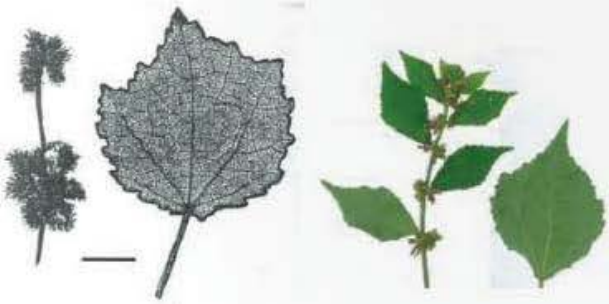
Andi Cairns provided valuable assistance with the layout and with suggestions on the manuscript. To all those who have suggested changes, who have provided lists of plants, particularly the staff of the Queensland Herbarium, my grateful thanks.

Triumfetta rhomboidea (Chinese Burr, Triumfetta Burr – Sparrmanniaceae formerly part Tiliaceae)*

Triumfetta, named after Giovanni Triumfetti (1658-1707) A Professor of Botany in Rome. Shrubby plant to 1.5 m tall, leaves usually 3-lobed, 3-veined at base. Flowers **yellow** in clusters, stamens 10-15 per flower; capsule to 9 mm long, to 8 mm diameter, covered in prickles. It is a common weed. A similar species occurring in the Townsville area is ***Triumfetta pentandra***, it may be distinguished by the flower only have 5 stamens and the fruit is densely hairy on one side only.

Triumfetta repens is a low spreading shrub, stamens 30-40 per flower, fruits from 17-22 mm long and 15-20 mm diameter, covered with firm prickles. Leaf shape variable in shape and size in both species.



T. rhomboidea (left), *T. pentandra* (right)

T. repens

Sida spp. (Malvaceae)

Sida is the Greek name for a water plant, as one of the first species described grew in a moist habitat.

These subshrubs frequently have leaves covered with stellate or star-shaped hairs and the leaf margins are often indented. Flowers **yellow to orange**, staminal filaments fused for most of their length to form a column. Stylar branches 5, fruit a capsule, the valves of the fruiting sections are referred to as mericarps, the hard sides of each are often rough. Most are weedy. Some common ones are:

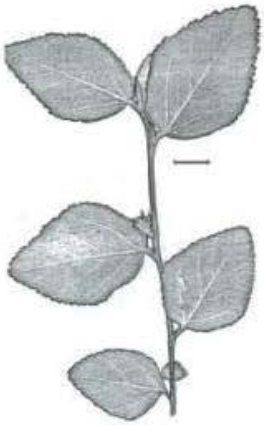
Sida atherophora, stems with stalked stellate hairs, calyx 10-ribbed at base, mericarps 6-9;

Sida cordifolia (Flannel Weed), plant densely softly hairy, hairs not stalked, leaves softly hairy almost velvety to feel, often appearing yellowish-green, calyx 10-ribbed at base, mericarps 10-11; which each bear 2 bristles about 3 mm long;

Sida rhombifolia (Common Sida, Paddy's Lucerne)*, the hairs are minute, not stalked, mericarps 9-10, each with 2 ribs on the back and 2 apical spines are present;

S. atherophora

S. cordifolia



S. rhombifolia

Annex 928

H. Suryawanshi & M. Patel, "Traditional Uses, Medicinal and Phytopharmacological Properties of *Erythrina Indica* Lam: An Overview", *International Journal of Research in Ayurveda & Pharmacy*, Vol. 2, No. 5 (10 Feb. 2011), *available at* http://www.ijrap.net/admin/php/uploads/649_pdf.pdf

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Review Article

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TRADITIONAL USES, MEDICINAL AND PHYTOPHARMACOLOGICAL PROPERTIES OF *ERYTHRINA INDICA* LAM: AN OVERVIEW

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ABSTRACT
Medicinal plants are the nature's gift to human society to make disease free healthy life. It plays a vital role to buildup and preserve our health. In our country more than thousands medicinal plants are recognized. The present review is therefore, an effort to give a detailed survey of the literature on its Phytopharmacological properties.
Erythrina indica belonging to the family Leguminosae is a compact shrub with knobby stems, growing wild throughout the costal forest of India. It is popular in indigenous system of medicine like Ayurveda, Siddha, Unani and Homoeopathy. In the traditional system of medicine various plant parts such as bark, root, leaves and fruits are used in fever, liver ailment, rheumatism, relieve joint pain, and to kill tapeworm, roundworm and threadworm.
Key words: *Erythrina indica*, Leguminosae, Phytopharmacological, collyrium, rheumatism.

INTRODUCTION

Medicinal plants continue to be an important therapeutic aid for alleviating the ailments of human kind. The search for eternal health and for remedies to relieve pain and discomfort drove early man to explore his immediate natural surroundings and led to the use of many plants, animal products, and minerals, etc. and the development of a variety of therapeutic agents. Today, there is a renewed interest in traditional medicine and an increasing demand for more drugs from plant sources. This revival of interest in plant-derived drugs is mainly due to the current widespread and strong belief that "green medicine" is safe and more dependable than the costly synthetic drugs, many of which have adverse side effects.

Description

Erythrina indica belonging to the family Leguminosae also known as Indian coral tree or Tropical coral tree or Tiger's clow or Moochy wood tree or Variegated coral tree, Sunshine tree, Coral bean, Pangara (Marathi). *Erythrina indica* is a compact shrub with knobby stems. It posses dense clusters of deep crimson flowers, that spread broadly open. *E. indica* is a medium-sized, spiny, deciduous tree normally growing to 6-9 m tall. Young stems and branches are thickly armed with stout conical spines up to 8 mm long, which fall off after 2-4 years rarely; a few spines persist and are retained with the corky bark. Bark is smooth and green when young, exfoliating in papery flakes, becoming thick, corky and deeply fissured with age. Leaves are trifoliate, alternate, bright emerald-green, petioles are long about 6-15 cm, rachis 5-30 cm long, prickly; leaflets smooth, shiny, broader than long, 8-20 by 5-15 cm, ovate to acuminate with an obtusely pointed end. Leaf petiole and rachis are spiny.

Flowers are bright red to scarlet, erect terminal racemes 15-20 cm long. Stamens are slightly protruding from the flower. Fruit is a cylindrical torulose pod, green, turning black and wrinkly as they ripen and thin-walled and constricted around the seeds. There are 1-8 smooth, oblong, dark red to almost black seeds per pod. Erythrina comes from the Greek word 'eruthros' meaning red, shows red flowers of the Erythrina species.[1-4]

Synonyms

Erythrina variegata orientalis, *Erythrina variegata* parcelli, *Erythrina variegata* picta

Vernacular Names

English name: Indian coral tree, Tiger's clow, Moochy wood tree, Sunshine tree.
Hindi: Dadap, Pharad, Ferrud.
Marathi: Pangara.
Sanskrit: Paribhadra.
Gujarati: Panarawas, Pararoo.
Bengali: Palidhar Palitu-Mudar.
Kannada: Varjipe, Harivana.
Tamil: Kalyan - Morangai.
Telugu: Bodita, Bodisa.
Malyali: Murukku, Mulmurukku.[1]

Table 1. MORPHOLOGICAL AND GENERAL CHARACTERS

Plant Type	Shrub, Small to medium-sized thorny tree
Roots	Deep roots, Tap roots
Type of stem	Hard, strong, rigid, wooded
Leaf Type	Trifoliate, Pinnate venation, Entire margin, Oval shaped
Leaf Arrangement	Alternate, heart shaped,
Leaf Colour	Green
Leaf Surface	Smooth, shiny.
Bark	Corky, Streaked with vertical lines of green, buff, grey and white.
Flower	Deep red in color, Looks like a tiger's claw
Seeds	Dry pod, kidney shaped, dark purple to red
Odour	Characteristic
Taste	Bitter
Plant Height	Medium (6 – 10 m)
Pollinators	Birds
Propagation/Cultivation	By seeds
Plant feature	Costal side plant, Forest plant, hill side plant.
Plant Utilities	Medicinal, Industrial, Commercial plant.

Taxanomy

Erythrina indica falls under the scientific classification as follows
Scientific classification
Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Fabales
Family: Leguminosae
Genus: Erythrina
Species: *Erythrina indica*[1, 5]

Fig.1. Leaves of E. Indica

Fig.2. Flower of E. Indica

Habit and habitat

Erythrina indica is well adapted to the humid and semi-arid and tropics and subtropics, found in zones with annual rainfall of 800 to 1500 mm. The species is most commonly found in warm coastal areas up to an elevation of 1500 m. The plant grows all over India in many forests and hills. It is frequently found around the Marshy Land, Plain Land. The Plant is a prickly shrub or woody vine reaching a length of 10 m.in height.

Phytoconstituents Present

The preliminary phytochemical investigation showed the presence of alkaloids, carbohydrates, amino acids, tannins, steroids, flavonoids.

Traditional/Ayurvedic Utilities

An Indian preparation is used to destroy pathogenic parasites and relieve joint pain. Juice from the leaves is mixed with honey and ingested to kill tapeworm, roundworm and threadworm. Women take this juice to stimulate lactation and menstruation. A warm poultice of the leaves is applied externally to relieve rheumatic joint pains. The bark is used as a laxative, diuretic and expectorant. Different parts of plant are used in traditional medicine as nervine sedative, collyrium, in opthalmia, anti-asthmatics, antiepileptic, antiseptic and as an astringent. Bark is used in fever, liver ailment and rheumatism. The leaf juice used to heal wounds and sores. Leaf paste applied for muscular pain in cattle. Leaf extract possess nematicidal property. The root extract possess antimicrobial activity. Bark is astringent and used as febrifuge and anthelmintic. It is also used as an antidote to strychnine. Its leaves are aperient; they also encourage the start of menstruation and of milk secretion. The bark is helpful in gallstone, liverishness, an expectorant, febrifuge, and vermifuge.[6-9]

Phytochemical Properties

Erythrina indica contain several phenolic metabolites, such as pterocarpans, isoflavones, flavanones and chalcones, some of which displayed antiplasmodial activity, antimycobacterial activity and cytotoxic activity against various cancer cell lines. It also contain alkaloids like N-norprotosinomenine (I), protosinomenine (2), erysodienone (3), 3-erythroidine, erysopine, erythraline, erythramine, erysodine, erysotrine, erythratine, N,N-dimethyltryptophan, hyparphorine and it also contains sterols like campesterol, β-sitosterol, β-amyrin. The isoflavones named as indicanines D and E together with 11 known compounds including 6 isoflavones like genistein, wighteone, alpinum isoflavones, dimethyl alpinum isofavone, 8- prenyl erythrinin 'C' and erysenegalensein E and one Erythrinassinate B. Flavonoids include apigenin, genkwanin, iso-vitexin, swertisin, saponarin, 5-Oglucosylswertisin and 5-O-glucosylisoswertisin. Glucoside swertiamarin, a triterpene betulin have also been isolated. The alcohol insoluble portion of the unsaponifiable matter has yielded n-hexosamol, heptacosine, nonacosane and non saponifiable matter of the petroleum ether extract has yielded myristic, stearic and oleic acids.[10-15]

Pharmacological Properties

Anti-Osteoporotic Effect

Study showed that *Erythrina indica* could suppress the high rate of bone turnover induced by estrogen deficiency and improve the biomechanical properties of bone in the lab rats.[16]

Cytotoxic

Study showed that isolated five compounds from the methanol extract of stem bark of Erythrina Variegata: epilupeol, 6-hydroxygenistein, 3ß, 28- dihydroxyolean-12-ene, epilupeol, and stigmasterol. Different compound showed varying degrees of Cytotoxicity.[17]

Anthelmintic Activity

The method described by Dash et al. was employed for evaluating anthelmintic activity. Pheritima posthuma was divided into seven groups. Each group consists of six earth worms of same type and treated with any of the following. 50 milliliter of test solution containing 50 and 100 mg /ml of test extracts. Ethanol, Chloroform and Ethyl acetate extract of leaves of *Erythrina indica* and Piperazine citrate (10mg/kg). The Mean time of paralysis and death was recorded in minutes. The paralysis time was recorded when no movement of any sort could be observed except when the worms were shaken vigorously. Times for death of worms were recorded when worms were neither moved while shaken vigorously or when dipped in warm water (50°C).[18]

Antiulcer Activity

Sakat Sachin et.al studied Antiulcer activity of methanol extract of *Erythrina indica* leaves in pylorus ligated and indomethacin induced ulceration in the albino rats. The methanol extract of E. indica leaves possess significant antiulcer properties in a dose dependent manner.[19]

Diuretic Activity

The method of Lipschitz et al was employed for the evaluation of diuretic activity. The animals were divided in to five groups (six in each) deprived of food and water for 18hrs. prior to the experiment. On the day of experiment, the Group I animals received normal saline (20 ml/kg. p.o.), the Group II animals received furosemide (20 mg/kg. i.p.), the Group III, IV and V animals received Ethanol, Chloroform and Ethyl acetate extracts (250 mg/kg) respectively. The total volume of urine was collected at the end of 5hr. The total volume of urine and the urine concentration of Na^+, K^+ and Cl^- the Na^+ and K^+ were measured by ß ame photometry.[20]

Analgesic Activity

Haque et.al were studied, the peripheral analgesic activity of methanolic extract of leaf of E. indica was determined by the acetic acid induced writhing inhibition method. The inhibition of writhing in mice by the plant extract was compared against inhibition of writhing by a standard analgesic agent, aminopyrine given orally at a dose of 50 mg/kg body weight. The number of writhing was calculated for 10 min 5 minutes after the acetic acid injection. The analgesic activity was determined by radiant heat tail-flick model in mice. Tail-flick latency was assessed by the Analgesiometer. The methanolic extract of leaf of *Erythrina indica* possesses significant analgesic activity. [21]

Cardiovascular Effects

G.K. Chatterjee et.al were studied, The intravenous administration of the aqueous extract at a dose, varying from 0.1-0.4mg/kg produced a sharp and short lived fall in B.P., both in cats and rats in acute experiments. The cats were sensitive as regards the hypotensive action than rats, since a moderate fall was noted with 0.12 mg/kg while in rats the hypotensive response noted only after 0.4 mg/kg. On the isolated frog hearts the extract has no action in smaller dose but at a dose of 5 mg resulted a complete but reversible block of the heart.[22]

Effect on Smooth Muscle

G.K. Chatterjee et.al were studied, The aqueous extract produced a contraction of intestinal smooth muscle in isolated guinea pig-ileum preparations at a dose of 1.3 x 10-5 g/ml; it is abolished by retreating the ileum with dephenhydramine but not abolished by pretreatment with atropine. [22]

Respiratory Effects

G.K. Chatterjee et.al were studied, In smaller doses, the extract did not affect the respiration in urethane treated guinea-pigs but at higher doses the rate of respiration increased but there was no change in its amplitude. The effect generally persisted for 15-20 minutes. At a very high dose (4.6 mg/kg, iv.) the respiration become shallow and in some cases even there was a short, lasting apnoea. [22]

CNS Effects

G.K. Chatterjee et.al was reported to the extract was relatively non-toxic and the mice can tolerate a dose more than 500 mg/kg, ip. of the extract. For CNS activity the extract was administrated at a dose of 80 mg/kg im. Pretreatment of mouse with the extract neither potentiated nor reduced the pentobarbitone dose induced sleeping time. Similarly the extract failed to protect the mouse significantly from pentylenetetrazol induced convulsions. [22]

Antioxidant Activity

Saraswathy A., et.al were investigated the ethanolic extract of the stem bark of *Erythrina indica* was screened for its *in vitro* antioxidant activity by Ferric thiocyanate and thiobarbituric acid methods were employed and it was found that the ethanolic extract of the stem bark of *Erythrina indica* possess significant antioxidant activity. [23]

CONCLUSION

There are thousands of different tribal and other ethnic groups in India. A part from the tribal groups many other rural people also possess important knowledge about the plants. In recent years, ethnomedicinal studies received much attention as this brings to light the numerous little known and unknown medicinal virtues especially of plant origin. They obviously deserve evaluation on modern scientific lines such as phytochemical analysis, Pharmacological screenings and clinical trials. In the present article, we have reviewed the literatures to collect the botanical, Ethnobotanical, phytochemical and pharmacological information on *Erythrina indica*. The leaves, bark and root are used in India for the treatment of various diseases. The different extract of *Erythrina indica* and species shows anthelmintic activity**,** anti-osteoporotic effect, cytotoxic, antiulcer activity, analgesic, antioxidant activity, diuretic activity.

A critical analysis of the literatures of *Erythrina indica* finds use as a medicine is fairly large, yet its therapeutic efficacy has been assessed only in few cases. In view of the wide range of medicinal uses of *Erythrina indica* as mentioned in Ethno botanical surveys, Ayurveda, Unani system.

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Annex 929

S.T. Gopukumar, et al., "Biochemical Profile and Potential Medicinal Use of *Ipomea Biloba* Present in the Western Coastal Line of Arabian Sea at South India", in *Drug Discovery, Threatened Medicinal Plants and Strategies for Sustainable Use* (S. Dominicrajkumar & J.K. Lal, eds., 2013)

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Drug discovery, Threatened medicinal plants and strategies for sustainable use

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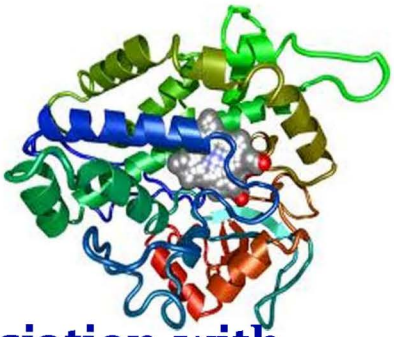


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"DRUG DISCOVERY, THREATENED MEDICINAL PLANTS AND STRATEGIES FOR SUSTAINABLE USE"

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IN

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BIOCHEMICAL PROFILE AND POTENTIAL MEDICINAL USE OF *IPOMEA BILOBA* PRESENT IN THE WESTERN COASTAL LINE OF ARABIAN SEA AT SOUTH INDIA

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ABSTRACT

Ipomea biloba is an aquatic perennial runner plant used as a medical herb for various diseases. The plant were collected and extracted for biochemical compound isolation. In this present study the medicinal uses and biochemical parameters such as enzymes, amino acids, antioxidants, chlorophyll content, calcium, iron and total phenol present in the plant by using different methods.

Keywords: *Ipomea biloba*, amino acids, sap, erosion, enzymes, minerals

INTRODUCTION

In India, large diversity of plant species is available; of these species some are either beneficial or harmful. Fruits and vegetables generally form indispensable constituents of human diets supplying the body with minerals, vitamins and certain hormone precursors, in addition to small amounts of protein and energy. The plant *Ipomea biloba* belongs to the plant family Convoluvulacea, a moving glory family. It is a semi-aquatic tropical plant. In Tamil it was known as "Kadamba Valli". *I.biloba* was mainly located on the west coast of India, bounded by Arabian Sea. It is established worldwide on many tropical beaches including those of Australia and the Caribbean [1][2]. The predominant soils in the district are laetrile soils. The plant size may be up to 100 feet long.

It grows well on nutrient-poor, moist, sandy, or calcareous soils [3]. The growth of *I.biloba* was extensive on the sand dunes near the shore "cyanodon dactylon" a gramiane member was also found growing luxuriously along *I.biloba*. This type of plant species are normally seen under the coastal areas of Arabian Sea. The leaves of the plants are greenish in color [4]. The flower of *I.biloba* is pink in nature. The plant produces adventitious roots at the nodes and run horizontally rather than vertically [5]. It does not tolerate prolonged frost conditions. It provides habitat for many diverse animal species including gopher tortoise, the endangered beach mice, scrub jay and the threatened kestrel.

MATERIALS AND METHODS

I.biloba was collected from west costal line of Manavalakurichi village,

Kanyakumari district, Tamilnadu, India. The leaves were separated and cleaned well. Cleaned leaves were then dried under shade. The drying process was continued until all the water molecules evaporated and leaves became well dried for grinding. The leaves were finely powdered and extracted with acetone solvent using Soxhlet apparatus.

In this study the presence of Carbohydrates and Pentose was analyzed by using Molisch test and Bial's test method. The presence of Tryptophan and Histidine were analyzed by using Hopkins cole and Pauly's method. The estimation of Protein was done by Biuret method. Total Phenol was estimated by using Bray and Thorpe method. The minerals such as iron and calcium were estimated using Clark & Coltip method and Dipyridyl method. The enzymes amylase and catalase were estimated by using Caraway and Sodium Perborate method. The Estimation of Lipid was done by using Bilgh's & Dyes method.

RESULTS

I.biloba is a plant with an immense medicinal property in it. The plant plays a vital role for both human as well as environment. The sap from the succulent leaves has been used as a first-aid to treat jelly fish stings. Both leaves and stems exude a watery white sap that may be a chemical protection against insect pests and grazing animals. The plant also serves nature by preventing soil erosion. The plant also provides Food & Shelter for some sea insects and animals. The qualitative and quantitative screeing of the I.biloba were carried out and the results were tabulated in table 1 and table 2 respectively.

Table: 1 Qualitative biochemical screening of *I.biloba*

S.No	Compounds	Inference
1	Carbohydrates	+
2	Pentose	+
3	Tryptophan	+
4	Histidine	+

Table: 2 Quantitative biochemical screening of *I.biloba*

	Compounds	Contents
1	Protein (0.2ml)	0.357g/dl
2	Protein (0.5ml)	0.4286g/dl
3	Total Phenol	920µg/dl
4	Iron	320µg/dl
5	Calcium	10mg/dl
6	Amylase	137 caraways
7	Catalase	4.329×10^{-4} µmol/min
8	Lipid	82.39g

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The essence of all beings is earth,
The essence of earth is water,
The essence of water is plants,
The essence of plants is the human being.

-Chandogya, from the Upanishads

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Annex 930

Xavier Romero-Frias, "Eating on the Islands: As times have changed, so has the Maldives' unique cuisine and culture", *Himal Southasian*, Vol. 29, No. 1 (5 Apr. 2013)

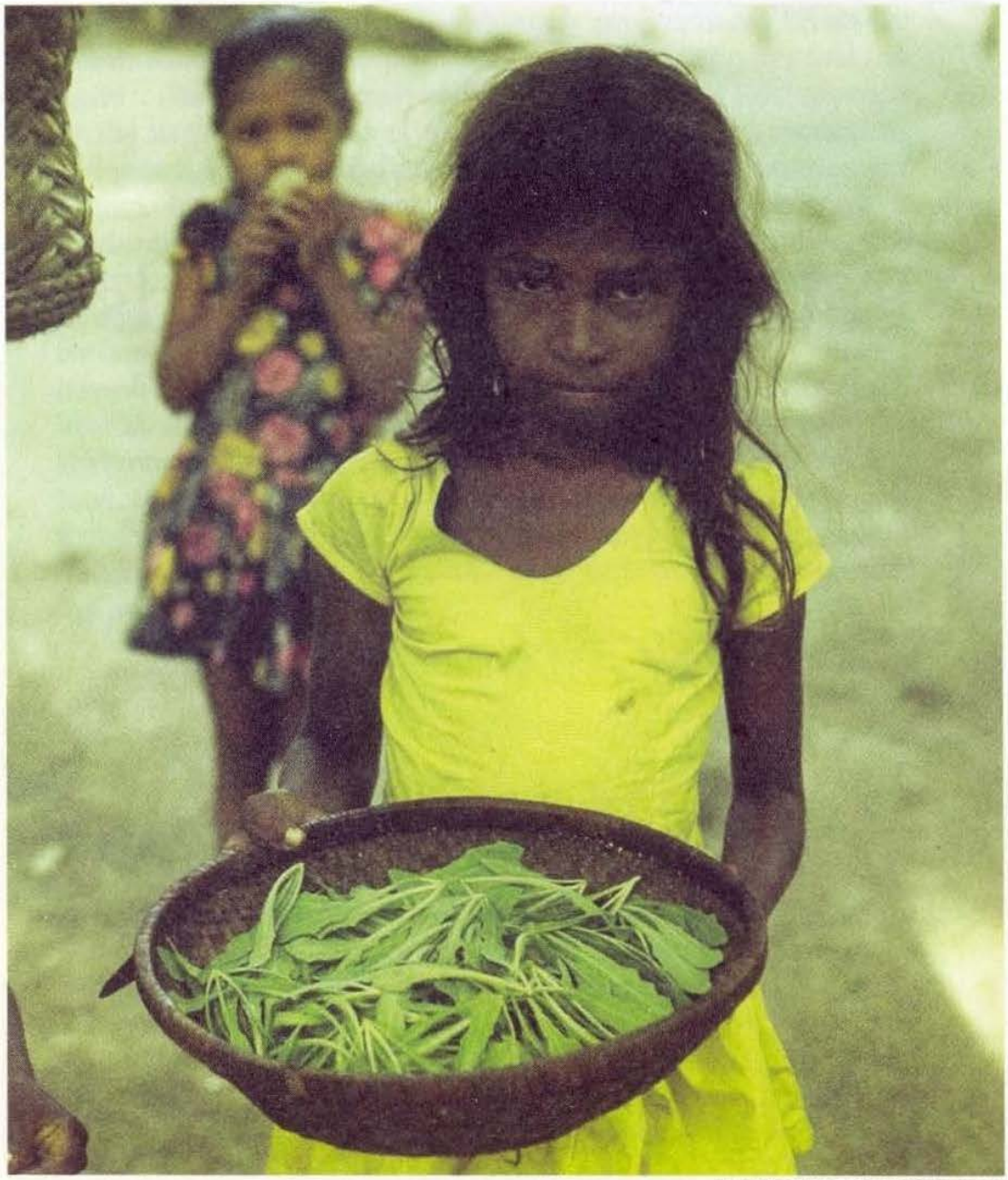
Eating on the islands

As times have changed, so has the Maldives' unique cuisine and culture.

BY XAVIER ROMERO-FRIAS

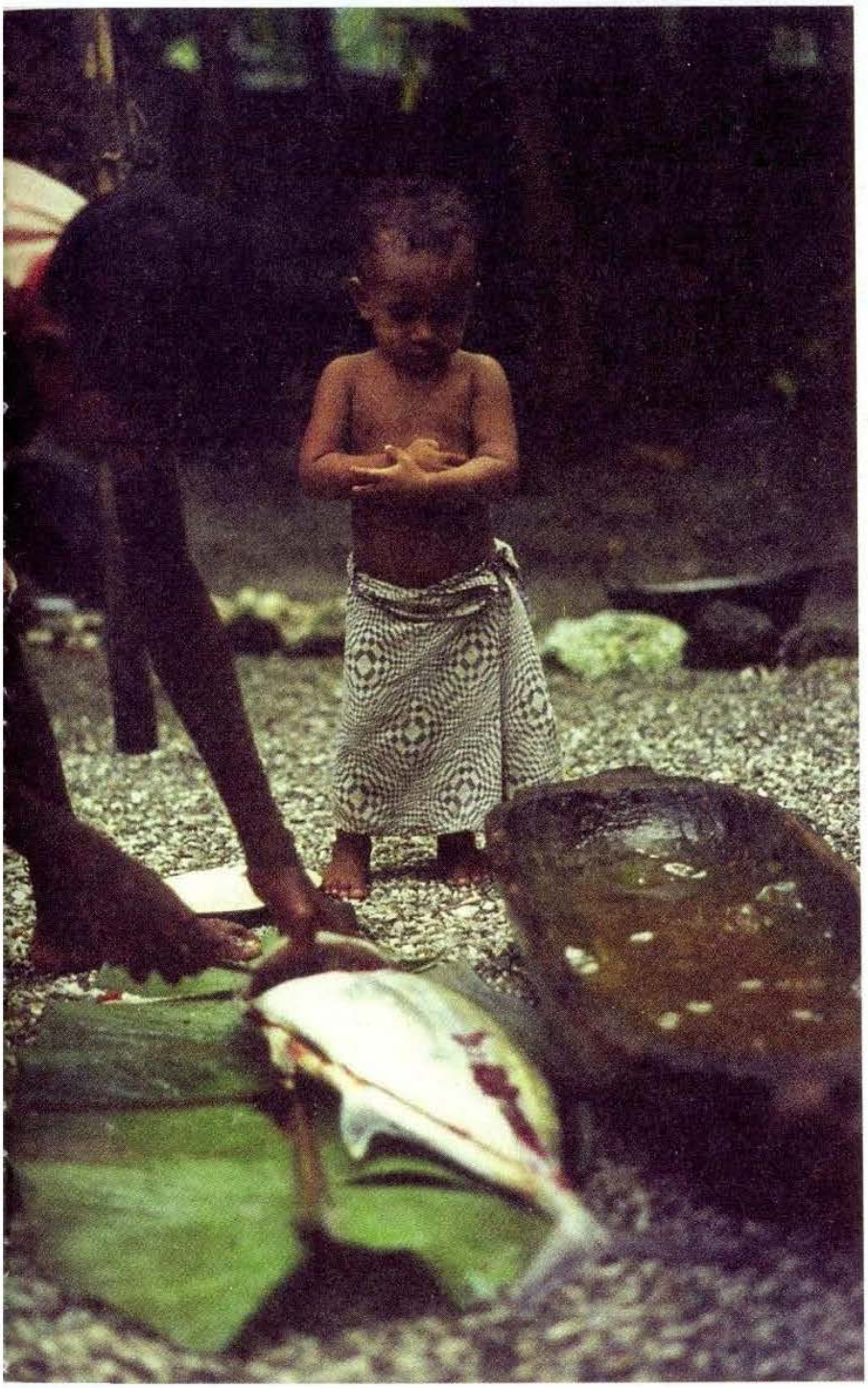
The Maldives has transformed somewhat in the last couple of decades. A few years ago while I was living in India, I met my friend Ahmed Nasim from the village of Funad on Fua Mulaku, a large and lonely island located far south of the Maldivian atoll chain. We had not seen each other for almost 20 years, and Nasim was eager to tell me about the changes that had occurred since the end of my 13 years in the Maldives: a harbour had been built on Fua Mulaku, and there were now paved roads. There was even an airport under construction.

Nasim and I shared good memories; he had often entertained me with local horror stories in the long, quiet Fua Mulaku evenings. I vividly recall the soft, warm light of oil lamps and the tranquility of his home, the two of us sitting on the large swing and his children playing or sleeping close to us.

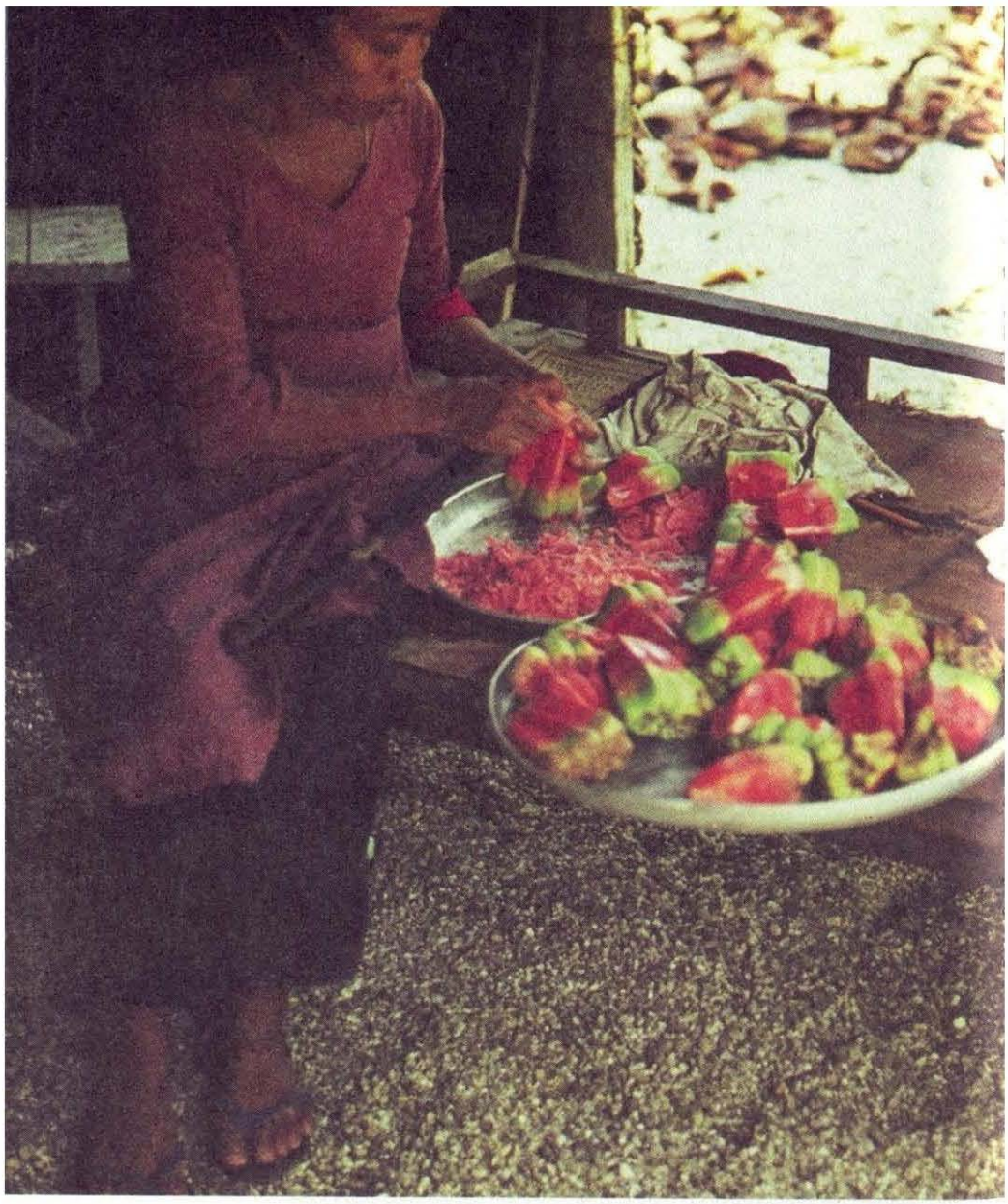


ALL PHOTOS: NILS FINN MUNCH-PETERSEN

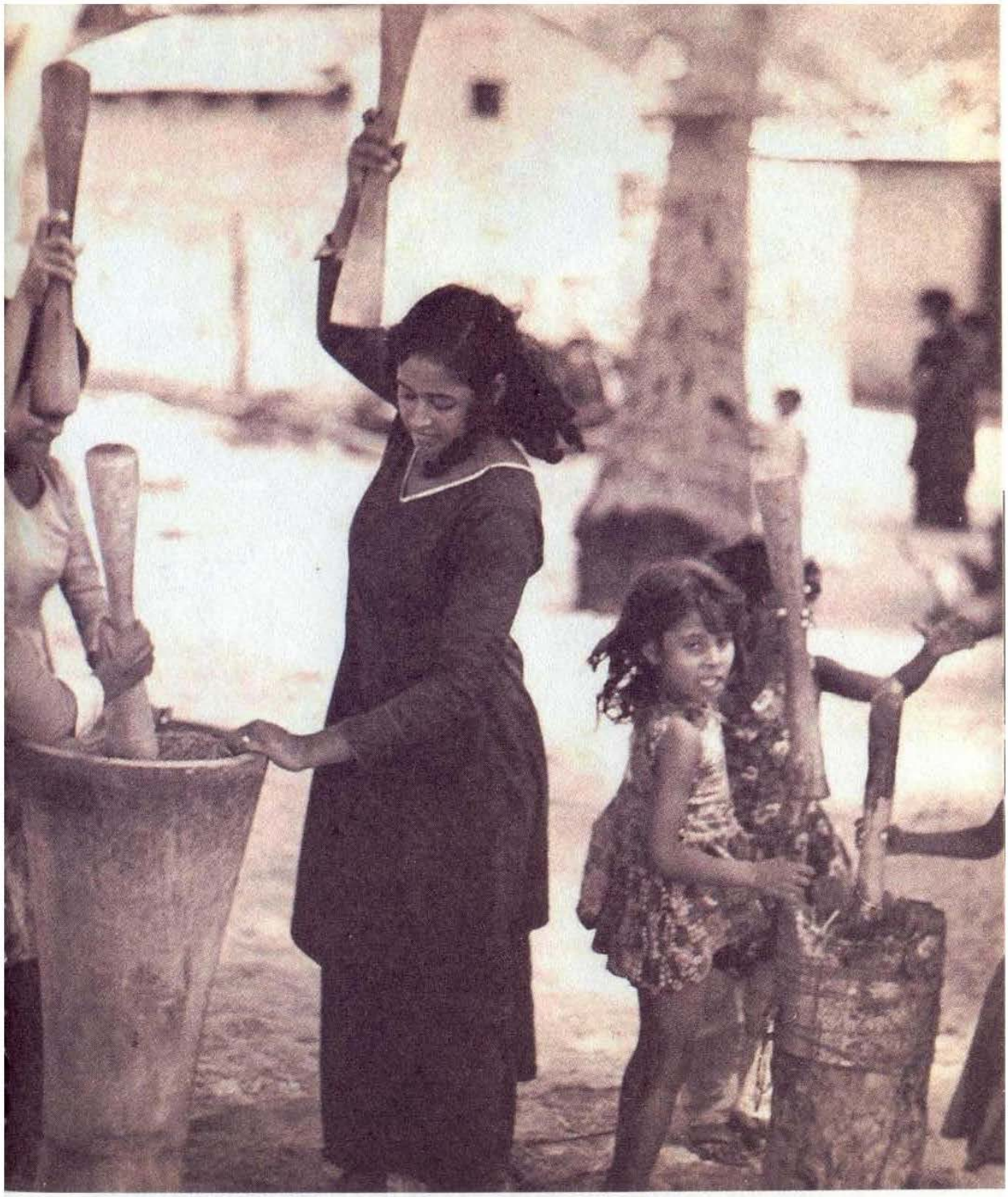
A girl with a harvest of *kullafila* leaves. Like in most traditional Asian cultures it was customary to send children to look for food. Kullafila (*Launaea sarmentosa*) grows in sandy terrain and is one of the most valued traditional greens in Maldivian cuisine. Fua Mulaku, 1977.



Cutting tuna the traditional way. The skipjack tuna is cut in a clearly defined way on every island. Every fish yields four longitudinal sections known as 'ari'. These can later be processed as Maldive Fish. Fua Mulaku, probably 1977.



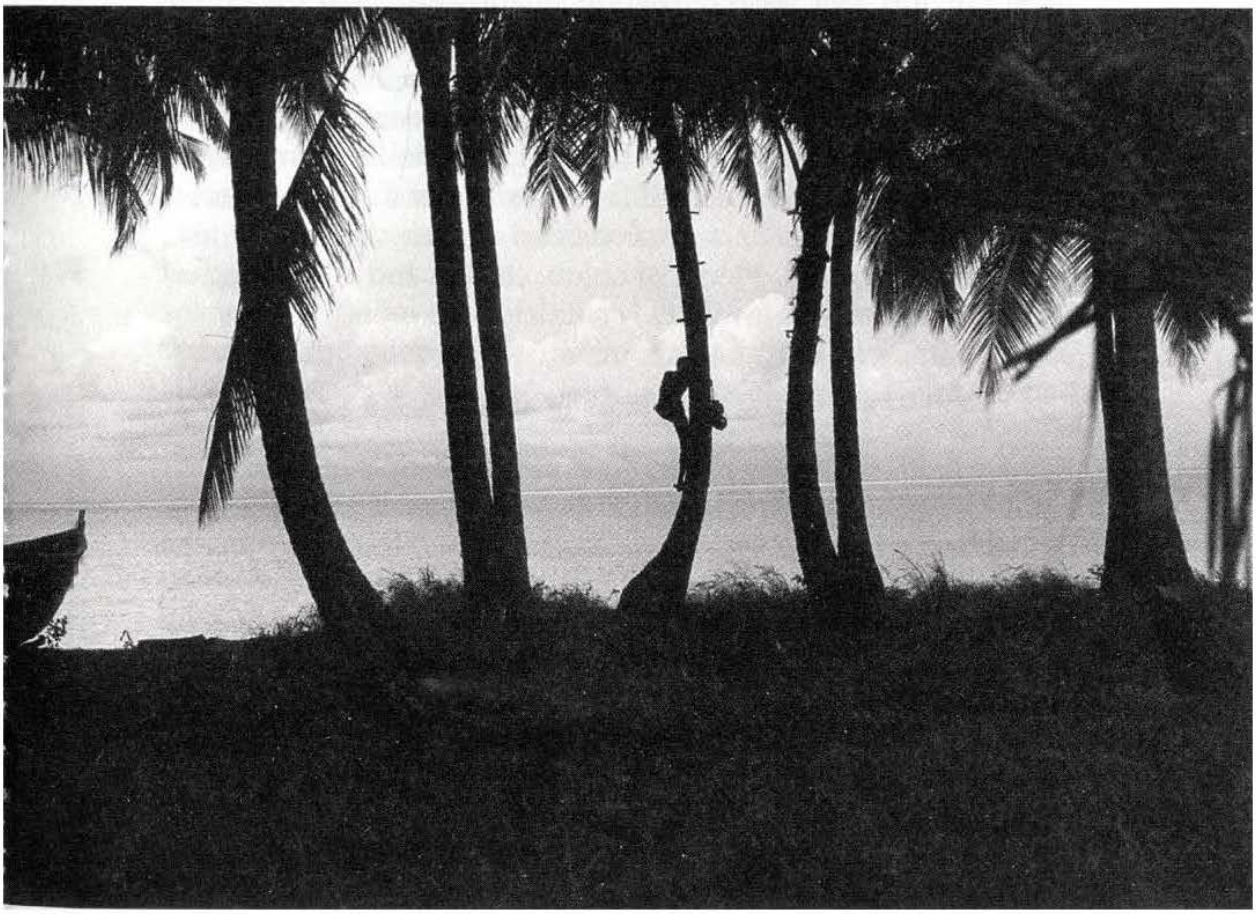
A woman in Dadimago slicing screwpine fruit at home.
Fua Mulaku, 1977.



Crushing millet with a wooden mortar and pestle.
Maalhosmadulu Atoll, 1974.

A woman harvesting taro tubers. Fua Mulaku, 1977.

One of the last palm-sap gatherers climbing a tree. Note the wooden footholds attached with rope that made climbing easier. Addu Atoll, 1977.



I casually asked him about the *Handi*, a female ghost that used to scare the local people and that many swore they had seen.

"It's not there anymore!" Nasim said.

I was surprised by how quickly and firmly he answered, so I asked him, "How come?"

"All our ghosts went away after they put round-the-clock electricity on the island."

What we ate on Fua Mulaku

It is not just the gentle lifestyle of the Maldivians that has undergone shifts since I first came to the atolls in 1979. Local food culture has experienced major adjustments in the interim, the biggest being from monotony to variety. The oceanic environment and the lack of fertile soil on the flat coral islands imposed a Spartan lifestyle with a diet of fish, coconut and starch. Average daily meals on most islands consisted of rice and boiled fish, eaten with fish broth. Pieces of onion, chillies and a few drops of lime juice, whenever available, completed the repast. Maldivians enjoyed the fare without complaint, while demanding quality and freshness.

Some islands also grew tubers such as taro. People ate with their hands, engaging an extra sense in the enjoyment of food. The grey, boiled taro would be squeezed into a fine puree by pressing the tubers firmly, one at a time, against the interior of the hand using the knuckle of the thumb. This puree was mixed with generous spoonfuls of fish broth and grated coconut.

Taro cultivation had particular importance on some large islands in the southern atolls. As a rule, women were in charge of the muddy taro patches. By the time they were teenagers, Fua Mulaku girls were experts at harvesting taro, and carried heavy baskets back home, gracefully balancing them on their heads. During World War II, when a British Royal Air Force (RAF) base was built on Gan, the southernmost island of the Maldives, nearby

Fēdu islanders lost their carefully-tended taro fields.

Currently, my friend Afrah tells me, very few local girls tend the taro fields. Except for a few old women who still cling to tradition, taro cultivation is mainly carried out by migrant workers from Bangladesh. This is a new development. Back in the 1980s, one saw only locals in the country – the few tourists were tucked away in the handful of resorts. The plight of these Bengali workers, seldom treated well by the locals, is often the subject of my exchanges with Maldivian friends, who expess concern that the island traditions of graciousness and hospitality have been weakened.

Wherever taro of the marsh-grown variety was not available, other tubers such as giant taro, cassava and sweet potato, as well as boiled breadfruit and also a variety of large unripe bananas, were eaten in the same way. Boiled giant taro is yellowish and its taste is quite pleasant, but a meal of giant taro mixed with grated coconut and fish broth leaves a strong itchiness on the roof of the mouth. This is why the tuber is known as *kahanala*, 'itchy taro' in Divehi.


In the traditional subsistence diet based on fish, coconut and starch, diversity was not a need or an option.


A starchy pudding known as *bondibaiy*, popular as a dessert in certain ceremonies, is prepared by slowly cooking rice or any tuber and adding coconut milk. A few pieces of aromatic screwpine are added for flavour. Traditionally this pudding was sweetened with *Divehi hakuru*, the Maldivian sugar obtained by heating coconut-palm sap. Today, few Maldivians want to make a profession of climbing the palms, and so sap tappers (*rāverin*) have almost entirely disappeared. Maldivian sugar is now a rare commodity.

Bōkibā, another enduring Maldivian favourite, is a thick cake available in two varieties: the spicy, non-sweet one that contains fish and chillies, and the sweet one, smooth and starchy. The latter is flavoured by sprinkling finely chopped onion on top before

baking. Maldivians love the seared-onion taste of this dessert, but it took me a while to get used to it, for flavouring cakes with onion is unusual anywhere else. Pieces of these heavy cakes, served with tea, were the traditional food on the morning of *Kuda Idu* – the first day after Ramzan that islanders would eat breakfast, after the mandatory prayers at the main mosque. Bōkibā was also the snack for fishermen to take on their fishing trips, as was *fathafolhi*, a flat pancake made with similar ingredients that was baked between banana leaves. Fua Mulaku fishermen favoured *alaia kaishia mahaia*, a snack consisting of pieces of boiled taro, coconut and Maldive Fish that I found quite appetising.

Currently, few Maldivians want to make a profession of climbing the palms, and so sap tappers (rāverin) have almost entirely disappeared.

On several islands, the core of the cultivated screwpine fruit (*Pandanus odorifer*), locally known as *kashikeyo* or *kēvah*, was an essential food item. In order to break up its fibrous texture, it was cut into very fine slices using a special knife sharpened only at the end. Women held this knife against the hip or thigh, using the weight of their bodies to cut the fruit. Kashikeyo has a pleasant, sweetish, carrot-like taste, and it was mostly used to cook sweets such as bondibaiy pudding, or a liquid drink sweetened with palm sugar that was generally drunk warm. I found that a soup made with the screwpine fruit, known as *lonokēvah* on Fua Mulaku, had an excellent taste, but my hosts served it very reluctantly, considering it an inferior dish.

Certain tubers such as *jícama* needed to be grated and soaked in water, with the water changed at least seven times, in order to neutralise the poison within. The result was *hittalafuh*, a kind of flour that was used to prepare flat cakes. When all other tubers were scarce, even the highly poisonous tubers of the flame lily (*Gloriosa superba*) were processed in this laborious manner to make them edible. Near-famine conditions used to be common in the Maldives,which is why the islanders went to great extents to obtain starchy foods to supplement the fish in their diet. In times

of scarcity people ate papaya stems, banana roots and the leaves of certain shoreline bushes common throughout the archipelago, such as beach cabbage and the octopus bush. These coarse items, however, were not appreciated in times of plenty.

Maldivians living on certain islands back in the 1970s were able to farm sorghum and millet in dry fields, and those fortunate enough to live on large, swampy islands could cultivate taro. But if the wetlands were brackish, not much could be harvested other than mangroves such as *kandū* (Bruguiera), which have edible pods. The green kandū pods look much like fresh beans, but they are tougher and need to be cooked for a long time with several changes of water to soften them and take away their bitterness. Once on Hurā, an island in North Male Atoll where there were mangroves, I saw my friends preparing kandū and asked if I could taste it. Politely, they brushed aside my request and gave me a bowl of bondibaiy pudding instead. They assumed that kandū was too coarse an item to give a guest.

As I discovered more of the ingredients and dishes of the Maldivian diet, I was also learning about the intricacies of the age-old island hospitality, always closely connected to food. The women of any household were invariably happy with me because I always relished their food and left my plate clean. Formerly, all cooks were women, except aboard ships; the kitchen was no place for a man.

Old tastes, new tastes

Fish is king of the Maldivian diet. The skipjack tuna is the most valued fish in the island gastronomy, its firmness of flesh, dark red colour and rich taste making it the favourite. Skipjack preserves well as 'Maldive Fish', which in the past was a reserve for lean times and was also a key trade item. Second to skipjack come other pelagic fishes related to it, such as yellowfin tuna, little tunny and frigate mackerel. The marlin and wahoo, whose flesh is firm though somewhat whitish, are also generally appreciated, but not as much as they are in nearby Kerala on the Indian coast. The catch of large fish is diminishing, my friends say, due to the

foreign boats engaged in industrial-scale fishing in the Indian Ocean. Apparently those large trawlers leave nothing in their wake wherever they pass.

Fish caught close to the reefs or within lagoons, known generically as *farumas*, were not regarded highly in former times. However, some of the larger species of farumas, such as red snapper, bluefin jack and mahi-mahi, are increasingly welcome on the table of average Maldivians. In the past, many of the reef fish were difficult to preserve using traditional methods. Nowadays, however, cold storage units and shops with deep freezers have made a wider variety of fish available for a longer time, there being less need to rely on the classical methods of preservation. Meanwile, those who work at tourist resorts have come to realise how much the foreigners appreciate reef fish.

Parrot fish, with its soft, somewhat smelly flesh, was traditionally despised, as were moray eels which, unlike in Polynesia where they are a delicacy, were never eaten in the Maldives. My friend Magieduruge Ibrahim Didi, however, had tasted a moray eel once out of curiosity. For this he quickly earned a reputation on his island, and it followed him years later when he was already an old man.

Before the arrival of tourists, Maldivians ate lobster, clams, squid and octopus only in food emergencies, when 'proper' fish was impossible to find. Even then it was not considered advisable for pregnant women to eat lobster or octopus. But even back in the 1980s, I met quite a few people who enjoyed the chewy flesh of the octopus. In the time-honoured Maldivian cuisine, octopus, as well as tough-fleshed fish such as marlin and shark, is cut into bite-sized pieces, daubed with a spicy chilli mixture and pan-seared over a strong fire. This method, known as *hanaakurun*, yields a somewhat dry but delicious dish. My friend Rasheed, a merchant-liner cook from Male', claims that the abundant chillies and garlic in the mixture are needed to mask the unpleasant aftertaste and smell of the species.

Mūsa, a cook from Maradū in Addu Atoll, told me that he had

learned to prepare crabs and lobsters for British military personnel before 1976, when the RAF base on Gan was closed. In order to cater to his seafood-loving British employers, he caught large crabs in a brackish lake on the northern part of Hitadu island, and lobsters on the Gan reef at night using a lamp. Mūsa cooked them as *kirugarudiya*, a mild curry made sour with pieces of green mango or bilimbi along with coconut milk, and added a touch of yellow colour with turmeric. Usually, Maldivians add spicy green chillies to the kirugarudiya, but the British asked Mūsa to desist.

> Such funerary meals were part of the traditional way of island life, but, discouraged by Islamic hardliners, they have been replaced today by birthday and wedding parties.

After the RAF base closed, Mūsa found employment in the then-nascent tourist industry and worked as a cook in one of the first resorts. Years later, long after the British had left, he still enjoyed the dishes he had invented while at Gan, and prepared them for his friends and family. I can confirm that Mūsa's lobster kirugarudiya over steamed white rice is outstanding.

In the past there were some attempts to cultivate rice in the marshy ground of Fua Mulaku, but none succeeded. Since ancient times, all rice in Maldives has been imported. Historically, parboiled rice from Burma was the Maldivians' favourite. It kept longer in storage, and the grains had a firmness that the islanders enjoyed. When rice spoiled, it was dried in the sun and reused to make sweets. Rice was considered high-status food, even on islands where tubers were the more customary fare. During special celebrations, such as funerary ceremonies celebrated as part of an extensive event that involved the ritual reading of the Quran, or during visits by high officials, rice was served alongside different curries. The greater the variety of dishes offered to the guests, the more prestigious the occasion. Habitually, at funerary ritual meals, a whole array of dishes in bowls were beautifully displayed along with bunches of ripe bananas around a huge central basin heaped high with a conical pile of rice.

Contrary to the leisurely pace of most Maldivian meals, I was amazed at how quickly mourners ate at funerary meals. Batches of guests took turns gulping down food as fast as they could, ending the meal by swallowing full glasses of water and chewing betel leaves with areca nut, and then swiftly leaving the house in order to make way for the next batch of quick-eating visitors. I was initially astonished that the guests would depart without so much as a 'by-your-leave' to their hosts, but this was evidently the local custom. Such funerary meals were part of island tradition, but, discouraged by Islamic hardliners, they have been gradually abandoned to be replaced by birthday and wedding parties and the like.

Fish, chicken, turtle, more fish

On my first trip to the southern atolls in 1979, I took the *Comet*, a slow wooden boat overloaded with goods that regularly made the journey between Addu Atoll and Male and was named after the first passenger jet that had landed at the Gan RAF base. The *Comet*'s captain was a talkative fellow who was more often smiling than not. The travellers made themselves comfortable with their pillows and mats on the overcrowded deck. It was there, the morning after the first long night aboard, that I first tried *mas huni*, a mixture of freshly-grated coconut and Maldive Fish that is eaten with chapatis at breakfast time.

Despite its high status, by and large the islanders did not consider it refined to eat rice in the morning. Accordingly, those that could afford flour would eat chapatis for breakfast, as they still do today. Chapatis are known as *roshi* in standard Divehi; in the southern atolls, where that word is considered rude, chapatis are referred to as *folhi*. There are different varieties of roshi: the most common are thin ones made with dough of only flour and some oil; another type, with grated coconut also added to the dough, are thicker.

Mas huni was eaten leisurely while sipping sweetened black tea, and with freshly baked chapatis it formed a delicious combination. Later I discovered that every house had its own recipe, and that it was of the utmost importance to slice the little

purple onions paper-thin, for the secret of Maldivian cuisine was cooking with care. Carelessness was frowned upon, and people complained loudly if there was any relatively big piece of onion in the mixture: "Is this mas huni? What is this cook doing?" When fish was scarce, finely chopped green leaves of certain local plants – such as *kullafila*, *mābulhā* and *massāgu* – replaced the fish in mas huni in smaller or greater proportion. Even though leaves added to the dish, unless the situation was desperate and there was no fish at all, the cook would be sure to add a certain amount of fish to make the dish deserve its name, for mas huni means 'fish-grated coconut'.

Although everyone in the country still praises traditionally made curry paste, present-day Maldivians find it more practical to buy readymade paste at convenience stores.

Mas huni spoiled quickly in the humid, tropical island climate. In rural households, any mas huni that had not been eaten in the morning was already stale by midday, and provided food for the household chicken. Even today, Maldivians prefer to eat the mas huni right after preparation, for it tastes best fresh and does not keep well even in a refrigerator.

Along with mas huni, curries remain another characteristic local preparation, normally cooked with tuna and whatever vegetable is available. In the Maldives, fish is almost never cooked together with rice; the one exception being *masbaiy*, a local dish somewhat similar to biryani, made by cooking diced fish and rice with peppercorns and turmeric together in the same pot. *Mas riha*, the most important curry in Maldivian cuisine, is cooked with fresh diced tuna and a mix of spices. Even though vegetables were used in certain curries, these could not be called true vegetarian preparations. All traditional Maldivian curries contain some proportion of fish in order to give them the 'right' taste. If a vegetable curry contained too little fish, Maldivians would complain: "*Mas raha nu la!* It does not taste like fish." Ideally, curries would include Maldive Fish that was not too dry. The larger and more generous the pieces in the curry, the more the guests would praise their hosts.

Kukulhu riha, chicken curry, is prepared using a different spice mixture. Formerly, kukulhu riha was kept simmering for a long time since the meat of the local chicken was quite tough. It was advisable to get hold of a chicken first before making plans to eat it on a particular day; catching a kukulhu was not easy, for they ran so fast that they almost flew. The life of these mostly wild local chickens included hunting for food on the vast expanse of dry reef at low tide, and sleeping on high tree branches to avoid prowling cats. Mohamed Ali ('Philippe'), who in the 1980s used to bring tourists to out-of-the-way corners of the archipelago on his yacht, the *Baraabaru*, told me that he once barbecued a Maldivian kukulhu, but the meat was so tough it was left uneaten. Nowadays, Maldivians mostly consume imported frozen chicken.

Turtle curry used to be prepared in the same way as chicken curry. A large leatherback turtle would yield many kilos of fine meat, which was normally distributed among the islanders and cooked right away, for it was not possible to preserve it in the traditional way. Turtles are now no longer served on the Maldivian table owing to strict protection measures.

With the passing of the years, as the capital has become noisier and more crowded, the number of restaurants in Male has increased.

Hardly any vegetable grew naturally on the sandy coral soil of the Maldives. Those few that did included small eggplants, pumpkins, *torā* (sponge gourds), *chichanda* (snake gourds) and *muranga* (drumstick), as well as chillies. Even these were often cultivated only with much effort. In their absence unripe green bananas, as well as certain green leaves, were also used in curries. In the past, at any given moment there could be an excess of a particular vegetable on one island and a total lack of it on another located not too far away. Traditional vegetables were grown on a small scale, and there was no established marketing and distribution system, often making them difficult to get hold of.

Quite a few Maldivian curries are given their singular flavour

by means of a locally made paste known as *havādu*, made by mixing spices such as coriander, fennel, black pepper, cumin, dry chillies, turmeric and curry leaves with grated coconut. The mixture was stirred in a pan over a searing fire, after which it was pounded with a pestle in heavy brass mortars and stored in glass jars. Although everyone in the country still praises traditionally made curry paste, present-day Maldivians find it more practical to buy ready-made havadu paste at convenience stores. Local cooking also uses *lonumirus*, a wet red-chilli-based mixture that is ground on flat stone grinders and used widely to make dishes spicier, including to daub fish in preparation for barbecuing.

The tastes of Ramzan

The preparation of food for the sunset meal during Ramzan – *rōda villun*, the breaking of the fast – has always been an important social activity in the Maldives. Women used to spend most of the day in the kitchen preparing special drinks, sweets, snacks and dishes. In traditional society, neighbours would help each other and work in the open in a very happy mood.

One typical Ramzan dish, a sweet-dough preparation known as *donkeyo kajuru*, contains mashed banana and sugar, and used to be a convenient sweet snack to prepare when there was an abundance of ripe bananas in a household. *Folhi* are sweet pancakes that are folded in the middle, and are known as *fonifolhi* in the southern atolls, where a folhi is a simple chapati. Similar sweets, such as *fathafolhi*, included egg in the mixture, often using turtle eggs instead of chicken eggs. This was especially so on Huvadhu Atoll, where there was an abundance of sea turtles in the past before the over-harvesting of their eggs – despite official protection and a ban on trading turtle shell – caused the population of these oceanic reptiles to crash.

Sweet drinks are also popular for breaking the Ramzan fast at sunset. These were originally prepared with locally available fruits, which have been partly replaced by imported syrup. The islanders love the new, garish colours, and condensed

milk is often added to the mixture. The Maldivians' favourite is a sweetened drink with floating pieces of watermelon. In the past, watermelons were brought in from Toddū, an island located to the northwest of Male Atoll. The quality of the watermelons was seldom up to standard, and for a foreigner used to larger and sweeter produce the coral-soil watermelons were disappointing. But it was Ramzan time, and this was the Maldives of over 30 years ago, and the traditional watermelon drink had to be prepared.

Another much-loved Ramzan drink is guava juice. Formerly, during the holy month, the price of guavas in the Male' market used to shoot up, with people ready to pay exorbitant prices for a handful of them. Other fruits traditionally used to make Ramzan drinks are ripe papaya, lime, mango, *Divehi ata* (custard apple) and *kalhuhuttu mēva* (pond apple), a kind of custard apple with an orange-coloured pulp. Not commonly eaten elsewhere, ripe pond apple has a taste somewhere between that of honeydew and overripe peach. Eventually, imported fruits and vegetables from India, Sri Lanka and Thailand allowed a greater assortment of Ramzan foods and drinks. But despite improved supplies, prices still tend to rise during the holy month owing to great demand.

Savoury snacks are also popular during Ramzan. These include *gulhā*, small ball-shaped dumplings stuffed with a mixture of tuna, onion, grated coconut and chilli. Depending upon the household and the cook, a few drops of lime, turmeric and chopped curry leaves are also added to the mixture, which is stuffed into the dough and then deep-fried. Currently, Maldivian culinary purists say that garlic is not to be added to gulhā, but some of the best gulhā I have eaten in the Southern Atolls had garlic and roasted dry chilli added to the filling. Gulhā dough can be made with wheat or rice flour, and the rice-flour gulhā are usually smaller, harder and crunchier. Flattened dough patties stuffed with the same mixture as gulhā and baked instead of fried are known as *masroshi*. Another popular short eat is *kavābu*, a kind of cutlet based on the same ingredients as the gulhā stuffing, minus the grated coconut, which are all mixed with flour, and often also with dal, before the lumps are deep-fried.

Hiti, a starchy curry made with boiled breadfruit or young taro together with curry paste, is also typically eaten during Ramzan, a little while after the breaking of the fast at sunset. Unlike other Maldivian curries, hiti is not served with chapatis or rice, but as a separate dish on its own, eaten with a spoon as a thick soup.

Eating out

I first arrived in Male in June 1979. Back then I regularly ate in the local teashops – friendly, noisy places mostly located close to the harbour area. The local word for the places was 'hotel', although they had little to do with hotels in the strict sense. They had fantastic names such as Queen of the Night, Stella Maris, Moon Café, Beach Crescent and Skyline. Later, there would even be one named Hotel Hilton. The walls were bare and there was no attempt at decoration, only big tables with simple, functional chairs. Overhead fans provided relief from the heat, and in the evening, the harsh luminosity of fluorescent lights lit the interiors.

Back then, having tea was a central custom in the island culture, and the teashops were male territory. The standard fare was a cup of already-sweetened black tea and a few snacks or short eats, which were put before the patrons on white plates in small sets of four. The most successful snacks were gulhā, kavābu, *bajiya* – the local samosa stuffed with Maldive Fish – masroshi, folhi and pieces of bōkiba, the local cake which comes in spicy and sweet versions. As the years passed, people complained that the gulhā and kavābu were getting smaller and smaller – perhaps an indication of the economic situation.

In Male there was also a place called Icege (Ice house), where people went in the evenings to eat ice cream, dance and listen to live music. It was lit by red, blue and green coloured lamps, and the stage where the band and singers performed imitated the jaws of a large whale. Unlike in the teashops, the crowd at Icege was made up of both men and women. Even though it was a mellow place and no alcohol was served, in 1980 Icege was closed under the hardline policies of Maumoon Abdul Gayoom, the new leader who allowed tourists to dance but not Maldivians.

Made with tinned, powdered milk from New Zealand, the local ice cream served at Icege was not very tasty, but I found the setting itself fascinating. There were young Maldivians dancing, and sitting around poorly lit tables quietly eating ice cream, clearly enjoying the stylish atmosphere of the establishment. Icege was the nearest thing to a 'sophisticated' place in the sleepy capital, then a quiet town of low houses with courtyards shaded by large trees, and unpaved streets that were muddy in the monsoon rains and dusty at other times.

> As the years passed, people complained that the gulhā and kavābu were getting smaller and smaller – perhaps an indication of the country's difficult economic situation.

There was also an Indian-owned restaurant in Majeedi Magu, the main street running across Male from east to west. The sign outside read 'Indian Restuarant', and the owners let the years pass without correcting the spelling. It was a small room with the walls painted blue. The fare was simple but sensible and successful: rice with Indian-style chicken curry and a bowl of *rasam*, the traditional South Indian soup, on the side. The place used to be full at lunchtime, especially on Friday when local Indian workers had a holiday, but there was a Maldivian clientele as well.

The difference between traditional teashops and restaurants in the Maldives is that women patrons are welcome in the latter. With the passing of the years, as the capital has become noisier and more crowded, the number of restaurants in Male has multiplied. Some of them have come a long way from the basic establishments of the 1980s. In one resort located on Rangali Island, Ari Atoll, there is even an underwater restaurant 5 metres below sea-level claiming to be the first of its kind in the world. The teashops are currently on the wane, for the tradition of office workers and fishermen meeting for tea has been largely replaced by coffee culture. At present, many of Male's largely unemployed young generation meet over coffee instead of sweetened black tea. Since they do not have much else to do, young customers usually linger for a long time in these coffee establishments.

Creative preservation

In earlier times, the lack of steady electricity beyond the capital dictated the need to preserve food in traditional ways. These included drying, smoking and boiling. In any traditional house, leftover fish broth or curry was boiled before being put aside for the night, and heated again in the morning. It was a disaster if a big pot of precious food spoiled, so local women were careful not to touch the liquid after having heated it. Even dipping a spoon into the liquid after it had been boiled could prove critical.

One result of this practice was *rihākuru*, a salty brown fish paste made by boiling tuna broth until most of the water evaporated. The resulting mixture could be preserved in jars for a long time. Rihākuru would substitute fish for the duration of a bad fishing season. In order to improve its taste, it could be processed by frying it with finely-chopped onions, garlic and chillies, along with some curry leaves and a few pieces of aromatic screwpine leaf. This delicious mixture kept for a long time in glass jars. Another mouth-watering preparation is *rihākuru diya*, made by mixing the brown tuna paste with finely chopped Maldive Fish, green chillies and onion, and adding in coconut milk at room temperature.

Other foods also required careful preservation. Limes and *bilimago* (bilimbi) were grown on some islands and were used to give food a sour flavour. If there was a surplus of the fruits they could be preserved as *lonu lumbō* (salty lemon) or *asāra* (chutney). But there was rarely much fruit left, for the demand was always high and the number of trees was restricted to those few growing in domestic yards. A blight has struck Maldivian lime trees in recent times, wiping out the small local harvest, and at present almost all limes used in Maldivian cuisine are imported.

It was also common for excess taro and breadfruit to be cut into chips and deep-fried using abundant coconut oil. After cooling, the chips would be put into large tins and stored for a long time, to be brought out as a present for visiting relatives and friends, for visits to other islands, or in lean times when other provisions were scarce. Fried breadfruit or taro chips also made excellent

snacks during long journeys between distant atolls. Other chips I especially favoured were *teluli roshi*, made by mixing chopped Maldive Fish, dry chillies, onion and garlic into chapati dough. The flattened raw chapatis were then cut into pieces and deep-fried. The same mixture could be used to make small marble-sized balls that were deep-fried and preserved in the same way. These were so hard that they were known as *dagandu gulhā*, meaning 'iron gulhā'.

Some leaves were deep-fried along with garlic, onion and Maldive Fish slices, as well as whole *hikandifaiy* (curry leaves) and dry chillies, in order to preserve them. Larger leaves such as *lhos*, from the *Pisonia grandis* tree, needed to be chopped into small pieces, but the little drumstick leaves common to the islands were already the right size and were used as they were after separating them from their small, hard stems. The oil was drained and the leaves were stored in empty tin cans. Known as *teluli faiy*, a spoonful of fried leaves was a welcome addition to the daily fare of rice and fish broth.

Sugar – in the past mostly the Maldivian palm-sugar – was also a good stabiliser. *Ulhaali* was a hard, spiral-shaped sweet popular in Huvadhu Atoll that was deep-fried and stored in cans. Sometimes taro and breadfruit chips were covered with glazed sugar (*karu hakuru*) and also stored away. Other traditional sweets, such as the tough, disk-shaped *āros*, made with Maldivian sugar and screwpine fruit or with any starchy tuber, as well as *bondi*, a sausage-shaped sweet made with tender coconut (*gabulhi*) flesh and palm sugar, were wrapped in banana leaves before being stored away. Āros and bondi sweets were valuable mercantile commodities when Maldivians sailed across the ocean to Sri Lanka and India on the traditional yearly trade journeys.

Certain foods were preserved by sun-drying them. On the sunny days of the dry season, women would spread mats in the street and put wedges of breadfruit out to dry. Once the sun dropped low, these were gathered into sacks or wooden boxes and brought out again the following day. Dried breadfruit was boiled and eaten with fish broth and grated coconut, but I found the flavour

rather too reminiscent of the box or sack in which the wedges had been stored. Unlike fresh boiled breadfruit, the dried variety took on a dark brown colour after being cooked that I didn't find attractive either. For me it was a source of wonder to see how many islanders, such as my friend and host Karaange Hasan Didi, actually relished a meal of dried breadfruit. But of course I was a foreigner, and some of the islanders' ways were bound to remain inscrutable to me.

Present-day island homes have refrigerators, making it easy to preserve groceries and fresh vegetables without any significant alterations in taste. By the mid-1980s, some vegetables such as carrots and cabbages began to be imported in large quantities, and for the first time basic salads could be prepared. Still, it was difficult to find more delicate items such as lettuce or strawberries. Nowadays, a number of companies are marketing and distributing fresh products, and all kinds of groceries are easily available, reaching even remote islands. Thanks to modern transport and technology, the number and variety of dishes on the dining table of the average Maldivian has multiplied exponentially. △

Annex 931

L. Watson & M.J. Dallwitz, "The grass genera of the world" (7 Dec. 2015), *available at* http://delta-intkey.com/grass/www/ischaemu.htm

The grass genera of the world

L. Watson and M. J. Dallwitz

Ischaemum L.

From the Greek *ischaimon* (a styptic), name originally given to *Digitaria sanguinalis* for supposed styptic qualities.

Including *Argopogon* Mimeur, *Collardoa* Cav., *Ischaemopogon* Griseb., *Meoschium* P. Beauv., *Schoenanthus* Adans.

Excluding *Digastrium*

Habit, vegetative morphology. Annual, or perennial; rhizomatous, or stoloniferous, or caespitose, or decumbent. *Culms* 10–350 cm high; herbaceous; branched above, or unbranched above. Culm nodes hairy, or glabrous. Culm internodes solid, or hollow. *Leaves* not basally aggregated; non-auriculate, or auriculate (with sheath auricles). Leaf blades linear (usually), or linear-lanceolate to lanceolate; broad (rarely), or narrow; cordate to sagittate, or not cordate, not sagittate; flat; pseudopetiolate, or not pseudopetiolate; without cross venation; persistent; rolled in bud. **Ligule an unfringed membrane**.

Reproductive organization. Plants bisexual, with bisexual spikelets; with hermaphrodite florets. The spikelets of sexually distinct forms on the same plant, or all alike in sexuality; hermaphrodite, or hermaphrodite and male-only (rarely), or hermaphrodite and sterile (rarely); overtly heteromorphic (the pedicelled spikelet sometimes much smaller, often asymmetric), or homomorphic.

Inflorescence. Inflorescence terminal or axillary, of spicate main branches; **usually digitate**. **Primary inflorescence branches (1–)2(–14) (usually paired, one-sided and locked back to back to simulate a single spike)**. Inflorescence spatheate (the uppermost leaf reduced to a spatheate sheath), or espatheate; not comprising 'partial inflorescences' and foliar organs. ***Spikelet-bearing axes*** 'racemes'; paired, or clustered (rarely solitary); **with substantial rachides (these stout, triangular)**; disarticulating; disarticulating at the joints. *'Articles'* non-linear (clavate or inflated); glabrous, or more often hairy. **Spikelets** paired; **secund (the raceme dorsiventral, its segments usually appearing U or V-shaped from the back owing to the thick internodes and pedicels)**; consistently in 'long-and-short' combinations; in pedicellate/sessile combinations, or unequally pedicellate in each combination. Pedicels of the 'pedicellate' spikelets free of the rachis (usually stoutly linear to obovoid, sometimes very short). The 'shorter' spikelets hermaphrodite. The 'longer' spikelets hermaphrodite, or male-only (rarely), or sterile (rarely).

Female-sterile spikelets. The pedicelled spikelet as large as the sessile or much reduced, variously compressed, often asymmetrical.

Female-fertile spikelets. Spikelets compressed dorsiventrally; falling with the glumes. Rachilla terminated by a female-fertile floret. Hairy callus present, or absent.

Glumes two; **more or less equal**; long relative to the adjacent lemmas; awned (the upper, sometimes), or awnless; very dissimilar (the lower leathery and usually 2-keeled, the upper 1-keeled above and sometimes awned). **Lower glume usually two-keeled (winged or not)**; convex on the back to concave on the back; not pitted; relatively smooth (rarely), or rugose (transversely), or tuberculate (on the margins); **7–11 nerved**. Upper glume 5–11 nerved. *Spikelets* with incomplete florets. The incomplete florets proximal to the female-fertile florets. **Spikelets with proximal incomplete florets**. *The proximal incomplete florets* 1; paleate. Palea of the proximal incomplete florets fully developed. **The proximal incomplete florets male**. The proximal lemmas awnless; similar in texture to the female-fertile lemmas; not becoming indurated.

Female-fertile florets 1. **Lemmas** less firm than the glumes (firmly membranous); not becoming

indurated; **incised**; 2 lobed; awned (usually), or mucronate, or awnless (rarely). Awns when present, 1; or mucros from a sinus; geniculate; hairless (glabrous); much shorter than the body of the lemma to much longer than the body of the lemma. Lemmas hairless; non-carinate; without a germination flap; 1–5 nerved. ***Palea*** present; relatively long; apically notched; awnless, without apical setae; thinner than the lemma (hyaline); not indurated; **nerveless**. *Lodicules* present; 2; free; fleshy; glabrous. *Stamens* 3. Anthers not penicillate. *Ovary* glabrous. Styles free to their bases. Stigmas 2; red pigmented.

Fruit, embryo and seedling. *Fruit* free from both lemma and palea; compressed dorsiventrally, or not noticeably compressed. Hilum short. Embryo large. Endosperm hard; without lipid; containing compound starch grains. Embryo without an epiblast; with a scutellar tail; with an elongated mesocotyl internode. Embryonic leaf margins overlapping.

Seedling with a long mesocotyl.

Abaxial leaf blade epidermis. *Costal/intercostal zonation* conspicuous. ***Papillae*** **present**; costal and intercostal. Intercostal papillae over-arching the stomata (but only from the subsidiary cells); several per cell (costal and intercostal long-cells with 1–2 irregular rows of small, thick walled papillae, the subsidiaries each with a small papilla at each end). *Long-cells* markedly different in shape costally and intercostally (the costals much narrower); of similar wall thickness costally and intercostally (quite thin walled). Mid-intercostal long-cells rectangular and fusiform; having markedly sinuous walls. *Microhairs* present; more or less spherical, or elongated; ostensibly one-celled, or clearly two-celled; panicoid-type (some in *I. commutatum* being 'balanoform'), or chloridoid-type; 18–48 microns long; 7.2–9.6 microns wide at the septum. Microhair total length/width at septum 1–4.4. Microhair apical cells 4–19.5 microns long. Microhair apical cell/total length ratio 0.29–0.61. *Stomata* common; 34.5–42 microns long. Subsidiaries papillate; predominantly triangular. Guard-cells overlapping to flush with the interstomatals. *Intercostal short-cells* absent or very rare (ignoring the bulbous bases of short prickles). *Costal short-cells* conspicuously in long rows, or neither distinctly grouped into long rows nor predominantly paired. Costal silica bodies 'panicoid-type'; cross shaped, or butterfly shaped, or dumb-bell shaped, or nodular; sharp-pointed.

Transverse section of leaf blade, physiology. C_4; XyMS–. PCR sheath outlines even. PCR cell chloroplasts centrifugal/peripheral. *Mesophyll* with radiate chlorenchyma. *Leaf blade* adaxially flat. *Midrib* conspicuous; with one bundle only, or having a conventional arc of bundles; with colourless mesophyll adaxially. Bulliforms not present in discrete, regular adaxial groups (the epidermis extensively bulliform, the cells irregularly grouped). Many of the smallest vascular bundles unaccompanied by sclerenchyma. Combined sclerenchyma girders present; nowhere forming 'figures'. Sclerenchyma all associated with vascular bundles.

Culm anatomy. *Culm internode bundles* in one or two rings.

Phytochemistry. Leaves without flavonoid sulphates (2 species).

Cytology. Chromosome base number, $x = 9$, or 10. $2n = 18$, 20, 40, 54, 56, and 68. 2, 4, 6, and 8 ploid (?).

Taxonomy. Panicoideae; Andropogonodae; Andropogoneae; Andropogoninae.

Distribution, ecology, phytogeography. 60 species; tropical and subtropical. Commonly adventive. Helophytic (mostly), or mesophytic, or xerophytic; shade species, or species of open habitats; halophytic, or glycophytic. Some in damp or shady places, some (e.g. *I. muticum*, *I. triticeum*) in coastal sand.

Holarctic, Paleotropical, Neotropical, and Australian. Boreal. African, Madagascan, Indomalesian, Polynesian, and Neocaledonian. Eastern Asian. Saharo-Sindian, Sudano-Angolan, West African Rainforest, and Namib-Karoo. Indian, Indo-Chinese, Malesian, and Papuan. Hawaiian and Fijian. Caribbean, Amazon, Central Brazilian, Pampas, and Andean. North and East Australian. Sahelo-Sudanian, Somalo-Ethiopian, South Tropical African, and Kalaharian. Tropical North and East

Australian.

Rusts and smuts. Rusts — *Phakopsora* and *Puccinia*. Taxonomically wide-ranging species: *Phakopsora incompleta* and *Puccinia versicolor*. Smuts from Ustilaginaceae. Ustilaginaceae — *Sorosporium*, *Sphacelotheca*, and *Ustilago*.

Economic importance. Significant weed species: *I. indicum*, *I. muticum*, *I. rugosum* (in ricefields), *I. timorense*. Important native pasture species: *I. muticum*, *I. rugosum*.

References, etc. Leaf anatomical: Metcalfe 1960 and this project.

Illustrations. • I. australe: Gardner, 1952. • General aspect (I. fasciculatum): Gibbs Russell et al., 1990. • Abaxial epidermis of leaf blade (I. fragile)

Contents

Annex 932

"*Capsicum annum var. glabriusculum*", *Natives For Your Neighborhood, available at* http://regionalconservation.org/beta/nfyn/plantdetail.asp?tx=Capsannuglab (accessed 31 May 2016)

Bird pepper, Cayenne pepper

Capsicum annuum var. glabriusculum

Solanaceae

Keith A. Bradley

Keith A. Bradley

Roger L. Hammer

Landscape Uses:

Kitchen gardens.

Ecological Restoration Notes:

A somewhat rare and ephemeral understory component of coastal hammocks.

Availability:

Grown by one or two native plant nurseries in South Florida.

Description:

Small short-lived shrubby herb with dark green shiny leaves.

Height:

Typically 2-3 feet in height. Often about as broad as tall.

Growth Rate:

Fast.

Range:

Southern United States south mostly along the Florida coasts to the Monroe County Keys; West Indies, Mexico, Central America and northern South America. Rare and ephemeral throughout its range in South Florida.

Habitats:

Coastal hammocks.

Soils:

Moist, well-drained limestone or calcareous sandy soils, with humusy top layer.

Nutritional Requirements:

Moderate; can grow in nutrient poor soils, but needs some organic content to thrive.

Salt Water Tolerance:

Moderate; tolerates brackish water or occasional inundation by salt water.

Salt Wind Tolerance:

Moderate; grows near salt water, but is protected from direct salt spray by other vegetation.

Drought Tolerance:

Moderate; generally requires moist soils, but tolerant of short periods of drought once established.

Light Requirements:

Light shade to full sun.

Flower Color:

White.

Flower Characteristics:

Semi-showy.

Flowering Season:

All year.

Fruit:

Red berry. Edible (very hot!).

Wildlife and Ecology:

Birds (especially mockingbirds) eat the green, un-ripened peppers

Horticultural Notes:

Can be grown from seed.

Comments:

A short-lived plant, generally living 1-2 years. It recruits readily in the garden from seed but does not become aggressive.

Gann, G.D., M.E. Abdo, J.W. Gann, G.D. Gann, Sr., S.W. Woodmansee, K.A. Bradley, E. Grahl and K.N. Hines. 2005-2016.
Natives For Your Neighborhood. http://www.regionalconservation.org.
The Institute for Regional Conservation. Delray Beach, Florida USA.

Annex 933

"*Macaranga grandifolia*", *Tropical Plant Catalog, available at* http://toptropicals.com/catalog/uid/macaranga_grandifolia.htm (accessed 31 May 2016)

Macaranga grandifolia, Macaranga longifolia, Macaranga mappa, Macaranga, Nasturtium Tree, Parasol Leaf Tree, Bingabing -

This catalog is for information only. If you don't see the price - the plant is not for sale.

Click on image to enlarge.
Pictogram Guide you may also see symbol definition in a pop-up window by mouse-pointing on pictogram

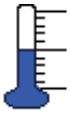
Macaranga grandifolia, Macaranga longifolia, Macaranga mappa
Family: Euphorbiaceae
Macaranga, Nasturtium Tree, Parasol Leaf Tree, Bingabing
Origin: Australia, Philippines












Macaranga grandifolia is a spectacular plant with tree-like habit and large, 1-2 ft wide, showy leaves. They feel tough in touch and resemble in shape nasturtium leaves. It is Philippines endemic and has been widely cultivated in Hawaii as a tropical ornamental. This plant has become very popular garden ornamental in many parts of the tropics for the extraordinary grandiose leaves, which are rounded-ovate in shape, with prominent, reddish veins and the stem attached towards the center of the leaf blade. The flowers are pinkish red and the males are held in coral-like, congested inflorescences. The leaf ash was eaten as a cure for enlarged bellies. Twine was made from the bark and the wood was used for fishing spears. The leaves were used to wrap food. Birds eat the ripe fruit. Separate male and female trees.

See Article about Macaranga.

Related species with slightly smaller leaves --Macaranga tanarius

Similar plants:

Annex 934

Dr. Peter P. Motavalli, Ph.D.,*Second Supplemental Expert Report on Soil Resources and Potential Self-Sustaining Agricultural Production on Itu Aba* (2 June 2016)

Second Supplemental Expert Report on Soil Resources and Potential Self-Sustaining Agricultural Production on Itu Aba

Dr. Peter P. Motavalli, Ph.D.

2 June 2016

I. Introduction

My name is Dr. Peter P. Motavalli and I have been a Professor of Soil Nutrient Management at the University of Missouri in Columbia, Missouri (U.S.A.) since 1999.[1] From 1994 to 1999, I taught and conducted research on soil nutrient management of Pacific Island soils, especially in the region of Micronesia, at the University of Guam. I previously provided a report, dated 9 March 2016, analyzing the soil resources and potential for agricultural production on Itu Aba. My CV is attached in an appendix to that report. I also provided a supplemental report, dated 24 April 2016, that addressed two documents included as exhibits to the *amicus curiae* submission by the Chinese (Taiwan) Society of International Law (CSIL).

In this second supplemental report, I provide observations on the "Visite Botanique au Récif Tizard", *Bulletin économique de l'Indo-Chine,* Septembre-Octobre 1936 – Report elaborated by the Division Botanique à l'Institut des Recherches Agronomiques de L'Indochine (hereinafter "the 1936 Report"), which is identified as Annex IV of the materials that the Tribunal obtained from the Bibliothèque Nationale de France and distributed to the Parties on 26 May 2016. An English translation of this document was provided to me by counsel for the Philippines on 28 May 2016 and is attached to this report as Appendix I.

II. Observations Regarding the Provenance of Samples

The 1936 Report contains analytical results for what appear to be four separate samples: (1) guano (Analysis No. 9.635); (2) natural phosphate (Analysis No. 9.636); (3)"[a]verage soil sample (at depth of 30 cm from surface)" (Analysis No. 9.637); and (4) coral sand (Analysis No. 9.638).

[1] The content of this second supplemental report does not reflect the official opinion or views of the University of Missouri. Responsibility for the information and views expressed in the report lies entirely with the author.

The text accompanying the analytical report states that the "[s]amples … taken" were from "phosphate[] … deposits" on Itu Aba but does not identify their specific source location. I suspect that the samples of the coral sand and "[a]verage soil" were taken in proximity to Itu Aba's principal phosphate deposits, which a map included in the 1936 Report indicates are concentrated in the southwestern part of the feature. The soil test results are therefore not likely to be representative of the soil resources elsewhere on the feature, nor do they purport to be. The possible proximity of the soil sample to guano and phosphate deposits could result in higher measured levels of soil organic matter and phosphate in the sample as compared to that of more representative soil samples taken in soil resources elsewhere on Itu Aba.

III. Observations Regarding Analytical Techniques and Measures of Soil Content and Composition for the "Average Soil Sample" (Analysis No. 9.637)

Of the four separate samples analyzed, this report focuses on the 1936 analysis of the "[a]verage soil sample" since the suitability of soil resources on Itu Aba for agricultural production is the primary criterion for evaluating the feature's ability to sustain agricultural production.

A. Soil Particle Size and Physico-Chemical Analysis of Soil

The soil particle size analysis (referred to as the "granular analysis") in the 1936 Report supports my previous conclusion that the soils on Itu Aba are generally dominated by coralline limestone sand and have a sand textural class. The analysis shows that 87% of the sample was sand. This mineral fraction of an uncultivated soil generally contains low plant levels of nutrients such as nitrogen and provides little nutrient retention and water-holding capacity to support crop growth. Soils dominated by sand-sized particles generally have low cation exchange capacity, which is important for nutrient retention. They also generally have

low water-holding capacity because both nutrients and soil water are largely retained by the clay and soil organic matter fractions in soils, which in sand-dominated soils are deficient.

The physico-chemical analytical results are also consistent with my earlier conclusions that the soil is very alkaline. The analysis in the 1936 Report indicates a very high pH (8.07) for the soil. Moreover, the analysis of the coral sand sample, which I would expect to be similar to the sand contained in the soil sample, shows carbonate levels of 39.3%, which are quite high. Plants growing in this soil are likely to suffer from deficiencies in several important nutrients, including potassium because this nutrient is in relatively low supply in this soil. In addition, micronutrients such as iron would be unavailable for plant uptake because the high soil pH transforms these nutrients into unavailable chemical forms (Stone et al., 2000).

B. Soil Nutrient Composition

In regard to soil nutrient composition, the 1936 analysis reported a low level of potassium, which would require soil amendments in order to sustain agricultural production.

Although there were relatively higher levels of certain other nutrients, the fact that 87% of the soil is comprised of coral sand and that it has a high pH means that these nutrients would be largely unavailable to agricultural crops because, as explained above, sandy soil provides little nutrient retention and a high pH impedes plant uptake of some nutrients. In any event, the 1936 analysis' reported measurements of nutrients are likely overstated because of the analytical techniques that were employed. In particular, a 10% hydrochloric acid extracting solution was used to measure phosphorus (described as phosphoric acid), calcium (described as lime), magnesium (described as magnesium oxide) and potassium. This likely overstated such measurements because the solution has a relatively high concentration of a strong inorganic acid compared to the weak concentration of acids used in most extractants

designed to assess soil nutrient availability. Using a weak concentration of organic acid produces more accurate results because, unlike the 10% hydrochloric acid solution, it does not dissolve less soluble forms of the nutrients that are not available to the plant.[2]

C. Soil Organic Matter

The 1936 Report indicates that organic matter comprised 9.44% of the sample, with 5.48% carbon and 0.32% nitrogen. Under some conditions, soil with these characteristics might support a modest level of agricultural production. However, that is not the case in regard to Itu Aba's soil in light of its dominance by sand and high pH, both of which significantly impede its ability to support agriculture. As stated, sandy soils are deficient in some nutrients and water retention, and high pH constrains plant uptake of some nutrients.

Regardless, the reported level of organic material is likely overstated. At the time the analysis was done the analytical techniques then in use tended to result in overestimations.[3] Further, the depth of the sampling is given as 30 cm, but no information was provided on whether the surface organic litterfall was removed prior to sampling the soil, which is standard procedure. Failure to do so would also overestimate organic matter. In that regard, it is significant that the soil analysis conducted by Xi (1947) eleven years later reported much

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[2] The report does indicate that a 2% citric acid solution was used to measure certain nutrients. However, its usage to measure phosphoric acid and potash levels indicates that the analysis was concerned with measuring the *fertilizer* value of the soil resource as opposed to its fertility (a measure of its amenability to agricultural production).

[3] The 1936 analysis likely used one of two methods to determine organic matter and total organic carbon: 1) the loss-on-ignition (LOI) combustion method, or 2) oxidation of soil organic carbon using dichromate or chromic acid method. Both methods have major limitations for estimating soil organic matter or total organic carbon. The LOI method is the crudest method of determining soil organic matter. It tends to overstate the amount of organic matter because the method does not distinguish between organic carbon and carbonates, an inorganic class of substances in which coralline limestone-derived soils are high. The dichromate-based methods also are likely to overstate organic matter because they depend on a static conversion factor to estimate the level of organic content, even though such factors vary considerably among different types of soils. For example, while one method assumes that the method oxidizes 77% of organic carbon, the oxidation level in nature varies from 59% to 94%, depending on the soil. The presence of chlorides, iron and manganese oxides in the soil also contribute to the overestimation of the soil total organic carbon results.

lower levels of organic matter on Itu Aba: 3.41% in the soil series and 6.89% in the guano layer.

* * *

In summary, the 1936 Report's analysis of an "[a]verage soil sample" on Itu Aba confirms my prior conclusions that the soil is sandy, calcareous, has a high pH, and lacks some major nutrients. In light of these characteristics, I conclude that Itu Aba's soil resources cannot sustain a meaningful level of agricultural production without the use of soil amendments and other major interventions.

Dr. Peter P. Motavalli, Ph.D.
2 June 2016
Columbia, MO, USA

References:

Stone, E.L., L. Migvar, and W.L. Robinson. 2000. Growing plants on atoll soils. Lawrence Livermore National Laboratory, University of California.

Xi, Lianzhi. 1947. Summary of land of Guandong Nansha Islands. Soil. 6: 77-80 (Annex 885)

APPENDIX 1: ENGLISH TRANSLATION OF ANNEX IV - “VISITE BOTANIQUE AU RÉCIF TIZARD”, BULLETIN ÉCONOMIQUE DE L’INDO-CHINE, SEPTEMBRE-OCTOBRE 1936 – REPORT ELABORATED BY THE DIVISION BOTANIQUE À L’INSTITUT DES RECHERCHES AGRONOMIQUES DE L’INDOCHINE

Vol. 39* SEPTEMBER-OCTOBER 1936

BULLETIN ÉCONOMIQUE DE L'INDOCHINE

[INDOCHINA ECONOMIC BULLETIN]

Agriculture, Animal Husbandry, Forestry

Industry, Commerce, Finance, Statistics

HANOI
GENERAL GOVERNMENT
OF INDOCHINA

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[4] Translator's Note: Term unclear. "Le barbone" can either be a grass (bluestem) or a disease of cattle.

INDUSTRY, COMMERCE, FINANCE, STATISTICS

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Monthly Statistics

Charts

Reports

BOTANICAL INVESTIGATION OF THE TIZARD REEF

The trawler *De Lanessan*, operated by the Nha Trang Oceanographic Institute, the Botanical Division of the Agronomic Research Institute of Indochina, on a research voyage to the Tizard Reef, had the good luck to take on board two specialists who had been assigned the task of studying the islands from the botanical point of view.

Three islands were visited, namely Itu-Aba, Nam-Yit, and Sand-Caye.

ITU-ABA

The island of Itu-Aba, located at 10°22'42" North latitude and 114°21'10" East longitude and approximately 315 nautical miles (approximately 600 km) from the coast of Annam, has an ellipsoidal shape. The island is 2 km 500 m long and 1 km wide and only 5 to 6 meters above sea level. It is therefore difficult to spot from far away.

Consisting entirely of exposed coral reefs, with a large population of visiting seabirds, it was covered entirely with their excrement. This excrement, which is very rich in phosphoric acid and nitric acid, attacks the coral limestone and forms calcium phosphates and nitrates. In this rainy climate, the nitrates were dissolved and washed into the ocean; the less soluble phosphates form very large deposits that the Japanese have been exploiting for a long time *(See: Decauville – “Inventory of phosphates prepared and overgrown by vegetation, mines etc.”).

Samples were taken and analyzed by the Chemistry Division of the Agronomic Research Institute. The results are presented at the end of this report.

VEGETATION

As might be expected, the vegetation on the island consists of very few species. Besides the imported plants: approximately one hundred coconut palms (carefully aligned in a southern portion of the island and sufficiently well established that they must already be very old), castor oil plants, and papaya trees scattered here and there all over the island. A total of approximately twenty species were identified.

The East and South coasts of the island, which are better protected from the monsoons, are covered by very beautiful vegetation, which is all the more luxurious because it grows in soil that is very rich in phosphates. On the other hand, the North and West coasts, although they have the same botanical species, are covered with scrubbier vegetation that is bare of foliage; there are many dead plants.

The most beautiful trees are *Cordia subcordata* (Boraginaceae) more than 20 m tall with trunks that reach 2 m in diameter. They are fairly numerous and scattered all over the island, especially toward the center.

Two *Erythrina indica*, also in the center of the island, have reached a height of 20 m with trunks 1 m in diameter.

Proceeding from the center of the island toward the East, there is a population of young Indian almond trees (*Terminalia Catappa*) from 5 to 6 meters high, the majority of which are offshoots of the stumps of old Indian almond trees that were undoubtedly used by the phosphate miners. Besides this population there is a single, very vigorous *Calophyllum inophyllum* that has reached a height of 5 to 6 meters.

Toward the Northeast, there are approximately twenty *Macaranga* trees—the exact species of which could not be determined because they were bare of flowers and fruit—that are 15 to 20 meters tall. They grow next to several *Ochrosia borbonica* that are some 10 meters tall and are bearing ovoid fruits that exude a white latex.

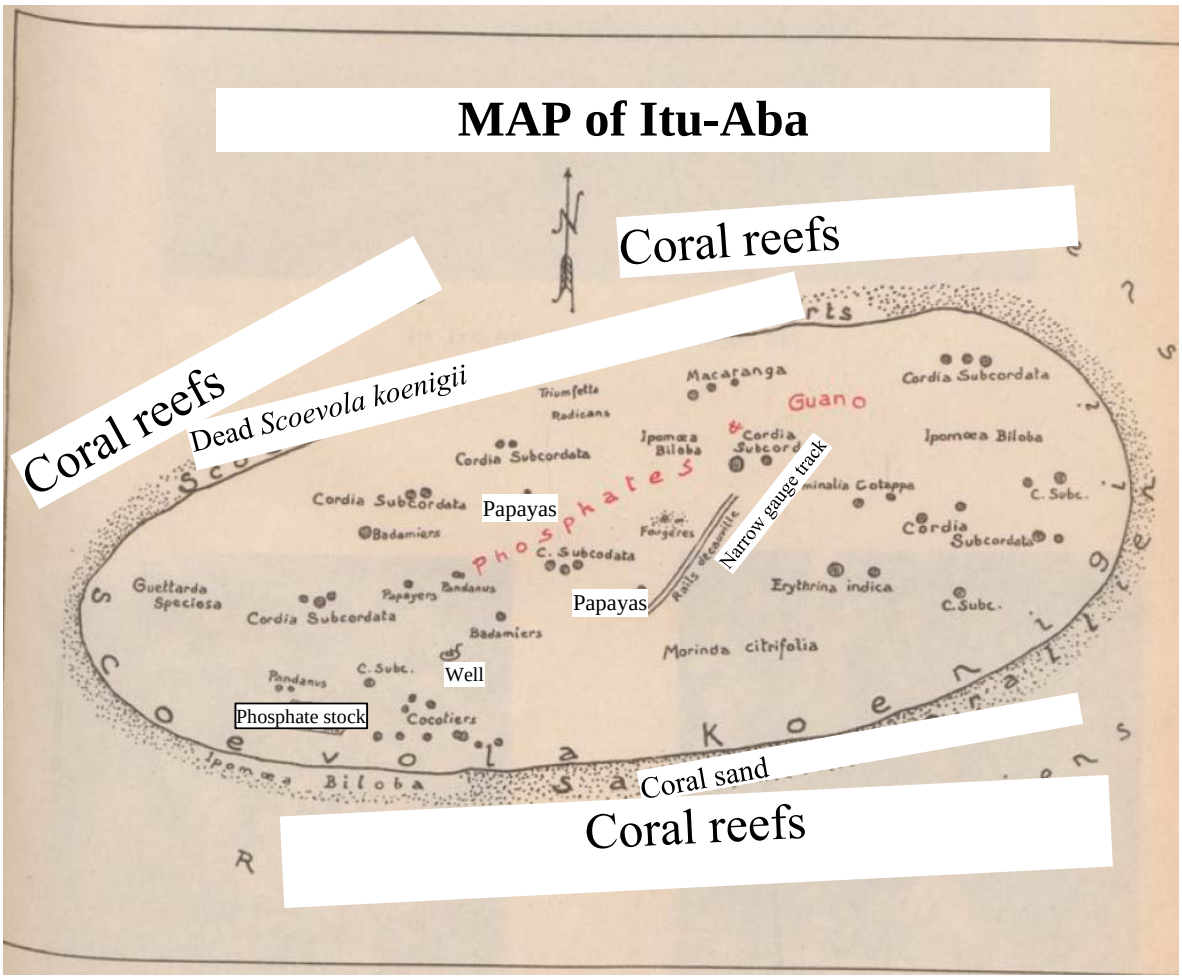
Those are the only trees on the island. Several species of shrubs also grow there. One of them, *Scoevola koenigii* (Goodeniaceae), which reaches a height of 5 to 6 meters, forms a belt of vegetation all around the island, outside of which there are only white sand beaches. But while on the South coast these shrubs are vigorous, quite green and covered with their white fruit, on the North coast they are dead and form only a hedge of bare branches.

In the center of the island, several *Guettarda speciosa* 2 to 4 m tall live among *Morinda citrifolia* (variety bracteata), which are very vigorous and loaded with fruit.

In the southwestern portion of the island, *Trema volutina* (Urticaceae), *Capsicum fructicosum* (Solanaceae) with red fruit, and *Clitoria macrophylla* (Papilionaceae), partly overgrown by *Capparis pumila*, are mixed with castor oil plants that were undoubtedly imported by the phosphate miners. Papaya trees, also undoubtedly introduced, are also found all over the island.

The ground cover consists of numerous herbaceous species. A tree fern that grows to heights of more than 1 m, *Blechnum sp.*, forms relatively impenetrable thickets over a major part of the island. Several […]

MAP of Itu-Aba



Island of Itu-Aba - South/Southeast Coast

SCOEVOLA KOENIGII

(South Coast of the island)

CORDIA SUBCORDATA

(Trunk more than 2 m in diameter)

ERYTHRINA INDICA

(Center)

MACARANGA Sp (Euphorbiacées).

(Northeast Coast)

Tree fern under *Guettarda speciosa*

Phosphate deposit overgrown by vegetation

[…] Cyperaceae, *Mariscus albescens*, are pushing up at the base of the *Cordia* and seem to be suffering from the drought. Several grasses, *Thuaria sarmentos* and *Ischoemum sp.*, are found here and there along the edge of the beach. Finally, toward the South and center of the island, probably where the original vegetation was destroyed for the extraction of the phosphate, there is an unbroken carpet of *Ipomea biloba* covered with purple or white flowers and fruit. To the north, this carpet of plants consists of rampant Trilliaceae, *Triumfetta radicans*, which is found on the shore and in the interior of the island.

To conclude this review of the vegetation, we noted, in the southwestern part of the island, several *Pandanus* bearing large fruits.

In summary, as expected and except for the introduced plants, the vegetation is very poor, since it consists of only about twenty species.

The island is now completely deserted and the clearings are no doubt being reforested by species similar to the existing ones.

All around the island a beach—approximately 17 meters wide at high tide—forms the limit between the fertile ground and the coral shelf, which is visible over more than 800 meters thanks to the green color of the water that covers it.

Some twenty species of marine algae were collected and delivered to the Oceanographic Institute, which is responsible for having them identified by specialists. Among them we noted *Padina australis* (collected in the open ocean at a depth of 150 meters between Itu-Aba and Sand-Caye), *Sargassum sp*. (collected on the beach at Sand-Caye), *Laurencia paniculata* and *Turbinaria ornata*.

The island, which was once heavily visited by birds, as evidenced by the large deposits of guano, was completely deserted from this point of view at the time of our visit.

The only visitors to the island currently seem to be Chinese and Japanese fishermen and ocean-going junks that haul up and set sail again during their seasonal voyages from China to Singapore or Japan to Singapore and back.

*

* *

ISLAND OF NAM-YIT

The island is located at 10°12'0" North latitude and 114°21'25" East longitude, 10 nautical miles from Itu-Aba. Surrounded by submerged coral reefs that are much more extensive than those of its neighbor, it is nevertheless much smaller in terms of surface area.

VEGETATION – Even less than on Itu-Aba. Same border of *Scoevola koenigii*, but even less flourishing. Many of the lower branches are stunted and bare of foliage. There is no *Ipomea biloba*, although *Triumfetta radicans* is all over the beach. There is one Lauraceae not found on Itu-Aba: *Cassytha filiformis*, a small creeping plant, very vigorous, loaded with pea-size fruit, grows quite abundantly here. The only trees on the island (about fifteen) are a few coconut palms.

SOIL - Coral sand only. There is no guano and consequently no phosphate.

This island is also deserted. Rich in nacreous shells, it is visited by Japanese fishermen who don goggles and dive to collect them.

*
* *

ISLAND OF SAND-CAYE

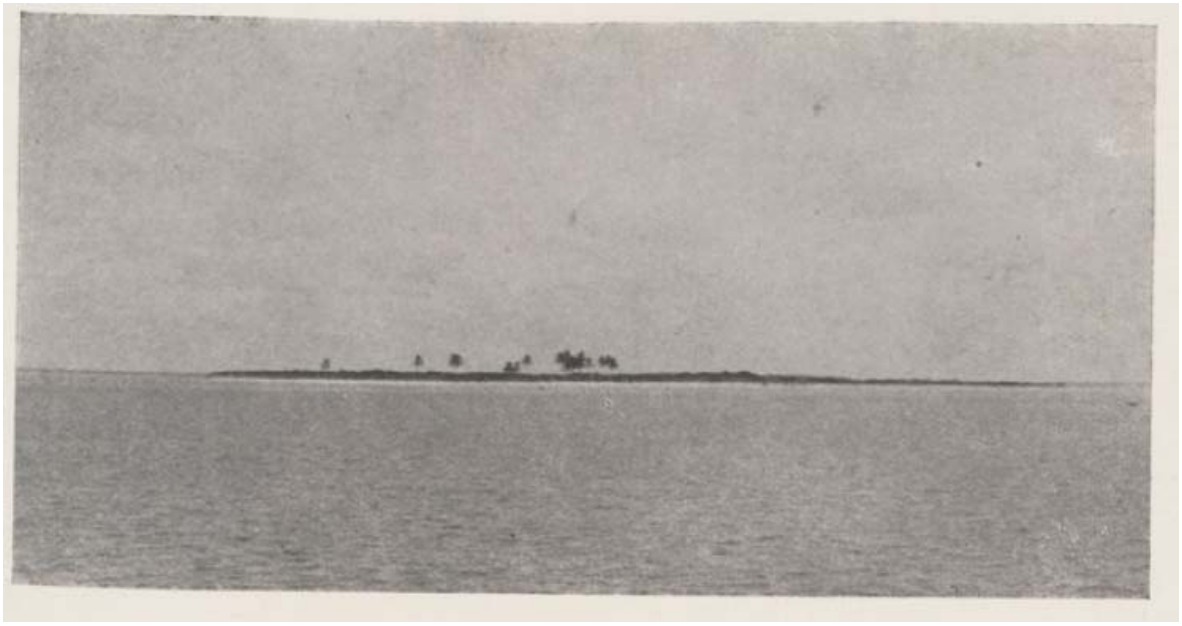
This island, which is part of the same formation at Nam-Yit, is half as large; it is located at 10°22'42" North latitude and 114°27'40" East longitude.

Sand-Caye is a desert island of no interest. No trees, only a few *Scoevola*. The herbaceous vegetation, which contains no new species, is sickly and stunted. There are a great many dead tree stumps.

This island is little visited by fishermen. There are no interesting shells.

NGUYÈN-DINH-NGOI,
Technical Specialist, Agricultural Services

& NGO-THETAN,
Assistant



NAM-YIT (General view)

SAND-CAYE (General view)

ANALYSIS BULLETIN No. 9,638	ANALYSIS BILLETIN No. 9,636
Type: Coral sand Entry date: May 5, 1936 Origin: Island of Itu-Aba Reference: Botanical Division of the I.R.A.I., shipping list dated May 4, 1936.	Type: Natural phosphate Entry date: May 5, 1936 Origin: Island of Itu-Aba Reference: Botanical Division of the I.R.A.I., shipping list dated May 4, 1936.
ANALYSIS RESULTS	ANALYSIS RESULTS
Hygroscopicity.....0.30 % Silica (SiO_2).....7.00 Carbonates (CO_2).....39.30 Chlorides (Cl).....Traces Lime (CaO).....50.05 Magnesium oxide (MgO).....1.83 Not measured.....1.82	Moisture.....8.30 % Loss to fire (including CO_2).....14.40 Silica (SiO_2).....1.00 Phosphoric acid (P_2O_5).....27.68 Carbonate (Calcimeter).....6.87 Lime (CaO).....45.56 Magnesium oxide (Mg).....Traces

Saigon, June 20, 1936
Director of the Chemistry Division
Signed: Tkatchenko

ANALYSIS BULLETIN No. 9.635

Type: Guano
Date of entry: May 5, 1936
Origin: Island of Itu-Aba
Reference: Botanical Division of the I.R.A.I., shipping list dated May 4, 1936.

Analysis results:

Hygroscopicity……..	10.30
Loss to fire …….	35.56
Mechanical analysis %	
Pebbles ……..	0
Gravel ……..	0
Fines …….	100
Granular analysis %	
Fraction I 2,000 to 1,000 gr……	16.7
— II 1,000 to 500 gr…….	29.0
— III 500 to 250 gr……..	21.8
— IV 250 to 100 gr……..	12.6
— V 100 to 50 gr. ……	2.7
"Sand"……..	"82.8"
— VI 50 to 20 gr……...	6.1
— VII 20 to 5 gr……	6.1
— VIII 5 to 2 gr……	2.0
"Silt"…….	"14.2"
— IX 2 to 0.5 gr……	1.0
— X > 0.5 gr…….	2.0
"Clay"……..	"3.0"
Organic Complex %	
Carbon (C)	5.81
Total nitrogen (N)	1.13
Ratio C/N……	5.15
Total organic matter……	10.01

Physico-chemical characteristics		
1. — pH		7.45
2. — Exchange acidity		0.35
3. — Hydrolysis acidity		2.6
Chemical characteristics % (Assessed with 10% HCl).		
Phosphoric acid (P_2O_5)	a.	19.19
Lime (CaO)		12.88
Magnesium oxide		0.54
Potassium (K_2O)	b.	0.09
Assimilables (Assessed with 2% citric acid)		
Phosphoric acid (P_2O_5)	c.	0.08
Potash (K_2O)	d.	0.03
Ratio 100 c/a……...		0.42
Ratio 100 d/b……..		33.3
Alumino-silicate colloids (Assessed with 5% KOH)	%	mé
Silica (SiO_2)……	0.08	0.7
Alumina (Al_2O_3)…….	1.00	9.8
Combined silica and alumina ($2SiO_2Al_2O_3$)	0.16	1.4
Free silica	–	–
Free alumina	0.93	9.1
Silica + alumina ($SiO_2 + Al_2O_3$)	1.08	10.5

Saigon, June 20, 1936
~~*Director, Chemistry Division*~~
Signed: Tkatchenko

ANALYSIS BULLETIN No. 9.637

Type: Average soil sample (at a depth of 30 m from the surface)
Date of entry: May 5, 1936
Origin: Island of Itu-Aba
Reference: Botanical Division of the I.R.A.I., shipping list dated May 4, 1936.

Analysis results:

Hygroscopicity……..	4.20
Loss to fire …….	9.70
Mechanical analysis %	
Pebbles ……..	0
Gravel ……..	0
Fines …….	100
Granular analysis %	
Fraction I 2,000 to 1,000 gr……	4.3
— II 1,000 to 500 gr…….	22.8
— III 500 to 250 gr……..	37.6
— IV 250 to 100 gr……..	18.7
— V 100 to 50 gr. ……	3.6
“Sand”……..	“87.0”
— VI 50 to 20 gr……...	4.0
— VII 20 to 5 gr……	4.0
— VIII 5 to 2 gr……	2.0
“Silt”…….	“10.0”
— IX 2 to 0.5 gr……	0.5
— X > 0.5 gr…….	2.2
“Clay”……..	“3.0”
Organic Complex %	
Carbon (C)	5.48
Total nitrogen (N)	0.32
Ratio C/N……	17.1
Total organic matter……	9.44

Physico-chemical characteristics		
1. — pH		8.075
2. — Exchange acidity		0.35
3. — Hydrolysis acidity		0.8
Chemical characteristics % (Assessed with 10% HCl).		
Phosphoric acid (P_2O_5)	a.	8.87
Lime (CaO)		39.10
Magnesium oxide		0.91
Potassium (K2O)	b.	0.03
Assimilables (Assessed with 2% citric acid)		
Phosphoric acid (P_2O_5)	c.	0.22
Potash (K_2O)	d.	0.01
Ratio 100 c/a……...		2.48
Ratio 100 d/b……..		33.3

Alumino-silicate colloids (Assessed with 5% KOH)	%	mé
Silica (SiO_2)……	0.22	1.8
Alumina (Al_2O_3)…….	0.02	0.2
Combined silica and alumina ($2SiO_2Al_2O_3$)	0.44	3.6
Free silica	0.19	1.6
Free alumina	-	-
Silica + alumina ($SiO_2 + Al_2O_3$)	0.24	2.0

Saigon, June 20, 1936
Director, Chemistry Division
Signed: Tkatchenko