Species Profiles for Pacific Island Agroforestry
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Gnetum gnemon (gnetum)

Gnetaceae (jointfir family)

ambiam*, *ambiamtupee **(PNG: Maring);** ***bago*** **(Philippines: Bataan, Tayabas, and Camarines);** ***belinjo*, *melinjo*** **(Indonesia);** ***blinjo*** **(E. Java);** ***dae*, *daefasia*, *daemalefo*** **(Solomon Islands: Kwara'ae); gnetum, joint fir, Spanish joint fir, two leaf (English);** ***maninjau*** **(Malaysia);** ***melindjo*** **(Singapore);** ***sikau*, *sukau*, *sukau buli*, *sukau motu*** **(Fiji);** ***tulip*** **(PNG: Tok Pisin);** ***voe*, *khalet*** **(Cambodia)**

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IN BRIEF

Distribution Found in Southeast Asia and Melanesia.

Size Can grow to 10–15 m (33–50 ft) in height.

Habitat Thrives in a tropical rainforest climate, rainfall 750–5000 mm/yr (30–200 in/yr), elevations of 0–1700 m (0–5600 ft).

Vegetation Associated with the diverse flora of Indomalayan and Melanesian humid rainforests and the cultivated species in homegardens and orchards.

Soils Prefers slightly acid to neutral, well drained soils and tolerates infertile and shallow substrates.

Growth rate Estimated at 0.75–1.5 m/yr (2.5–5 ft/yr) in height.

Main agroforestry uses Improved fallow, windbreak, living trellis.

Main products Nut, leaf vegetable, timber.

Yields Nut production may reach 80–100 kg/tree/yr (176–220 lb/tree/yr).

Intercropping Shade tolerant, it is intercropped with many species including *A. camansi*, *Pandanus* spp., durian (*Durio* spp.), rambutan (*Nephelium lappaceum*), *Parkia* sp.

Invasive potential Although not reported as invasive, its shade tolerance indicates the potential for invasiveness in new environments.

PHOTO: G. D. CARR

Leaves and flowers.

INTRODUCTION

Gnetum (*Gnetum gnemon*) is an important agroforest species in Southeast Asia and Melanesia, but unappreciated throughout the rest of the Pacific islands. This small- to medium-size tree up to 15 m (50 ft) in height is native to Indo-Malaya and perhaps Melanesia. The species is found in dry and humid forests of the region. It is a spontaneous regrowth species in fallow forests and is also planted as a cultivated species in both backyard gardens and orchards. The species is tolerant of shade, open areas, a fairly large temperature range, a wide rainfall regime, and in all likelihood infertile soils. Young seedlings respond positively to phosphorous. As indicated by its absence in atoll islands, the species may not be tolerant of salt spray. Gnetum is an important food and cordage species in for Melanesia. It is also used as a timber species and medicine. It is used as a trellis for climbing species, i.e., *Dioscorea* yams.

DISTRIBUTION

Native range

Gnetum is native from Assam (northeastern India) eastward through Malesia to Fiji. The tree is present in Assam, Cambodia, Vietnam, Thailand, Malaysia, Malayan Peninsula and islands, Fiji, Papua New Guinea, Solomon Islands (Santa Anna), and Vanuatu (Pentecost, Ambae, Maewo, Torres Islands). It is native to dry to humid tropical forest to lower montane forest (up to 1700 m [5600 ft] in elevation in Papua New Guinea). The tree is commonly found along rivers and streams, in both cultivated and natural ecosystems. In the Bismarck Mountains of Papua New Guinea, the tree is a component of breadfruit and pandanus orchards. In Fiji, the species is found at up to 850 m (2800 ft) in elevation. Gnetum also native to Vanuatu, where it is rare, and Samoa (Walter and Sam 2002).

Current distribution

It is said to have been introduced to the Andaman Islands, Sumatra, and Java. Several sources indicate that the species is present in the Caroline Islands of Micronesia (e.g., Walter and Sam 2002, Smith 1979). However, a careful review of Fosberg et al. (1979, 1982) indicates that the species is not present in any of the islands of Micronesia and that any reference to the species is most likely based on a misidentification. Specifically, *Phalaria nisidai* Kaneh., which is found on Babeldaob and Urukthapel in Palau (Fosberg et al. 1979), was probably misidentified as *Gnetum gnemon*. Additionally, after some 30 years of plant collecting, the curator of the Guam Herbarium has not found the species in Micronesia. Finally, there is no vernacular name for *Gnetum gnemon* in Palau (Fosberg et al. 1980). It would also be expected that if *Gnetum gnemon* was present and/or culturally significant in Palau, it would have a Palauan name. Therefore any reference to this species being present in Micronesia should be considered dubious.

BOTANICAL DESCRIPTION

Preferred scientific name

Gnetum gnemon L.

Family

Gnetaceae (jointfir family)

Non-preferred scientific names

G. gnemon var. *sylvistris* L.
G. acutatum Miq.
G. gnemon var. *ovalifolium* (Poir.) Blume
G. vinosum Elmer

Common names

ambiam, *ambiamtupee* (PNG: Maring)
bago (Philippines: Bataan, Tayabas, and Camarines)
belinjo, *melinjo* (Indonesia)
blinjo (East Java)
dae, *daefasia*, *daemalefo* (Solomon Islands: Kwara'ae)
gnetum, joint fir, Spanish joint fir, two leaf (English)
maninjau (Malaysia)
melindjo (Singapore)
sikau, *sukau*, *sukau buli*, *sukau motu* (Fiji)
tulip (PNG: Tok Pisin)
voe, *khalet* (Cambodia)

Size

Gnetum is a small- to medium-size tree that reaches 10–15 m (33–50 ft) in height and attains a trunk diameter of up to 40 cm (16 in). Branches are noticeably swollen at the base.

Typical form

The tree is slender with a straight main stem. There are numerous whorls of branches down to the base.

Flowers

The species is dioecious, having male and female reproductive organs on separate plants, but not completely so. As a member of the gymnosperms, gnetum does not have flowers. Instead, the species has cones or strobili (singular, strobilus) which are an aggregation of sporangia-bearing structures at the tip of a slender stem or axis. The staminate strobilus is an axis (analogous to a slender spike), 3–5 cm

(1.2–2 in) in length, having many pairs of cup-shaped bracts arranged in whorls. The staminate strobilus or male cone which bears the microsporangia (pollen sacs) is also called a microsporanginate strobilus. The ovulate (female) strobilus is 6–10 cm (2.4–4 in) in length and bears the ovules or seeds. It is also called a megasporangiate strobilus. This axis bears a "pair of opposite sheathing bracts at the base, followed by five or six whorls of ovules, with five to seven ovules in a whorl" (Chamberlain 1935).

Top: Fruits still attached to branch. Bottom: Stem and branch attachments. PHOTOS: B. TOMLINSON

Leaves

Leaves are dark green, shiny, smooth, acute at both ends, opposite, and variable in size and shape. Typical size of leaves is 10–20 cm (4–8 in) long and 4–7 cm (1.6–2.8 in) wide. Leaf shape is elliptic, lanceolate, and ovate oblong. Branches flush and flower throughout the year.

Fruit

Fruits are yellow, turning purple-red or orange-red with maturity, and ovoid, 1–3.5 cm (0.4–1.4 in) in length. The skin is thin. In Indonesia this species fruits three times per year, March–April, June–July, and September–October (Cadiz and Florido 2001).

Seeds

There is one large ovoid or ellipsoid seed per fruit.

Bark

The bark is gray and marked with conspicuous raised rings in the position where older branches have fallen off.

Rooting habit

The trees are deeply rooted with a strong taproot.

Similar or look-a-like species

Gnetum costatum is a similar looking tree. Fruit of *G. costatum* is spindle shaped and its leaves are leathery compared with the ovoid or ellipsoid fruits and smooth leaves of *Gnetum gnemon*.

GENETICS

Known varieties

There are several varieties of *Gnetum gnemon* including the tree form (var. *gnemon*) and shrub forms (vars. *brunonianum*, *griffithii*, and *tenerum*). *Gnetum gnemon* var. *gnemon* is the commonly cultivated variety that is characterized by its tree form and large fruits.

ASSOCIATED PLANT SPECIES

The general flora includes the many components of the species-diverse Indomalayan and Melanesian humid rainforests. Walter and Sam (2002) report that in New Guinea a close relative, *G. costatum*, is found in forests of *Lithocarpus*, *Anisoptera*, and *Hopea*.

Associated species commonly found in native habitats

Gnetum is often planted as a cultivated species in homegardens and orchards. In Papua New Guinea, this species can be found in association with breadfruit (*Artocarpus* spp.), *Pandanus conoideus* and other food and fiber species (Kennedy and Clarke 2004). Some of these arboreal complexes are quite old, as evidenced by the macrobotanical remains found in archaeological sites. For example, macrobotanical remains of *Canarium* from New Guinea have an age date of 14,000 BP (Before Present). The species is a natural component of the rainforest, and is often a spontaneous component of fallow forests.

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

This species is best suited to a tropical rainforest climate as it is very common at low elevations in the Indomalayan and Melanesian regions.

Elevation range

0–1700 m (0–5600 ft) in Papua New Guinea

Mean annual rainfall

750–5000 mm (30–200 in/yr). It thrives best where the rainfall is 3000–5000 mm/yr (120–200 in/yr).

Rainfall pattern

The tree grows in climates with bimodal or uniform rainfall patterns.

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

2–7 months (CABI 2003)

Mean annual temperature

22–30°C (72–86°F)

Mean maximum temperature of hottest month

32–36°C (90–97°F)

Mean minimum temperature of coldest month

13.8–22°C (57–72°F)

Minimum temperature tolerated

12.8°C (55°F)

A 10 m (33 ft) tall gnetum at Kompiai Village, Jimi Valley, Western Highlands District, Papua New Guinea, 1600 m (5200 ft) above sea level (1967). PHOTO: H. MANNER

Soils

It prefers generally slightly acid to neutral soils. As a tropical rainforest species, gnetum is probably adapted to soils of low fertility.

Soil texture

It grows in light to heavy soils (sands, sandy loams, loams, sandy clay loams, sandy clays, clay loams, and clays).

Soil drainage

It requires freely draining soils.

Soil acidity

Neutral to mildly alkaline soils (pH 6.1–7.4)

Special soil tolerances

The tree tolerates infertile and shallow soils. It can grow on soils high in clay or sand, and also on calcareous rocks, given continuous soil moisture.

Tolerances

Drought

The tree can tolerate several months of drought, assuming soil moisture retention, seepage water, or irrigation through the dry season.

Full sun

The tree can grow in full sun.

Shade

Gnetum is very tolerant of shade.

Frost

Its native range is frost free, so it is unlikely to tolerate frost.

Waterlogging

The tree does not tolerate waterlogging.

Salt spray

The tree is intolerant of salt spray as it is not a coastal species.

Wind

This species is a favored species in the arboriculture of the Reef Islands because of its resistance to cyclones (Henderson and Hancock 1989 cited by Walter and Sam 2002).

Abilities

Regenerate rapidly

Gnetum is probably a rapid regenerator as evidenced by its spontaneous growth in fallow forests. The tree has been recommended for environmental protection (regreening) programs (CABI 2003).

Coppice

The tree regrows readily from pruning. Pruning can be used to control tree size, induce shoot flushing for harvest of leaf vegetable, or to improve tree shape.

Other

It has a mycorrhizal association (with *Scleroderma sinnamariense*) that makes phosphorous and some micronutrients more readily available (Cadiz and Florido 2002).

GROWTH AND DEVELOPMENT

Growth rate

While the growth rate is moderate at 0.75–1.5 m/yr (2.5–5 ft/yr), the rate is probably higher when the tree is young and in sunlight and lower when it is in the understory. In experimental conditions, mycorrhizal inoculation appears to enhance seedling growth under shaded conditions in acidic soils (Salim et al. 2002).

Flowering and fruiting

Trees flower several times a year, with maximum fruiting probably occurring with the rainy season. In Indonesia gnetum flowers at least three times per year, with fruiting coinciding with the rainy season (Cadiz and Florido 2001). Fruiting begins within 5–8 years in seedlings.

Reaction to competition

There is little information as to the reaction to competition. However, as this species can regenerate spontaneously in fallow forests and is tolerant of shade and open conditions, the species is probably a good competitor.

GNETUM GENETICS

From an evolutionary perspective, *Gnetum gnemon* is an interesting taxa, whose origin and relationships to angiosperms are not completely understood. The plant is a gymnosperm (seed plants with naked ovules), which unlike angiosperms does not have flowers in the true sense of the word. Chamberlain (1935) wrote that the Gnetales arose during the Upper Cretaceous as a branch of the Coniferales, which in turn evolved from the Pteridophytes (ferns). However, because *Gnetum gnemon* and other members of the order (*Ephedra* and *Welwitschia*) have some characteristics also found in the angiosperms (for example, leaves that look like angiosperm leaves), some botanists believe that the Gnetales are ancestors of the angiosperms (Chamberlain 1935). There is evidence suggesting that the process of double fertilization in *Gnetum gnemon* evolved in a common ancestor of angiosperms and Gnetales, which are the closest living relatives of the flowering plants (Carmichael and Friedman 1996). Additionally, early phylogenetic analyses, based on morphological similarities, placed the angiosperms and gnetophytes in a clade called "anthophytes," which emphasized their shared possession of flower-like reproductive structures (Winter et al. 1999). However, based on genetic evidence, it appears that *Gnetum gnemon* is more closely related to the conifers (in contrast to the the anthophyte clade), and that the process of double fertilization and the reproductive structures of the angiosperms and gnetophytes evolved independently (Winter et al. 1999).

PROPAGATION

This species is fairly easily propagated. It can be propagated by seed, air-layering, grafting, cutting, or budding (Cadiz and Florido 2001). To propagate a few trees, an appropriate method is to transplant volunteers from under a tree. Direct-seeding in the field is a popular propagation method.

Propagation by seed

Seed collection

Large, mature fruits are collected from the ground. Embryo development may not be complete when the fruit drops, as full development of the embryo takes place on the ground.

Seed processing

The outer skin is removed and the seeds air-dried in the shade.

Seed storage

The seeds are classified as orthodox in terms of storage, which means they remain viable when stored dry for extended periods.

Pre-planting treatments

No pre-planting treatments are recommended.

Growing area and media

The seed is pre-germinated in a bed of alternating layers of seed and sand. The germination bed is kept in shady conditions. Additional phosphorous may improve seedling development. Inoculation with the mycorrhizae fungi *Scleroderma sinnamariense* also improves seedling growth (Cadiz and Florido 2001).

Germination

Seeds take 45–360 days to germinate (Cadiz and Florido 2001). The germination bed should be watered daily to hasten germination.

Time to outplanting

Germinated seedlings are transplanted to containers, where they are raised for about 6 months prior to outplanting.

DISADVANTAGES

The species has no major drawbacks. Yield potential, products, and markets for gnetum products all require further research.

Potential for invasiveness

Due to its shade tolerance, this species could be considered a potential weed threat to native plant communities.

Diseases and pests

No major pests or diseases have been observed (Cadiz and Florido 2001). The trees should be guarded against rats and squirrels, which eat the seeds.

AGROFORESTRY/ENVIRONMENTAL PRACTICES

As an agroforest species, this tree serves as a trellis for yam and other climbers. It also is used as a border species and has some value as a soil enhancer.

Crop shade/overstory

The tree is used to provide shade for shade-loving plants (Salim et al. 2002).

Homegardens

The tree is found occasionally in homegardens.

Improved fallows

It can be used for dryland rehabilitation and afforestation, as it has the ability to improve soil physical properties (Salim et al. 2002).

Boundary markers

Gnetum is grown along field borders (Cadiz and Florido 2001).

Windbreaks

It is cultivated in the Reef Islands because of its resistance to cyclones (Walter and Sam 2002).

Host plant trellising

The tree is used as a support for yam and other shade-tolerant climbers (Thaman 1990).

Ornamental

The tree is attractive and can be pruned to size. Therefore it is suitable for use in homegardens as an ornamental.

USES AND PRODUCTS

Gnetum is more utilized in Southeast Asia and Melanesia (Vanuatu, Papua New Guinea, Solomon Islands, and Fiji) than in the rest of the Pacific islands. The primary products are the seeds and leaves for human consumption.

Nut/seed

The seeds are eaten raw, boiled, fired, or roasted. In East

Java, "blinjo" chips made from gnetum seeds are an important home industry. The mature nuts are husked, mashed, made into a small flat cake, and sun dried. The chips are fried in oil and sold by street hawkers (Cadiz and Florido 2001, Anon nd:b). In Mejono village, East Java, chips are manufactured by some 320 home-based companies that employ 780 workers and produce 600 mt (660 t) of chips per year (Yayuk nd.).

Leaf vegetable

In Vanuatu the leaves and young inflorescence are boiled or braised in small bamboo pots and flavored with coconut cream. In parts of Papua New Guinea, the leaves and inflorescence are cooked with game, pork, or a sauce made from red pulp of *Pandanus conoideus*. *Gnetum gnemon* var. *tenerum* is an important leaf vegetable in southern Thailand (Verheij and Sukendar 1991).

Other vegetable

In addition to the young leaves, flowers and fruits are used as vegetables, eaten raw, boiled, or roasted (Salim et al. 2002). The outer flesh of the nut, ripe or unripe (still green), can be fried to make a chewy snack or added to other dishes (Potter 2004).

Medicinal

The leaf sap is used medicinally to cure an eye complication.

Timber

The wood is used for tool handles and house beams. In Indonesia the wood is employed for paper pulp and house construction. In Malaysia and Hong Kong the wood is used for paper, boxes, and house construction (Agroforestry 2005).

Fuelwood

The wood can be burned for firewood.

Rope/cordage/string

The bast fibers are used to make cordage for fishing lines, fishnets, and string bags (known in New Guinea pidgin as bilum). The fiber is durable in seawater. The fiber is also used for a well known musical bowstring (Verheij and Sukendar 1991).

Other

The fungus *Scleroderma sinnamariense*, a usual mycorrhizal associate of gnetum, produces a fruiting body that is edible.

COMMERCIAL PRODUCTS

As described above, the pounded and dried nuts form the basis of an important home industry in Java, Indonesia. Cadiz and Florido (2001) state that the chips are an Indonesian export. A potential economic use of this plant is the utilization of its bark in rope making (Salim et al. 2002).

Spacing

Trees are planted 5–12 m (16–40 ft) apart in fields prepared by removing weeds and shrubs.

Management objectives

After planting, occasional weeding is required (Cadiz and Florido 2001, Verheij and Sukendar 1991). Trees can be pruned to encourage new shoot growth for leaf vegetable. It is not known how harvesting of shoots affects fruiting, as the inflorescences are borne both on young shoots and older branches (Verheij and Sukendar 1991).

Advantages and disadvantages of growing in polycultures

Advantages of gnetum include shade tolerance and amenability to cultivation. Additionally, the tree provides useful nuts and a leaf vegetable throughout its life, which can be 100 years or longer.

Yields

In West Sumatra, large trees are said to yield 20,000–25,000 fruits per year. The maximum production of nuts is projected to reach 80–100 kg/tree/yr (176–220 lb/tree/yr) (Cadiz and Florido 2001).

Processing required

Processing the seeds, such as in the making of blinjo chips, can greatly enhance marketability of gnetum.

INTERPLANTING/FARM APPLICATIONS

Example system 1 (CABI 2003)

Gnetum gnemon var. *tenerum* plants are raised from seed, air-layers or root suckers and planted 2 m (6.6 ft) apart, usually as intercrop among durian (*Durio* spp.), rambutan (*Nephelium lappaceum*), *Parkia* sp., etc., to benefit from the shade of the trees.

Example system 2 (Ragone 2004)

Gnetum is grown for its edible leaf in *Artocarpus camansi*

and *Pandanus* orchards in the Jimi Valley, Papua New Guinea.

PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

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

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Gnetum gnemon (gnetum)

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