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Polynesian Arrowroot in the Marshall Islands

Makmok
Makmōk

Polynesian Arrowroot in the Marshall Islands
Makmōk

Notes on the occurrence, utilisation, and importance of Polynesian Arrowroot (*Tacca leontopetaloides*) in the Marshall Islands

*Dirk H.R. Spennemann*

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Executive Summary

This paper reviews the biology, geographical distribution, abundance and relative importance of the Polynesian arrowroot (Taccia leontopetaloides) in the Marshall Islands.

Polynesian arrowroot (Taccia leontopetaloides L.) or makmök in Marshallese is a large perennial herb growing without much need for tending and annually providing a harvest of tubers. These are very acrid in taste and the bitterness needs to be washed out by a lengthy process. Makmök been reported throughout the Marshall Islands, absent only on Wake (Eneen-Kio), Bokak and Bikar. The plant is deciduous, sprouts in early (northern) spring, flowers in the summer months and matures October to January, at which time the tubers have grown to full size. The tubers are commonly shaped like somewhat irregular flatish spheres, 0.5-4" in diameter with a thin, brown skin and whitish starchy interior. Arrowroot is common on the ground layer in coconut grassland/scrubland, if the cover with other plants is not too dense. The plant is said to have very good resistance to droughts. The stems and leaves above the ground may wither entirely, but the tuber soon sends up new stalks and leaves. Arrowroot starch is the richest unenriched natural starch on earth. The starch content of the tubers varies from 10-25% of the tuber weight depending on growth location and soil substrate. Unprocessed tubers in the Marshall Islands contain approximately 80% water, 10% fibre and ~10% extractable starch. The fine crystal structure of arrowroot starch makes it easily digestable and therefore a favourite food for weak and sick people as well as small children.

Arrowroot production

Starting at plant cycle, the crop of the previous year is harvested. Only the large tubers are taken. The small tubers left behind, acting as seedlings for next year's crop. The collected arrowroot tubers are cleaned in the lagoon of earth and sand and every tuber is rubbed on a rough but soft coral until it is reduced to a reddish mash. A pit is dug 1-2m diameter and 0.5-0.75m deep. Sides and bottom of the pit are lined with coconut fronds and a large, strongly plaited mat which protrudes a good distance over the edge of the pit. This pit serves as a trough in which to catch the strained out flour. Resting on the orifice of the pit is a wooden box, which acts as a strainer, and whose lower part is open and only covered with a mesh made from coconut coir. In order to prevent any large pieces as well as any foreign material from falling into the mat, the coconut mesh is covered with a sticky flexible creeping root. The arrowroot mash is wrapped in the net-like wrapper of young coconut leaves, which acts as a real filtering cloth. This is placed in the box and watered with sea-water and continuously kneaded. The water carrying with it arrowroot starch runs into the trough-like mat underneath, the starch gradually settling to the bottom. After two or even three hours the sifted starch is sifted for a second or even a third time, the last washing with fresh water. During this pouring and leaching process, the arrowroot loses its bitterness. When all the water is skimmed off or has dissipated, the flour is scraped together and hung up in the wrapping of a young coconut leaf, thus allowing the water to run off and drip out of the starch. After about two or three days the hardened lump of
starch is crushed on a mat and placed in the sun so as to dry out thoroughly. Provided it is kept dry and away from weevils, ants, cockroaches and the like, the starch will keep indefinitely. About seven baskets of unprocessed tubers result in one basket of processed dried flour.

"Makmôk does not grow large anymore"

Today, throughout the Marshall Islands there exists a notion that arrowroot no longer grows as large as it used to. Arrowroot, it is claimed, also no longer grows in some areas as tall. Both is brought into connection with the effects of the nuclear testing which took place on Enewetak and Bikini Atolls.

Based on archival and field research the following was found:

• Today arrowroot is still abundant on most atolls and can be found in many open semi-shaded areas.

• Along other traditional food plants, such as taro, arrowroot has been replaced by flour and rice, which are easier to acquire and to prepare.

• Arrowroot was traditionally very common, planted and grown at a number of places. It was traditionally cultivated on a low level, tended to keep weeds and other plants away.

• If untended and not looked after, arrowroot tends to come under pressure from other plants competing for space, nutrients and air. Main competitors are mekubwebe (Wedelia biflora) and merkinojojo (Vigna marina). The fact that the arrowroot plants have to put all their energies into leaf growth, in order to keep up with the competition, rather than producing a seed stalk and then reproducing a large tuber, leads to the fact that the tubers recovered from modern arrowroot are only small.

• The decline of arrowroot in the Marshall Islands has little to do with the radiation effects, but is a result of the reduction of the importance of traditional food items occurring over the same time.

A future for arrowroot production?

Cora, for most outer islanders still the sole means of a cash income apart from handicraft production, has become a less and less lucrative commodity. Other income generating schemes do not always work, and in order to increase the standard of living, the lowering of expenditure by import substitution is a feasible option. Previous botanical and agricultural studies had shown that arrowroot does very well under coconut, provided that competing vegetation is kept away. This arrowroot would be a very suitable intercrop in copra plantations. Based on an analysis of arrowroot tending, production and starch extraction, one pound of arrowroot starch costs the producer and self-consumer $0.84.
Preface

Arrowroot - the term conjures up images of childhood, biscuits. In early days of the author's involvement with historical and anthropological research in the Marshall Islands, arrowroot was presented by many as an almost mythological food source, long since gone, hardly any knowledge on the technicalities, but fondly remembered as a good tasting food item. So far so good. Other matters being more pressing, the topic was set aside, kept cooking on a very small flame, just sufficient to keep the interest.

The origin of this very study, then, lay in the observations that contrary to the commonly heard assertions Polynesian arrowroot was still abundant on some atolls of the Marshall Islands. In the course of ethnographic work, as well as preparations of background studies for the Independent Nationwide Radiological Study, the then author set out “to spend one weekend on the matter, and to pull together all that is known about arrowroot”. In the beginning this appeared to be a most simple thing to do, there was little published, or so it seemed, and the initial “scoop” with the net brought as little as expected, and thus did little to debunk that notion of “a single weekend’s worth of work”. In the event, though, deeper probing and casting the net wider, combined with more thorough canvassing of all sorts of sources suddenly brought about a wealth of data. Now, quite many more weekends later, the study has come to a halt. Not to a conclusion, as there are still sources uncanvassed, outside the range of feasibility as far as the Marshall Islands are concerned. It was decided to take stock of what is known and to present it in a coherent manner, to provide a foundation to built on future work on arrowroot, as well as other cultivars in the Marshall Islands and in Micronesia.

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D.H.R.S.
Majuro Atoll
December 1991
Introduction

There are a number of food plants traditionally utilised by the Marshallese. The main food plant was, and in fact still is, without doubt, the breadfruit (Artocarpus altilis and A. mariannensis), followed by Pandanus and, especially in the southern atolls, where it could be grown, swamp taro (Cyrtosperma chamissionis). However, especially for the northern atolls in the Marshall Islands another tuberous plant was one of the major suppliers of starch: arrowroot.

Arrowroot is a plant which grows without much need for tending and annually provides a harvest of tubers. These tubers are very acid in taste and the bitterness needs to be washed out by a lengthy process. According to oral traditions, Letao, the perpetual trickster of Marshallese folklore, urinated on the arrowroot out of revenge for his brothers actions, and arrowroot is bitter ever since.

Today, throughout the Marshall Islands there exists a notion that arrowroot no longer grows as large as it used to. Arrowroot, it is claimed, also no longer grows in some areas as tall. Both are brought into connection with the effects of the nuclear and thermonuclear explosions which took place in the 1940s and 1950s on Enewetak and Bikini Atolls.

This report represents a compilation of all available information on the occurrence, utilisation and importance of arrowroot in the Marshall Islands. First we will have a look into the environmental background of the Marshall Islands. Then we will discuss the biology of the arrowroot plant (Tacca leontopetaloides) and its occurrence both within the Pacific and within the Marshall Islands in particular. A subsequent section on the traditional utilisation of the plant by the Marshallese is followed by a discussion of the role of arrowroot in modern Marshallese culture.

The study then looks into the Marshallese notions on the diminishing of the arrowroot crops and investigates the real and perceived reasons for this phenomenon. A final section discusses the potential future for arrowroot production. A series of appendices discusses the plant in Marshallese folk tales, provides a glossary of Marshallese words connected with the plant, a regional terminology for it and displays the data of the analysis section.
THE MARSHALL ISLANDS (AELON KEIN AD), comprising 29 atolls and 5 islands, are located in the north-west equatorial Pacific, about 3790km west of Honolulu, about 2700km north of Fiji and 1500km east of Ponape (figure 1). With the exception of the two north-western atolls, Enewetak and Ujelang, the Marshall Islands are arranged in two island chains running roughly NNW to SSE: the western Ralik ("sunset") Chain and the eastern Ratak ("sunrise") Chain (figure 2).

The atolls of the Marshall Islands, comprising well over 1200 islands and islets, are scattered about in an ocean area of well over 600,000 square miles. The combined ocean area encompassed in the 200 mile EEZ is well over 1.5 million square miles. By contrast, the total enclosed lagoonal area of all 29 atolls is only slightly more than 4,500 square miles, while the total combined land area of the atolls is as little as 70 square miles.

Not counting the five islands, Jemo, Jabwat, Kili, Lib and Mejit, the atolls of the Marshall Islands range from very small, with less than 3.5km², such as Nadikdi (Knox) Atoll to very large. With 2,173km² lagoonal area, Kwajalein Atoll has the distinction to be the atoll with the World's largest lagoon. The atolls support narrow sand cays set on the more or less ring-like reef platform. Only few of the islands of the atolls have a land area greater than 0.5 sq.miles and on most of them the distance between the lagoon and the ocean side is less than 300 yards.

All atolls have a carrying capacity of a population based on the available land area, the soil quality, the level of precipitation and the resulting overall horticultural productivity of the atoll. Traditionally, that is without the import of food sources from outside the Marshall Islands, atolls of the southern Marshalls had a higher carrying capacity than the northern ones, a distribution which coincided with precipitation.¹

![Figure 1. Location of the Republic of the Marshall Islands in the Pacific Ocean.](image)

For the total lack of physical elevation and hence orographic rainfall patterns, the precipitation in the Marshall Islands is solely governed by the general Pacific-wide climatic belts as well as by highly localised micro-climatic rainfall over the lagoons. On the regional scale, there is a distinct precipitation gradient running from the equatorial zone in the south to the north. The further north the atoll is located, the less precipitation can be expected. Thus Jaluit, located at 5°47'N has a precipitation of almost 4000mm per annum, while Wake,² located at 19°28' has only a precipitation of less than 1000mm per annum.

¹ Williams & Sabath 1982.
² At present Wake Island is politically part of the United States of America and not of the Republic of the Marshall Islands.
Figure 2 Map of the Marshall Islands.
Table 1. Geographical characteristics of the atolls of the Republic of the Marshall Islands.

<table>
<thead>
<tr>
<th>Atoll</th>
<th>Location (Lat. &amp; Long.)</th>
<th>No. of Islets</th>
<th>Land area (km²)</th>
<th>Lagoon area (km²)</th>
<th>Ratio land to lagoon area</th>
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</thead>
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<td>East</td>
<td></td>
<td>area</td>
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<tr>
<td>Taongi</td>
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<td>4.33</td>
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<tr>
<td>Wotje</td>
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<td>170°00'</td>
<td>72</td>
<td>8.18</td>
<td>9</td>
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</tbody>
</table>
Variations in precipitation even among different parts of the same larger atolls are also common. In many instances, especially during the drier season, rain-bearing clouds may be seen to pass over a particular stretch of land, while they may miss another completely. Thus rainwater catchment is, to some degree, completely fortuitous. The lack of elevated land features that otherwise might control local weather and remote air circulation patterns contribute to the variability in the rainfall.

Pedological analyses of the Marshall Islands are limited but more detailed pedological assessments were undertaken of Majuro, Arno, Mile and two islands on Maloelap. Not following, the classification of tropical sand soils adopted by Stone in a study on Arno Atoll, or even mentioning the classification of soils proposed by Fosberg in a study of the northern atolls of the Marshall Islands, Laird distinguishes a series of coral sand derived soils, called the Ngedebus series and another series, the Majuro series. According to U.S. soil terminology, the Ngedebus series belongs to the group of carbonatic, isohyperthermic Typic Tropo-sammets, while the Majuro series belongs to a group of sandy-skeletal, carbonatic Typic Tropo-sammets.

Previous soil classifications have been the Arno Atoll series, consisting of black or dark brown loamy sands and sandy loams with a high organic content; the Shioya series, comprising greyish brown sands and gravels, only rarely loamy sands; and the Jemo series, which has a high organic A horizon, resembling a peaty soil little intermixed with calcareous sands.

The general principles of sediment deposition are well reflected in the soil series of of most larger islets, with the lagoonal side having finer grained and the ocean sides having coarse and rubbly surfaces. The leeward coastal fringe is defined by loamy sand, typically consisting of a greyish brown loamy sand in the surface horizon, which is underlain by light greyish sand, which in turn rests on pinkish white or pink gravelly corralline sand. The windward coastal fringe consists of a Ngedebus-rubble complex which is characterised by a higher component of coral rubble. The Ngedebus-rubble complex is very limited in width and represents the shingle ridge and boulder rampart commonly found on the windward islets.

The interior of the larger islands is characterised by loamy sands with dark surfaces, indicative of an increased humus content in the soil derived from decayed vegetation. While the vegetation cover in these areas may be as dense as that of areas closer to the shore, their distance from the active shore makes wave washing due to tidal waves and cyclonic surges less likely, thus permitting the accumulation of organic sediments. The soils are not very fertile and can mainly be used for growing coconuts and Pandanus.

2 Stone 1951.
The Biology of Arrowroot

In this section we will have a closer look at the various biological aspects of the arrowroot plant, such as its taxonomy, morphology, habitat, origin, and nutritional value.

**Taxonomy**

The family TACCAEAE consists of only one living genus, Tacca, which comprises several species. The scientific taxonomy of Polynesian arrowroot is shown in table 2.

Table 2. Taxonomy of Polynesian arrowroot

<table>
<thead>
<tr>
<th>Order SPERMATOPHYTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division TRACHEOPHYTA</td>
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<tr>
<td>Class ANGIOSPERMAE</td>
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<tr>
<td>Subclass MONOCOTYLEDONEAE</td>
</tr>
<tr>
<td>Family TACCAEAE J.R. &amp; G. Forster (1776)</td>
</tr>
<tr>
<td>Genus Tacca J.R. &amp; G. Forster (1776)</td>
</tr>
<tr>
<td><em>Tacca leontopetaloides</em> (Linnaeus) O.Kuntze 1891</td>
</tr>
<tr>
<td><em>Leontice leontopetaloides</em> Linnaeus (1753) (Syn.)</td>
</tr>
<tr>
<td><em>Tacca hawaiiensis</em> Limpr. (Syn.)</td>
</tr>
<tr>
<td><em>Tacca involucrata</em> Schumacher &amp; Thonn. (1827) (Syn.)</td>
</tr>
<tr>
<td><em>Tacca pinnatifida</em> J.R. &amp; G. Forster (1776) (Syn.)</td>
</tr>
<tr>
<td><em>Tacca palmata</em></td>
</tr>
<tr>
<td><em>Tacca chantrieri</em> André</td>
</tr>
</tbody>
</table>

In the Marshall Islands only one species, *Tacca leontopetaloides* occurs.

Common names for the plant are Polynesian arrowroot (English)\(^2\) and \(\mu\)ak\(\mu\)ok (Marshallese).\(^3\) Other vernacular names of the Pacific area, with special emphasis on Micronesia, are set out in Appendix B.

*Tacca*, its biology and occurrence, has been described a number of times for the Marshall Islands, though commonly more in passing. The studies in which it figures vary widely, from botanical to ethnographical, from nu-

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\(^1\) After Lamberson 1987; Synonyms after Sproat 1968; Neal 1965:228; Purseglove 1972:517; Winters 1957:83. The listing of the *Tacca* species is incomplete.

\(^2\) In Western literature on Pacific plants *Tacca leontopetaloides* is also known as "arrowroot", "Tacca", "East Indian arrowroot", "Island arrowroot", "Tahiti arrowroot", "Fiji arrowroot". "African arrowroot" is a vernacular synonym for *Tacca involucrata* which in turn is a synonym for *T. leontopetaloides*. The German ethnographic literature on the Marshall Islands, the main source for 19th century data, describes arrowroot as "Pfellwurz".

For comparison, "Indian arrowroot" (*Circum angustifolia*) and "Queensland arrowroot" (*Canna edulis*) have similar vernacular names, but belong to totally different families of plants. The term "East Indian Arrowroot" is also used as opposed to West Indian Arrowroot (*Maranta arundinacea*), which was discovered first for European eyes and received its name from the fact that the plant was used by West Indian natives to treat wounds inflicted by poisoned arrows (Masefield 1948:44-45; Winters 1957:60).

\(^3\) Apart from the official spelling \(\mu\)ak\(\mu\)ok as shown in the current edition of the Marshallese-English Dictionary (Abo et al. 1976:212), there is an abundance of phonetic variations by which the Marshallese name has been spelled in the literature. Often the terms would vary even within the same source. The following is merely a sampling: magem\(\dot{\text{o}}\)k (Erdland 1906:152); makem\(\dot{\text{o}}\)k (Bryan 1972:132); makem\(\dot{\text{o}}\)k (Mason 1947); makm\(\dot{\text{k}}\) (Finsch 1893; Wendler 1911); makm\(\dot{\text{k}}\) (Anderson 1951); makm\(\dot{\text{k}}\) (Stone 1951); mak\(\dot{\text{m}}\)wik (Erdland 1906); makm\(\dot{\text{k}}\) (Curtis 1986); mogemog (Hernheim 1886); mogemog (Finsch 1893); mogemog (Wendler 1911); mogumok (Kothebe 1821: II 26); mokem\(\dot{\text{o}}\)k (Krämer & Neermann 1938:137); mok mok (Fosberg & Sachet 1962:13); mokm\(\dot{\text{k}}\) (Muray et al. 1958; Feeney 1951); mokm\(\dot{\text{k}}\) (Krämer 1905); mugge-mug (Goetz 1914).
Figure 3. Arrowroot (*Tacca leontopetaloides* O.Kuntze).
Figure 4. Arrowroot (*Tacca leontipetaloides*). Leaf.

trional to agricultural assessments. *Tacca* figures in the following sources in a varying degree of detail:

*Tacca leontopetaloides* (Linnaeus) O.Kuntze

*Tacca pinnatifida* J.R. & G. Forster (1776)
(Syn.): Finsch 1893; Volckens 1903; Chamisso 1910; Krämer 1905; Wendler 1911 (as *Tacca pinnifida*); Erdland 1914; Kodzumi 1917; Krämer & Neumann 1938 (as *Tacca pinnatifida*); Okabe 1941; Bryan 1944; Merrill 1945; Chamisso 1986.
MORPHOLOGY

Polynesian arrowroot, a large perennial terrestrial herb, is growing as "a volunteer plant on every inhabited island in Micronesia." The plant is deciduous, sprouts in early (northern) spring, flowers in the summer months and matures in the late fall to mid-winter (between October and January), at which time the tubers have grown to full size.

The plant has a 1-3cm thick petiole measuring between 0.3 and 1.3m, but commonly about 0.6 to 0.8m in height, with one to commonly three broad, deeply lobed leaves measuring about 0.25-0.30m across (figure 4). The leaves have a prominent rib system with a well-developed mid rib and less well developed branching ones. The individual leaf segments are oval shaped, commonly with pointed tips, although a variety with more rounded leaf tips occurs. The leaf colour of a healthy growing plant ranges from light green to dark green.

Every plant pushes one or at most two flower stalks, which are some 0.2-0.3m, sometimes as much as 1m, above the top of the leaves. The flower cluster measures between 4 and 10 cm in diameter. The individual flowers are small (1-3cm in diameter) with six or more leafy bracts, of faint greenish colour, and numerous, 20-40, purple-coloured thread-like bractlets.

The flower stalks standing well above the main plant are quite distinctive, even from afar (figure 5). As Wendler remarks:

"The filaments which hand down from the stalks, the Marshallese call them beard of the arrowroot, with their dark red colour give variety to the green landscape."

![Figure 5. Arrowroot (Tacca leontipetaloides)](image)

The fruit ripened on the stalks is globular, ellipsoid to ovoid in shape, with a smooth, yellowish skin and a six-ribbed cross-section (figure 6). The fruit measures between 10 and 35mm in length and between 7 and 25mm in diameter. It contains a large number of seeds which are 3-8mm long, 1.5-3mm thick and are slightly kidney-shaped with a polygonal cross-section. The seeds are of dark brown to dark reddish brown colour and have a soft whitish core.

The tubers grow at the end of the roots, similar to the common white potato (figures 7 & 11). The tubers (rhizomes) are about 10 to 15cm below

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1 Sproat 1968:64.
2 Dey (1954:34) observed a flowering of Tacca during July and especially August in the Tuamotu. This is borne out by the observations in the Marshall Islands.
4 Wendler 1911:269 "bwödak in makmok".
the soil surface, rarely more than 25cm. They are commonly shaped like somewhat irregular flattish spheres, varying in diameter from 1 to 10 centimetres and 1 to 6cm in height, with a thin, light brown skin and whitish starchy interior. When cut the tuber emits a thin whitish secretion. A new tuber is formed close to the one of the previous year. Although the tubers are generally described as small, there are reports of rather large tubers, weighing over 500 grams.\textsuperscript{1} The number of tubers for each mature plant can range from one to well over thirty, with numbers between ten and twenty being the most common.\textsuperscript{2}

Figure 6. Arrowroot (*Tacca leontipetaloides*). Side-view of and cross-sections through a seed capsule.

Individual weights were obtained from all tubers recovered end of May and early June 1991 from over 30 arrowroot plants from Woja Island, Majuro Atoll, and various islets on Mile Atoll which had already sprouted and driven sizeable stalks and leaves (table 3).

The largest of the tubers weighed over 230g, with several other weighing over 100g (figure 15). These data, although of a more anecdotal value, show that the plants tend to show a preponderance for small tubers, with a few big ones added. A series of samples collected from Mile Atoll (table 4) showed tuber sizes up to 240 g.

The Marshallese distinguish between a male and a female arrowroot plant. The female arrowroot is known to bear more and especially larger tubers, with the effect that these plants are preferred for harvesting over their male counterparts.

Morphologically, male and female plants, apart from their flowering stalks, can be distinguished as follows:

- the leaves of the male plant are less deeply serrated;
- the leaves of the male plant are somewhat darker in colouring and have a more relieved surface.

\textsuperscript{1} Taylor (1950) reports on a tuber weighing 550 grams from the northern Marshall Islands. In the Philippines *Tacca* tubers of over 0.3cm diameter have been reported (Brown 1954:383).

\textsuperscript{2} Hiyane (1967) mentions numbers between 12 and 36 per plant. Own investigations showed numbers between 1 and 40.
Figure 8. Arrowroot (*Tacca leontopetaloides*) on Majuro I. (Laura), Majuro Atoll. Whole plant.

Figure 9. Arrowroot (*Tacca leontipetaloides*) on Majuro I. (Laura), Majuro Atoll. Leaf.
(The major divisions of the scale are in 10cm intervals).
Figure 10. Arrowroot (*Tacca leontipetaloides*) on Majuro Atoll. Comparison of a whole plant from Majuro I. (Laura), (left) with a single leaf stalk from Woja I. (right).

Figure 11. Arrowroot (*Tacca leontipetaloides*) on Majuro I. (Laura), Majuro Atoll. Tubers of previous year (photo taken in June 1991). (The major divisions of the scale are in 10cm intervals).
Figure 12. Purple-stemmed variety of Tacca leontopetaloides.; Left: Plant in growth position. Note the less incised leaves. Right: Cut leaf stalks. Arbar Island, Mile Atoll. Photo: Dirk H.R. Spennemann
Figure 14. Schematic relationship of the observed varieties of *Tacca leontopetaloides*

**VARIETIES**

Two varieties of *Tacca leontopetaloides* have been reported from atolls in Micronesia. The common variety produced a large number of small tubers, depending on the fertility of the soil, competition with other plants and rainfall. The other variety is described as producing only a single large tuber.¹

The latter variety is said to have been introduced into the Marshall Islands by the Japanese sometime during the 1930s. It came from the South Pacific area, and had, it appears, first been established in the Carolines and then in the Marshalls. In the 1960s the one-tuber variety grew on Arno, Majuro, Jaluit and “other atolls”.²

According to the literature, apart from the tuber there are no visible differences between the plants, and no different vernacular names are given. Under ideal conditions, the tuber of the single-tuber arrowroot variety can grow up to 30cm in diameter and to over 2kg in weight.³

Own observations on Mile Atoll have shown that there are four varieties or subvarieties. Three varieties have green stems and stalks, while one pushed violet/purple leaf stalks.⁴

The tubers of this purple-stemmed variety had a brownish skin and a yellow to white interior when cut. The three green-stalked varieties fall into one which produces only a single large

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² Hiyane 1967. There are two arrowroot varieties distinguished in Niue, one common variety (pia) and one, which has an acrid taste (teve) and which is not commonly eaten (Smith 1983:15).
³ Hiyane 1967. The size of the tubers is on the whole greater on the high islands (tuber diameter 6-9 inches on average, up to 12 inches maximum), since the soils are richer in nutrients, than on the low coral atolls (2-3 inches on average; Purseglove 1972:518; Herklots 1972:472).
⁴ Seen on Arbar Island, Mile Atoll, where it made up about 5% of all arrowroot plants.
tuber and two which produce more than one tuber. Among the latter varieties is one which has a purplish/reddish flesh when cut, and one which has a yellowish-whitish flesh.

According to an informant the purple variety was introduced by the Japanese from Pohnpei sometime in the 1930s.1

**HABITAT**

Botanical investigations in the Marshalls have shown that it thrives well in salt-spray protected areas with only slightly shaded conditions and no standing water, such as in breadfruit and coconut groves without substantial understorey.2 Arrowroot is common following plant communities:

Coconut grassland/Coconut scrubland. Tacca is common on the ground layer in this community, if the cover of secondary genera, such as Hernandia, Callophyllum, Pemphis, Scaevola, Morinda and Pandanus is not too dense. Tacca thrives well in two of three types of coconut grassland/scrubland, that is on the lagoonal shores (figures 23, 25 and 26 and dunes and in the low interiors. It is largely absent or less well developed in coconut scrubland on the boulder ridges and on stoney land.3

Breadfruit forest. Tacca also grows well in a cultivated breadfruit forest, where the understorey of secondary plants has been largely exterminated and where there are some gaps in the canopy (figure 27).4

Arrowroot is absent from dense primary of secondary scrub forest both on the ocean side as well as in the sandy interiors5 because these plant communities are too dense and therefore too shaded. It is present in incipient secondary forest,6 apparently until such a time that the forest becomes too dense.7

The soil conditions which Tacca requires are not restricted to loamy sands as suggested by Stone8 as it does well on lagoonal, nutrition-poor sandy ground (figures 20 and 21), although it definitely is not a colonising plant such as Scaevola or Messerschmidia (Tournefortia) and therefore largely absent from non-coconut communities on lagoonal shores.9

On the other hand, seen on a larger picture, it does well on sandy areas which as far as food plants are concerned would otherwise be unproductive.10 In the Marshall Islands Tacca does well in all semi-shaded areas, and except in very infertile areas does not show stunted growth or chlorosis.11

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4 Hatheway 1953:18; Pers. observation Nalu I. Mile Atoll.
5 Hatheway 1953:22ff; 31ff.
6 Hatheway 1953:47.
7 Stone (1951:24) mentions that "in densely shaded areas, such the interior of Arno and the wartime abandoned groves on L’angar, Tacca is soon eliminated as a crop; this was well recognised by the people of L’angar in explaining why the small amount of Tacca now [1951] found there."
9 Hatheway 1953:35. Its salt intolerance also keep its out of saline flats and mangrove communities (ibid. 36-41).
11 Hiyane 1967.
Data from Chuuk indicate that on the high islands of Micronesia the plant is restricted from sealevel to about 1000 feet elevation, with a rainfall requirement of 1250-2500mm (50-100") per annum. It is said to grow well where cassava\(^1\) thrives, but that it cannot be planted in inter-cropping with it.\(^2\)

**GROWTH CONDITIONS AND COMPETITORS**

The plant is said to have very good resistance to droughts. The stems and leaves above the ground may wither entirely, but the tuber soon sends up new stalks and leaves.\(^3\)

Based on the available literature it appeared that where *Tacca*’s grows well, its main competitors for light, space and nutrients are *Wedelia (Wollastonia) biflora*\(^4\) and *Vigna marina*\(^5\), and *Ipomea* spp.,\(^6\) all of which seem to be more capable of surviving increasing bush growth.

Since there is a notion in the Marshall Islands that arrowroot does no longer grow well because of radiation-related problems (see further below), a systematic assessment of the growth conditions of *Tacca* was conducted. Given that fieldwork was to be carried out on Mile, that atoll was chosen as the first stage of assessment.

Growth conditions of *Tacca* were observed on all islands visited by the author during the survey. These were: Tokowa, Burrh, Nalu, Garu, Mile, Bogukurikku, Enajet, Jibinmen, Anewa, Lukunor, Namake (no *Tacca* seen), Enanlik, Dobo-en (no *Tacca* seen), Bokwa-en-keaar (no *Tacca* seen) and Arbar. Details of these are spelt out in table 3.

Tuber samples of *Tacca* were collected at eight locations: Tokowa, Nalu, Garu, Mile, Enajet, Jibinmen, Lukunor, Enanlik and Arbar. Details of these are spelt out in table 4.

Another observation, conducted over a six month time span, was carried out on Majuro Island (Laura), Majuro Atoll. Two communities were observed, one in a coconut grassland, and the other on the lagoonal shore. At the tip of the island, *Tacca* was seen in a coconut grassland community in March 1991. The plants were not doing too well, being some 0.4 to 0.5m high. They saw competition by *Polypodium scolopendria* and an assortment of grasses.

The coconut grassland was cleared by means of a front-loader in late April 1991, and a number of coconut trees was also felled. All surface vegetation had been taken off, or pushed about by the front-loader. A certain amount of the top soil had also been removed in the process. In mid May *Tacca* had sprouted again, and pushed leaves some 10 to 20cm high. At this time, a second clearing and removal of further coconut trees occurred, the freshly sprouted *Tacca* once again removed or driven over. During the next observation of the land plot in early August most *Tacca* had recovered, but only to height of 10-20cm. Plants located closer to the stems of the few remaining coconut palms had done better, reaching height of about 40cm. The final observation occurred in early October 1991. Most of the *Tacca* which had resprouted in the open spaces had disappeared. The only *Tacca* in evidence were those close to

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1. *Manioc (Manihot esculenta, Family EUPHORBIAEAE)*
4. Marshallese: *merkubwebwe*.
5. Marshallese: *merkinenejojo*.
the palms. It appears that the plants could not recover from having their surface parts destroyed twice and from having the shade removed.

A second group of *Tacca* was seen on the lagoonal beach zone of Majuro Island, just above an erosion cut. These plants, were between 0.6 and 0.7m high. The plants saw some competition by *Wedelia biflora* and *Vigna marina*. At the time of observations, the *Tacca* plants were doing well and were not crowded by competition. By end of April the vegetation pattern had changed little, the plants still in a comparatively uncrowded environment. In mid-May the plants had pushed flower stalks reaching up to 1.2m. The plants had come under severe competition by *Wedelia biflora* and *Vigna marina*. The shoreline was at that time accreting, providing new ground to be colonised especially by *Vigna marina* (figure 21). In early August the plants had grown higher and were under heavy competition, most of the leaves shaded by *Wedelia* and a number of stems and flower stalks overgrown with climbing *Vigna*. An occasional visitor would not have been able to make out the *Tacca* plants in the tangle thus presented. During the final observations in early October, *Tacca* had completely disappeared, *Wedelia* and *Vigna* being the dominant plants.

If we summarise these observations from Mile and Majuro Atolls, then the growth and tuber production of *Tacca* is controlled by the following factors:

- soil conditions
- light conditions (shading)
- competitor plants

The main competitor plants identified during the survey were (in declining order of importance):

- *Wedelia biflora*
- *Vigna marina*
- *Ipomea pre-caprae*
- *Polypodium scolopendria*

It would appear that the competitive plant growth, which crowds *Tacca*, forces the plant to push more and especially higher leaf stalks to gain access to the light, thereby exhausting the starch resources in last year's tuber, rather than creating energy to push new large tubers.

**RESISTANCE TO DRAMATIC ENVIRONMENTAL CHANGE**

The previous section then leads on to the resistance of *Tacca* to climatic extremes such as typhoons. Some data can be drawn on. Fosberg described the effects of Typhoon *Ophelia* (Jaluit, 1958) on several plant species. He mentioned that “doubtless some plants [were] too deeply buried for recovery and others removed by erosion, but those in most situations [were] apparently unaffected, even where inundated by salt water.”

This property, as well as the fact that the inundated tubers were still edible, made the plant in traditional times a prime food for the starvation period following typhoons.
Table 3. Occurrence of arrowroot (Tacca leontopetaloides) on the islands of Mile Atoll and the vegetation composition surrounding Tacca.

<table>
<thead>
<tr>
<th>Island</th>
<th>Tacca leaves</th>
<th>height flowers</th>
<th>Tacca Status</th>
<th>Brown spots</th>
<th>Soil condition</th>
<th>Canopy</th>
<th>Vegetation Understory</th>
<th>Groundcover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anewa</td>
<td>0.5-0.7</td>
<td>1.2-1.5</td>
<td>free</td>
<td>20%</td>
<td>medium, low humus cont.</td>
<td>1:COC 2: 1:PAN 2:MOR 1:grass 2:POL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arbar</td>
<td>0.5-0.7</td>
<td>0.9-1.0</td>
<td>comp.</td>
<td>5%</td>
<td>medium, medium humus cont.</td>
<td>1:COC 2:ART 1:MOR 2:MUS, COC 1:Grass 2:VIG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bogukurikku (centre)</td>
<td>0.6-0.8</td>
<td>1.2-1.5</td>
<td>choked</td>
<td>0%</td>
<td>coarse, low humus cont.</td>
<td>1:COC 2: 1:GUE, SCA 2:MOR 1:POL, Grass 2:SCA, WED, VIG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burrh (west) (in grass)</td>
<td>0.5-0.6</td>
<td>1.2-1.5</td>
<td>comp.</td>
<td>20%</td>
<td>medium-coarse, medium humus cont.</td>
<td>1: COC 2: ART, PAN 1: PAN 2:COC, MOR 1:Grass 2:POL, VIG, WED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burrh (west) (in grass, but more shaded)</td>
<td>0.2-0.5</td>
<td>—</td>
<td>comp.</td>
<td>30%</td>
<td>medium, medium humus cont.</td>
<td>1: COC 2: ART, PAN 1: PAN 2:COC, MOR 1:Grass 2:POL, VIG, WED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enajet</td>
<td>0.4-0.6</td>
<td>1.0-1.2</td>
<td>comp.</td>
<td>30%</td>
<td>medium, medium humus cont.</td>
<td>1:COC 2:ART 1:ART 2: 1:grass 2:WED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enanlik</td>
<td>0.9-1.2</td>
<td>1.5-1.8</td>
<td>free</td>
<td>10%</td>
<td>fine-medium, medium humus cont.</td>
<td>1:COC 2: 1:COC 2: 1:grass 2:CUC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garu (centre, inland)</td>
<td>0.3-0.6</td>
<td>0.8</td>
<td>free</td>
<td>20%</td>
<td>very fine-medium, medium humus cont.</td>
<td>1:COC 2:SCA, PAN 1:SCA 2:COC, PAN 1:POL, VIG 2:POL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garu (centre, inland)</td>
<td>0.5-0.8</td>
<td>1.2</td>
<td>free</td>
<td>20%</td>
<td>very fine-medium, medium humus cont.</td>
<td>1:COC 2:SCA, PAN 1:COC 2:SCA, PAN 1:POL, VIG 2:POL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jibinmen (west end) (in scorched area)</td>
<td>0.3-0.4</td>
<td>—</td>
<td>free</td>
<td>0%</td>
<td>fine, low humus cont.</td>
<td>1:none 2: 1:COC 2:SCA, MOR 1:VIG 2:POL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jibinmen (west end) (in unaffected area)</td>
<td>0.4-0.5</td>
<td>0.8-0.9</td>
<td>free</td>
<td>0%</td>
<td>fine, low humus cont.</td>
<td>1:none 2: 1:COC 2:SCA, MOR 1:VIG 2:POL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jibinmen (200m from west end)</td>
<td>0.3-0.9</td>
<td>1.2-1.5</td>
<td>comp.</td>
<td>10%</td>
<td>fine, low humus cont.</td>
<td>1:COC 2:SCA, MOR 1:VIG 2:POL, SCA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lukunor (east end)</td>
<td>0.4-0.7</td>
<td>0.8-1.0</td>
<td>free</td>
<td>0%</td>
<td>fine, medium humus cont.</td>
<td>1:COC 2:CAL* 1:none 2: 1:Grass 2:VIG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mile (southeast, inland) (in Wedelia)</td>
<td>0.2-0.4</td>
<td>—</td>
<td>—</td>
<td>10%</td>
<td>medium, medium humus cont.</td>
<td>1:COC 2:CYR 1:GRASS 2:WED 1:POL, VIG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mile (centre, lagoon side) (on runway end)</td>
<td>0.3-0.7</td>
<td>0.9-1.2</td>
<td>—</td>
<td>5%</td>
<td>fine-medium, low humus cont.</td>
<td>1:none 2: 1:COC 2:SCA, PAN 1:POL, VIG 1:POL, grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mile (north, lagoon side)</td>
<td>0.3-0.5</td>
<td>0.7-0.9</td>
<td>—</td>
<td>40%</td>
<td>fine-medium, low humus cont.</td>
<td>1:COC 2: 1:COC 2: 1:POL 2:VIG, CAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mile (east, inland)</td>
<td>0.4-0.6</td>
<td>—</td>
<td>—</td>
<td>5%</td>
<td>medium, medium humus cont.</td>
<td>1:COC, ART 2: 1:ART, PAN, MOR 2:ART 1:Grass, WED 2:VIG, CYR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nalu (centre, inland)</td>
<td>0.3-0.5</td>
<td>1.8</td>
<td>—</td>
<td>0%</td>
<td>very gravelly, high humus cont.</td>
<td>1:ART 2:COC, PAN 1:ART 2:COC, PAN 1:VIG, WED 2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nalu (centre, lagoon side)</td>
<td>0.5-0.7</td>
<td>1.0</td>
<td>—</td>
<td>50%</td>
<td>fine-medium, medium humus cont.</td>
<td>1:COC 2:PAH 1:COC 2:PAH 1:VIG, WED 2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nalu (centre, lagoon shore)</td>
<td>0.5-0.7</td>
<td>0.6</td>
<td>—</td>
<td>0%</td>
<td>fine-medium, medium humus cont.</td>
<td>1:COC 2:PAH 1:COC 2:PAH 1:VIG, WED 2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nalu (south, lagoon shore) (Tacca dominates)</td>
<td>0.3-0.7</td>
<td>1.0-1.2</td>
<td>—</td>
<td>10%</td>
<td>fine-medium, medium humus cont.</td>
<td>1:COC 2:PEM 1:COC 2:PEM 1:POL, VIG, WED 2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tokowa (west end) (in grass)</td>
<td>0.3</td>
<td>—</td>
<td>—</td>
<td>0%</td>
<td>fine-medium, medium humus cont.</td>
<td>1:COC 2:ART, PAN 1:ART 2:ART, PAN 1:VIG, WED 2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tokowa (west end) (in Wedelia)</td>
<td>0.9</td>
<td>1.5</td>
<td>0%</td>
<td>fine-medium, medium humus cont.</td>
<td>1:COC 2:ART, PAN 1:ART 2:ART, PAN 1:VIG, WED 2:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tokowa (east end) (in grass, more shade)</td>
<td>0.3-0.7</td>
<td>—</td>
<td>—</td>
<td>0%</td>
<td>fine-medium, medium humus cont.</td>
<td>1:COC 2:ART, PAN 1:ART 2:ART, PAN 1:VIG, WED 2:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: *) no Tacca underneath the Callophyllum trees. Abbreviations: ART – Artocarpus altisii A. mariannensis; CAL – Callophyllum inophyllum; CAS – Cassytha filiformis; COC – Cocos nucifera; CUC – Cucurbita pepo; CYR – Cyrtosperma chamissonis; GUE – Guettardia spectosa; IPO – Ipomea pes-caprae; MES – Messerschmidia (Tournefortia) argentea; MOR – Morinda citrifolia; MUS – Musa sapientum; PAN – Pandanus tectorius; PEM – Pemphis acidula; POL – Polypodium scolopendria; SCA – Scaveola sericea; TRI – Triumfetta procumbens; VIG – Vigna marina; WED – Wedelia biflora.
Table 4. Details of *Tacca* sampled on Majuro and Mile Atolls

<table>
<thead>
<tr>
<th>Sample N°</th>
<th>Island</th>
<th>Atoll</th>
<th>Nº of plants</th>
<th>Nº of tubers</th>
<th>Nº of tubers &gt;20 g</th>
<th>Total weight</th>
<th>Weight largest tuber</th>
<th>Mean tuber weight</th>
<th>1σ Dev.</th>
<th>Exploit. tuber weight</th>
<th>Exploit. tubers (% total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Woja</td>
<td>Majuro</td>
<td>6</td>
<td>17</td>
<td>25</td>
<td>2203.8</td>
<td>234.4</td>
<td>30.62</td>
<td>42.31</td>
<td>1812.0</td>
<td>34.7</td>
</tr>
<tr>
<td>2</td>
<td>Tokowa</td>
<td>Mile</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>167.60</td>
<td>54.6</td>
<td>13.97</td>
<td>15.96</td>
<td>96.1</td>
<td>16.7</td>
</tr>
<tr>
<td>3a</td>
<td>Nalu</td>
<td>Mile</td>
<td>1</td>
<td>20</td>
<td>7</td>
<td>426.50</td>
<td>137.0</td>
<td>21.33</td>
<td>31.57</td>
<td>325.9</td>
<td>30.0</td>
</tr>
<tr>
<td>3b</td>
<td>Nalu</td>
<td>Mile</td>
<td>1</td>
<td>17</td>
<td>6</td>
<td>442.80</td>
<td>145.9</td>
<td>26.05</td>
<td>37.47</td>
<td>386.3</td>
<td>35.3</td>
</tr>
<tr>
<td>3tot</td>
<td>Nalu</td>
<td>Mile</td>
<td>2</td>
<td>37</td>
<td>7</td>
<td>869.3</td>
<td>145.9</td>
<td>23.50</td>
<td>34.49</td>
<td>712.2</td>
<td>32.4</td>
</tr>
<tr>
<td>4</td>
<td>Garu</td>
<td>Mile</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>693.10</td>
<td>159.5</td>
<td>99.01</td>
<td>40.06</td>
<td>693.1</td>
<td>100.0</td>
</tr>
<tr>
<td>5</td>
<td>Mile</td>
<td>Mile</td>
<td>6</td>
<td>101</td>
<td>17</td>
<td>1149.60</td>
<td>159.5</td>
<td>11.38</td>
<td>9.41</td>
<td>584.0</td>
<td>16.8</td>
</tr>
<tr>
<td>6</td>
<td>Enajet</td>
<td>Mile</td>
<td>3</td>
<td>50</td>
<td>11</td>
<td>885.40</td>
<td>68.4</td>
<td>17.71</td>
<td>28.96</td>
<td>633.6</td>
<td>22.0</td>
</tr>
<tr>
<td>7</td>
<td>Jibinmen</td>
<td>Mile</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>552.50</td>
<td>163.1</td>
<td>78.93</td>
<td>77.81</td>
<td>544.7</td>
<td>85.7</td>
</tr>
<tr>
<td>8a</td>
<td>Lukunor</td>
<td>Mile</td>
<td>1</td>
<td>35</td>
<td>9</td>
<td>422.00</td>
<td>240.6</td>
<td>12.06</td>
<td>14.46</td>
<td>293.5</td>
<td>25.7</td>
</tr>
<tr>
<td>8b</td>
<td>Lukunor</td>
<td>Mile</td>
<td>1</td>
<td>23</td>
<td>8</td>
<td>402.80</td>
<td>58.9</td>
<td>17.51</td>
<td>17.78</td>
<td>308.7</td>
<td>34.8</td>
</tr>
<tr>
<td>8c</td>
<td>Lukunor</td>
<td>Mile</td>
<td>1</td>
<td>15</td>
<td>3</td>
<td>186.80</td>
<td>71.3</td>
<td>12.45</td>
<td>18.06</td>
<td>133.1</td>
<td>20.0</td>
</tr>
<tr>
<td>8d</td>
<td>Lukunor</td>
<td>Mile</td>
<td>1</td>
<td>11</td>
<td>3</td>
<td>223.70</td>
<td>64.0</td>
<td>20.34</td>
<td>24.64</td>
<td>179.8</td>
<td>27.3</td>
</tr>
<tr>
<td>8tot</td>
<td>Lukunor</td>
<td>Mile</td>
<td>4</td>
<td>84</td>
<td>23</td>
<td>1235.30</td>
<td>62.3</td>
<td>14.71</td>
<td>17.93</td>
<td>915.1</td>
<td>27.4</td>
</tr>
<tr>
<td>9</td>
<td>Enanlik</td>
<td>Mile</td>
<td>1*</td>
<td>40</td>
<td>19</td>
<td>1107.60</td>
<td>71.3</td>
<td>27.69</td>
<td>35.29</td>
<td>987.8</td>
<td>47.5</td>
</tr>
<tr>
<td>10</td>
<td>Arbar</td>
<td>Mile</td>
<td>1*</td>
<td>55</td>
<td>3</td>
<td>487.40</td>
<td>184.3</td>
<td>8.8</td>
<td>6.5</td>
<td>71.6</td>
<td>5.5</td>
</tr>
</tbody>
</table>

* one plant cluster, exact number of stalks not determined.

**DISEASES**

The plant is described as relatively disease free and a natural reserve starch food on atoll soil conditions.\(^1\) Hatheway mentions a sickness affecting coconuts, which was well recognised by the traditional Marshallese. From Hatheway's descriptions it appears that *laora* was common well before the war and is not a new disease. *Laora*, is characterised by wide-spaced coconuts, most of them either dead or dying, with little if any foliage, most of which is brown save for the rib of the leaves and the centre of the frond. It predominantly occurs in the centres of islands in areas which had previously been under breadfruit cultivation, or had been cleared for habitation areas and is most likely caused by soil deficiencies, such as phosphorus.\(^2\) Locals seem to argue that a lack of salt is the cause. *Laora* also affects arrowroot growing under the affected coconuts.

Although common under palms, the affected arrowroot has yellow leaves except along the veins; the leaves exhibit characteristic brown spots of 3-6mm in diameter (figure 28).

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\(^1\) Owen 1965:7. Also described as disease-free for Chuuk: Paul 1965.

\(^2\) Hatheway 1957:1-3.
Figure 15. Frequency distribution (by weight class) of tubers recovered from 26 already sprouted plants from various locations on Mile Atoll (Locations Nos. 2-10).

It is likely that the brown spots with yellow halos described in the literature on Marshallese arrowroot and observed by the present author\(^1\) are caused by *Cercospora taccæ*\(^2\) fungus which is transmitted by airborne spores, or *Mysopharella* spp. described

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\(^1\)Hatheway 1953:11; Pers. observation Majuro (Laura) I., Majuro Atoll in end of May 1991.

\(^2\) *Cercospora* (*Cercosporina*) *taccæ* is a fungus affecting arrowroot. It consists of circular to irregular leaf spots of up to 10mm diameter, of reddish-brown colour, sometimes surrounded by a yellowish halo. The transmission of this fungus is airborne (by spores). The distribution of the *Cercospora* fungus is in the Philippines, Palau (McKenzie & Jackson 1990a:9; 17), Federated States of Micronesia (Yap; Chuuk; McKenzie & Jackson 1990b:14; 26), Republic of the Marshall Islands, Kiribati, Tuvalu, Fiji, Tonga, W. Samoa, Futuna and 'Uvea (Kohler 1985:35; 36; 38); Niue, and the Cook Islands (McKenzie & Jackson 1990a: 17). In addition, another not specified identified *Cercospora* fungus is known from Palau and the FSM, which also affects *Tacca* (McKenzie & Jackson 1990a: 17; Chupp 1953:560; Sydow & Sydow 1913:406).
to infest arrowroot foliage in Futuna & ‘Uvea (Western Polynesia).\footnote{Kohler 1985:35; 36; 38.}

An agricultural assessment of the 1960s stated that “occasionally mites and aphids attack the leaves, but on the whole no great damage is done by these insects.”\footnote{Hiyane 1967.} An unspecified root disease is reported from the Marshall Islands, resulting in tubers which are poisonous to pigs.\footnote{Soucie 1983:200.}

Roaming pigs, where present, were identified as the prime pest due to their uprooting the plants in search for earth grubs and the like.\footnote{Ibid.} In her assessment of the subsistence agriculture of Namu Atoll, Pollock describes pigs as the main pest for arrowroot.\footnote{Pollock 1970:162-163.}

**NUTRITIONAL VALUE**

Arrowroot starch is the richest unenriched natural starch on earth.\footnote{Murai et al. 1958; Wohltmann 1905.} The starch content of the tubers varies according to growth location and soil substrate. It varies from 10–25% of the tuber weight. Unprocessed tubers in the Marshall Islands contain approximately 80% water, 10% fibre and ~10% extractable starch,\footnote{Hiyane 1967.} while *Tacca* tubers analysed in the Philippines contained 22.3–24.8% starch.\footnote{Bacon 1908:96; Allen 1929:251.}

A study conducted in the late 1950s examined the nutritional value of Pacific cultigens.\footnote{Murai et al. 1958:102-105.} Tests of arrowroot tubers in the Philippines showed that the tubers tested contained about 68% water, with a starch content (wet) of 24.03%. After water extraction the starch content was as high as 75.1%. The tubers analysed had no alkaloids and no cyagontic glucoides.\footnote{Allen 1929:251, quoted after Brown 1954:384.}

Tests of arrowroot flour obtained from the Marshall Islands (table 5) showed that arrowroot flour more closely resembles corn starch than cereal flowers as it has about 86% carbohydrate, 12% moisture and less than 0.2% proteins. The calcium level (58 mg) is higher than expected in a highly purified starch. It is possible that the calcium-rich ground water used for the final washing process may account for this.\footnote{See further below.}

The fine crystal structure of arrowroot starch makes it easily digestable and therefore a favourite food for weak and sick people as well as small children.\footnote{Sproat 1968:68; Erdland 1914:39.}

**Table 5. Nutritional value of arrowroot flour (per 100 grams edible portion)**\footnote{Source: Murai et al. 1958:104.}

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>12.1%</td>
</tr>
<tr>
<td>Calories</td>
<td>346</td>
</tr>
<tr>
<td>Protein</td>
<td>0.18 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.05 g</td>
</tr>
<tr>
<td>Carbohydrate (Total)</td>
<td>85.74 g</td>
</tr>
<tr>
<td>Carbohydrate (Fibre)</td>
<td>0.0 g</td>
</tr>
<tr>
<td>Ash</td>
<td>1.89 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>58.0 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>7.2 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>0.55 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.0 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.0 mg</td>
</tr>
</tbody>
</table>
Figure 16. Recolonisation by *Tacca leontopetaliiodes*
Recolonisation of a salt scorched grass-covered runway,
Jibinmen Island, Mile Atoll. Photo: Dirk H.R.Spennemann

Figure 17. Recolonisation by *Tacca leontopetaliiodes*
Recolonisation of a burnt patch of soil Garu Island, Mile Atoll.
Photo: Dirk H.R.Spennemann
Figure 18. Recolonisation by *Taccu leontopetaloides*. Recolonisation of a cleared track on Nalu Island, Mile Atoll. Photo: Dirk H.R. Spennemann

Figure 19. Recolonisation by *Taccu leontopetaloides*. Recolonisation of a bulldozed area on Majuro Island (Laura), Majuro Atoll, three weeks after bulldozing. Photo: Dirk H.R. Spennemann
Figure 20. Arrowroot (*Tacca leontipetaloide*) in a beach herb and broadleaf plant community on Jibinmen Island, Mile Atoll. Close-up of the plant community. Note the competition by *Vigna marina*, sprouting *Cocos* and some *Scaevola*. Photo: Dirk H.R. Spennemann

Figure 21. Arrowroot (*Tacca leontipetaloide*) in a beach herb and broadleaf plant community on Ma juro I. (Laura), Majuro Atoll. Close-up of the plant community. Note the overcrowding of *Wedelia bi flora* and *Vigna maria*. Photo: Dirk H.R. Spennemann
Figure 22. Arrowroot (*Tacca leontipetaloides*) in a beach herb and broadleaf plant community on Majuro I. (Laura), Majuro Atoll. Close-up of the plant community. Note the overcrowding of *Wedelia biflora* and *Vigna marina*. Photo: Dirk H.R Spennemann

Figure 23. Arrowroot (*Tacca leontipetaloides*) under coconut (*Cocos nucifera*) on Nalu Island, Mile Atoll. Close-up of the plant community. Note the *Tacca* competing with taro (*Crytosperma chamissonis* and *Colocasia* spp.), *Polypodium scolopendria* and some grasses. Photo: Dirk H.R Spennemann
Figure 24. Arrowroot (*Taccæa leontipetaloides*) in a beach herb and broadleaf plant community on Lukunor Island, Mile Atoll. Close-up of the plant community. Photo: Dirk H.R Spennemann

Figure 25. Arrowroot (*Taccæa leontipetaloides*) under coconut (*Cocos nucifera*) on Lukunor Island, Mile Atoll. Close-up of the plant community. Note that *Taccæa* forms the dominant crop with only minor competition by *Vigna marina*. Photo: Dirk H.R Spennemann
Figure 26. Arrowroot (*Tacca leontipetaloides*) under coconut (*Cocos nucifera*) on Nalu Island, Mile Atoll. Close-up of the plant community. Note the *Tacca* competing with *Polypodium scolopendria*. Photo: Dirk H.R Spennemann

Figure 27. Arrowroot (*Tacca leontipetaloides*) under breadfruit (*Artocarpus altilis*) on Nalu Island, Mile Atoll. Close-up of the plant community. Note the *Tacca* competing with *Polypodium scolopendria*. Photo: Dirk H.R Spennemann
Figure 28. Arrowroot (*Tacca leontipetaloides*) on Majuro I. (Laura), Majuro Atoll. Diseases. Close-up of the leaf. Note the brown spot with the lighter coloured ring, most probably caused by (*Cercospora taccae*). Photo: Dirk H.R Spennemann

Figure 29. Arrowroot (*Tacca leontipetaloides*) on Majuro I. (Laura), Majuro Atoll. Diseases. Close-up of the leaf. Beginning of browning at the perimeter of the leaf. Photo: Dirk H.R Spennemann
Occurrence of Arrowroot

IN THIS SECTION WE WILL HAVE A close look into the occurrence of arrowroot, both in terms of the overall regional distribution within the Marshall Islands as a whole, and within individual atolls; as well as in terms of the abundance of arrowroot.

ORIGIN

*Tacca leontopetaloides* is a pan-Pacific cultigen, which is believed to have originated somewhere in South-East Asia. Its present distribution includes Africa, the Indian subcontinent including Sri Lanka, islands in the Indian Ocean and Australia.

The plant is considered to be of aboriginal introduction into Oceania as a whole and to all inhabited islands groups in particular (see also Appendix B). Once established, it will propagate by itself and will become a "wild plant", capable of continuous renewal.

DISTRIBUTION OF ARROWROOT IN THE PACIFIC

Arrowroot being as it is a pan-Pacific cultigen is believed to originally have been taken along by the Austronesian colonisers of most of the Pacific. In the geographical region surrounding the Marshall Islands arrowroot has been reported from the following areas: Kiribati, Tuvalu, Pohnpei, Yap, Truk, Funafuti, Nauru, and Ebon. See also Hawaii (Chamisso 1986:304; Ihara 1971; Handy 1940:299; Hiroa 1957:11).

In Melanesia it is reported from the Solomon Islands (Whitmore 1966:203), from New Guinea (Shaw 1984:123); New Caledonia (Soucie 1981); Vanuatu (Dingley et al. 1981:II 345 quote fungus affecting *Tacca*).


The arrowroot in Kiribati (Tarawa) attained a height of 1.6m. According to informants to Catala (1957:108) these plants were said to have been brought 15 years previously y (i.e. about 1936) from the Marshall Islands, brought a Gilbertese man who married a Marshallese woman. McKenzie & Jackson 1990a: 17 quote fungus affecting *Tacca* from Kiribati. This is somewhat confirmed by Wendler’s (111) statement that the inhabitants of the Gilbert Islands and Nauru were either unacquainted or deprecated this food item.

*Tacca* not seen by Moul (1957) on Onotoa. It is also absent from the Line Islands, such as Canton (Degener & Gillaspie 1955; Hataheway 1955). It has been found on Caroline Atoll, Southern Line islands, but an import by a whaler in the 1830s seems likely (Clapp & Sibley 1971).


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2 Masefield 1948:45; Lisowski et al. 1976.

3 Herklots 1972:473.

4 Fosberg 1957:15.

5 For Micronesia and the Marshall Islands see text.

6 Woodroffe 1985; McKenzie & Jackson 1990a: 17 quote fungus affecting *Tacca*. Nanumanga (Besnier 1971); Nanumanga (Besnier 1971); Dingley et al. 1981:II 345 quote fungus affecting *Tacca*; Funafuti (Dingley et al. 1981:II 345 quote fungus affecting *Tacca*); Nui (ibid.); Vaitupu (ibid.).
peii,\textsuperscript{1} Kosrae,\textsuperscript{2} Mokil,\textsuperscript{3} Eastern Caroline (outer islands of Pohnpei),\textsuperscript{4} Yap,\textsuperscript{5} Western Caroline (outer islands of Yap),\textsuperscript{6} Chuuk,\textsuperscript{7} Mortlock Islands (outer islands of Chuuk),\textsuperscript{8} Belau,\textsuperscript{9} southwestern Carolines (outer islands of Belau),\textsuperscript{10} atolls north of Belau,\textsuperscript{11} Guam\textsuperscript{12} and the northern Marianas.\textsuperscript{13}

The distribution in the Western Pacific has been plotted in figure 30. It needs to be noted that this distribution map is incomplete given the sources consulted.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{distribution_map}
\caption{Distribution of \textit{Tacca leontopetaloides} in Micronesia and the Western Pacific.}
\end{figure}

\textsuperscript{1} Rehg \& Sohl 1979; Glassmann 1952:116.
\textsuperscript{2} Lee 1976.
\textsuperscript{3} Harrison \& Albert 1977.
\textsuperscript{4} Nanoluk (Krämer 1935:133; Marshall \& Fosberg 1975); Pingelap (St.John 1948).
\textsuperscript{5} Müller 1917: 157 (not eaten at the time, but starch used for clothing); McKenzie \& Jackson 1990b:14; 26 quote fungus affecting \textit{Tacca}. Jensen 1977.
\textsuperscript{6} Puluwat (Damm 1935:15; Manner \& Mallon 1989); Ulithi (Lessa 1977); Woleai (Alkire 1974; Sohn \& Tawerilman 1976); Ifaluk (Damm 1935:8); Satawal (Damm 1935:10; Fosberg 1969:5); Fais (Krämer 1937: 331; 390; Fosberg \& Evans 1969:5).
\textsuperscript{7} Krämer 1932:35; Paul 1965.
\textsuperscript{8} Hiyane 1971a (late 1960s; Nama I); McKenzie \& Jackson 1990b:14; 26 quote fungus affecting \textit{Tacca}.
\textsuperscript{9} Krämer 1926:57; McManus \& Josephs 1977. According to Kubary (1895:173) arrowroot not too common, mainly because of a lack of tending. Osbed 1977:8; McKenzie \& Jackson 1990a:9; 17 quote fungus affecting \textit{Tacca}.
\textsuperscript{10} Sonsorol (Kubary 1895:84); St.Davids/Burat/Bunaj (Kubary 1895:109).
\textsuperscript{11} Kayangel Atoll: Gressitt 1953:3.
\textsuperscript{12} Safford 1905:380.
\textsuperscript{13} Chamorro language: Topping \textit{et al.} 1975. Villagomez 1965. In the mid-1960s the plant was no longer popular and thus was no longer tended, leading to the gradual extermination of the stands.
Figure 31. Distribution of *Tacca leontopetaloides* in the Marshall Islands
It is also reported for the Polynesian outliers in Micronesia, Nukuoro and Kapingamarangi. It is not reported to have been used on Nauru, but this is most likely due to incomplete research rather than absence of occurrence.

The anthropogenic distribution of arrowroot becomes evident if one observes that the plant—for example—is absent on traditionally never inhabited Johnston Atoll, which otherwise, climatically and pedologically, is comparable to the Marshall Islands.

**GENERAL DISTRIBUTION OF ARROWROOT IN THE MARSHALL ISLANDS**

Apart from coconut and Pandanus, arrowroot is the cultivar with the widest distribution in the Marshall Islands (figure 31). In the literature and by personal observation it has been reported from the following atolls and islands:

- Ailinginae,
- Ailinglaplap,
- Ailuk,
- Arno,
- Aur,
- Bikini,
- Ebon,
- Enewetak,
- Erikup,
- Jabwat,
- Jaluit,
- Jamo,
- Kili,
- Kwajalein,
- Læ,
- Likiap,
- Majuro,
- Maloelap,
- Mejit,
- Mile,
- Nadikdik,
- Namo,
- Namorik,
- Rongelap,
- Rongerik,
- Taka,
- Ujæ,
- Ujelang,
- Utirik,
- Wotho,
- and Wotje.

2. Lieber & Dikepa 1974; Niering 1956: 5; 7; 23.
3. Hambruch 1914; see also Wendler 1911.
15. Volckens 1903; Koidzumi 1913; Okabe 1941; St. John 1946 (collected, reported in Fosberg & Sachet 1962: 12); Fosberg & Sachet 1962: 12 (includes older references); Fosberg 1961b: 60; 1961c: 98; 1990: 24.; MacKenzie 1956; 1961. The plants were seen on Imroj, Mejato, Kinajon, Majuieark and Pingelap Islands after typhoon Ophelia had struck in 1958, while it was no longer found on Jabor I. (Fosberg 1961c: 98).
25. Also known as "Knox Atoll". Spennemann 1991b. Nadikdik had been inhabited until devastated by a typhoon in 1905 (Jeschke 1905; 1906) which killed the entire population (but 2) on the island. Reutilisation of the islands occurred in the 1930s when the copra was collected. Today a single household is present.
Based on the available records, arrowroot is absent only on Wake (Eneen-Kio), Bokak (Taongi), Bikar, and Lib. The absence of arrowroot at the latter location is somewhat doubtful, given the fact that no adequate botanical research has been conducted on that island. The absence of arrowroot on the northern three atolls is likely due to the lack of adequate precipitation, or because no one utilised these atolls on a frequent basis.\(^1\)

The fact that several traditionally uninhabited islands and atolls of the Marshall Islands, such as Ailinginae, Jemo, Taka or Eriku, also have arrowroot, indicates that the plant has been brough there to serve as a food resource when needed.\(^2\) On the other hand, while the use of plant names and especially cultivars is frequent, none of the place names in the Marshall Islands has the word for arrowroot as a term (Bender 1963). This could indicate either that arrowroot was a low-status crop, or that it had little importance in the regular horticulture, outside the starvation season.

**ARROWROOT DISTRIBUTION OVER TIME**

In this subsection we will compile the historic evidence on arrowroot in the Marshall Islands from the available literature. It should be noted that the available literature is very diverse and does not evenly cover the Marshall Islands. In addition, given the diversity, the listing below is bound to be incomplete.

**1816/17**

Processed arrowroot flour was offered to members of the Russian Exploring Expedition during their stay on Wotje Atoll.\(^3\)

**1885**

Arrowroot was seen to grow "in abundance all over the island" of Ujae.\(^4\)

**1951**

Seen doing very well on Uterik I., Uterik Atoll.\(^5\)

**1956**

Arrowroot is said to be "omnipresent and quite dense" on Uterik and was used "quite extensively by the Kili-Bikinians for starch [for clothes] and food."\(^6\)

**1958/60**

Said to occur spontaneous in the interior of most larger islets of Jaluit Atoll.\(^7\) An assessment of the effects of typhoon Ophelia (1958) on the islands of Jaluit Atoll included an assessment of the plants and the subsistence economy. Arrowroot is mentioned as a secondary food source "usually used between the breadfruit and the Pandanus seasons."\(^8\)

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\(^{1}\) Chamisso 1986; Kotzebue 1821: II 26; Hiyane 1971a (late 1960s; Ormej I); Fosberg 1990:24.

\(^{2}\) The absence of *Tacca* on Wake Atoll is well documented, given the abundance of botanical research carried out there. The vegetation has been described by the following authors: Ayers 1940; Barrows 1936; Bryan 1959; Drummond-Hay 1939:338; Fosberg & Sachet 1969; Fosberg 1957; Fosberg 1959b; Groom 1936; Parr 1941:92; Peale 1848; Pickering 1858: 246-247; Spennemann 1991 (Wake); and Wilkes 1845:V 284-285.

\(^{3}\) Kotzebue 1821: II 26.

\(^{4}\) Humphrey was shipwrecked in the *Rainier* on Ujae in 1884 and stayed there for several months (Humphrey 1887:88). See also Hezel 1979:140 for other sources on the incident.

\(^{5}\) Fosberg 1955a.

\(^{6}\) Wiens 1957:23.


\(^{8}\) Fosberg & Sachet 1962:12.

1968
In a 1968 assessment of the nutrition on Namu Atoll, Pollock states that in “November when arrowroot corms should have been ready to dig up, there were only barely enough to make starch for clothes, let alone for food.” At the time, arrowroot cultivation — like taro cultivation — had almost died out since seed corms were no longer planted to ensure supply for the following year.  

1990
Seen growing about knee-high in January 1990 on Mile I., Mile Atoll. Plants were competing with other vegetation for space. 

1991
Arrowroot was seen growing abundantly at the end of Majuro Island (Laura), Majuro Atoll, in a plot recently cleared by front-end loader down to the bare soil. The plants had an average height of 0.5m, although some plants of 0.75 m were seen.

Arrowroot was seen by the present author on a number of islands of Mile Atoll, as well as on Aelon-eo on Nadidik Atoll in 1991.

**ARROWROOT DISTRIBUTION ON SPECIFIC ATOLLS**

In this subsection we will compile the geographic evidence on arrowroot in the Marshall Islands from the available literature. It should be noted that the available literature is very diverse and does not evenly cover the Marshall islands so that the listing below is bound to be incomplete. For those who read this study from cover to cover, some of the text will be repetitive from the previous subsection.

**Bikini Atoll**
The German district administrator visited the atolls of the Marshall Islands, among them Bikini, in 1912 with an eye on potential land purchases to improve the copra production of the protectorate. On Bikini he found on 5% of the two larger islands, Eniu and Bikini “under cultivation with coconut and arrowroot.” In 1985, 30 years after the nuclear tests, Tacca was again found on some islands, such as Bikini, while it had been present before the testing on Bikini, Eniu and Nam. Fosberg notes that Tacca was one of the plants growing without cultivation assistance rendered by people.

**1950s/60**
Said to occur spontaneously in the interior of most larger islets of Jaluit Atoll. An assessment of the effects of typhoon Ophelia (1958) on the islands of Jaluit Atoll included an assessment of the plants and the subsistence economy. Arrowroot is mentioned as a secondary food source “usually used between the breadfruit and the Pandanus seasons.”

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2 According to Namu informants it is easier to gather coconuts for copra to sell and to but rice, than to grow taro and arrowroot as staple foods. Also, pigs were seen as a major pest uprooting the plants.
3 Own observations. Competitors were mainly Wedelia biflora and Vigna marina.
4 It is worth noting that Bikini is the only atoll in the entire document, where arrowroot is mentioned. German Colonial District Administrator Merz to Imperial German Gouvernour in Rabaul (New Britain), Auf die Erlass von 15. November 1911 No. 7188/11 von 21 Januar 1912 No. 779/12 und vom 11. April 1912 No. 3410/12 betreffend den Landereiwerb in den Marshall Inseln. Letter dated 16 May 1912. Ms. contained in German Colonial Archives from Rabaul, New Britain, Papua New Guinea, Record Series G2, Record Group Y40; Australian Archives, A.C.T. Records Depository, Canberra (Australia).
5 Fosberg 1987:D-9; D-17; Taylor 1950.
6 Fosberg & Sachet 1962:12.
Kili Island

An agricultural survey of 1956 found that "there is no way of determining how much of an area this [arrowroot] covered or the amount now growing on Kili. Arrowroot is found scattered through the village area and coconut groves. They seem to be vigorously growing but all of them showed signs of chlorosis and in some cases pretty bad. There was no system of planting and most of them are volunteer growth. Arrowroot is used quite extensively by the Kilians for starch [for clothes] and food."  

Kwajalein Atoll

In 1912 the German district administrator visited Kwajalein Atoll in order to inspect recent coconut plantings and also with an eye on potential land purchases to improve the copra production of the protectorate. He found that most of the young coconuts had been overgrown with scrub which caused the young coconut to die off. He goes on to say that there "where the [vegetation] is really cleared, arrowroot will grow well. The soil seems to be excellent both for this [arrowroot] and coconuts."  

Lae Atoll

In 1912 the German district administrator also visited Lae Atoll with an eye on potential land purchases to improve the copra production of the protectorate. He found that most of the islands of the atoll were under cultivation with coconut, Pandanus and arrowroot.  

Majuro Atoll

In 1967 the subsistence patterns of some families on Laura, Majuro Atoll, were investigated. At the time, Laura (~700 persons) was by far not as urbanised as it is today (1988: 1575 persons). The assessment found that of the nine households analysed utilised arrowroot starch. That may be a result of the particular time of the year when the study was conducted, but the omission of arrowroot in the introduction and discussion of food items indicates that it had lost its importance altogether.

In end of May/early June 1991 arrowroot was seen growing abundantly at the northern end of Majuro Island (Laura), in a plot recently cleared by a front-end loader down to the bare soil. The arrowroot plants, which were the only plants in the area apart from coconut palms, had an average height of 0.5m, although some plants of 0.75 m were seen. On an area of approximately 15 by 30 metres 8 coconut palms and 22 arrowroot plants were counted.

On the shoreward side of the plot, which had not been cleared, arrowroot plants were seen with leaf stalks standing up to 1m tall and flower stalks standing well over 1.5m tall. These plants were in the process of becoming choked by competitive vegetation, namely Wedelia biflora and Vi...
**gna marina** (figure 21). Progressively new leaves would be pushed, only to be overtaken again by **Wedelia**.

**Maloelap Atoll**

For 1989 arrowroot was described by the Micronesian Resource Study to grow "throughout the island in small quantities, with the most plentiful crops on two southern **wato**, Lautkan and Eoon-epje. Arrowroot is a commonly used local food though in short supply. Every household is said to make **makmok**, but also buys imported cornstarch for cooking. The harvest season is September-November."

**Mile Atoll**

During fieldwork in June 1991 a large number of **Tacca** were seen on a number of islands. Growth conditions of **Tacca** were observed on all islands visited by the author during the survey. These were: Tokowa, Burrh, Nalu, Garu, Mile, Bogukurikku, Enajet, Jib-inmen, Anewa, Lukunor, Namake (no **Tacca** seen), Enanlik, Dobo-en (no **Tacca** seen), Bokwa-en-keaar (no **Tacca** seen) and Arbar. Details of these are spelt out in table 3.

**Namu Atoll**

In a 1968 assessment of the nutrition on Namu Atoll, Pollock states that in "November when arrowroot corms should have been ready to dig up, there were only barely enough to make starch for clothes, let alone for food."1 At the time, arrowroot cultivation—like taro cultivation—had almost died out since seed corms were no longer planted to ensure supply for the following year.2

**Rongerik Atoll**

The Bikini people which had been moved to Rongerik Atoll to allow for Bikini being used as a nuclear test site found that although arrowroot grew there, its tubers were smaller than they were used to on Bikini. The plant was also found to be less abundant than on Bikini, but this attributed to the fact that there were less coconut groves than on Bikini.3

**Ujae Atoll**

A contemporary source of the mid 1880s mentions that "arrowroot grew in abundance all over the island." Starch was made for both local consumption and trade.4

**Uterik Atoll**

Raymond Fosberg during the northern Marshalls survey conducted in 1951, mentions the following for Uterik:

"The Polynesian arrowroot, **tacca leontopetaloides**, grew in unusual abundance and luxuriance as ground cover in the coconut groves here. Each year, in the late fall, it fruits and dies down to the ground. here it was beginning to turn yellow, and the fruits were essentially mature. The tubers, mistaken for potatoes by other members of our party, were being harvested in some quantity by the Marshallese. They were grated and the starch was washed out and dried in large balls, about the size of a child's head. Whether this was normally so practiced was not certain. It may have been the result of a food shortage because of the typhoon.5 There was some complaint about lack of flour."6

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2 According to Namu informants it is easier to gather coconuts for copra to sell and to but rice, than to grow taro and arrowroot as staple foods. Also, pigs were seen as a major pest uprooting the plants.

3 Kiste 1968:51.
4 Humphrey 1887:88.
5 Typhoon **Georgia** 21 March 1951.
6 Fosberg 1955a:5.
Wotje Atoll

Processed arrowroot flour was offered to members of the Russian Exploring Expedition during their stay on Wotje Atoll:

"A white lump was brought to me, resembling white chalk, the use of which I did not learn till I had become more acquainted with the islanders. A plant grows here, called by the natives mogumuk, and its root, which resembles a small potatoe, is dried in the sun and rubbed to powder; it produces a fine flour, which when pressed into lumps, may be kept for a long time without spoiling. When it is to be eaten, a little is broken off one of these lumps, mixed with water in a cocoa-shell, and boiled until it becomes a thick pap: its taste is not amiss, and has great resemblance to our potatoes: this plant grows wild."

\[1\] Kotzebue 1821: II 26.
Traditional Marshallese Arrowroot Production

In this section we will have a detailed look at the traditional utilisation of arrowroot by the Marshallese people. This includes an assessment of the role arrowroot played in the diet, the planting and tending processes, harvesting practices, starch extraction procedures, the regional distribution of arrowroot production and finally the food dishes derived from the starch, as well the other uses of arrowroot.

Role of Arrowroot in Traditional Micronesian Culture

Throughout Oceania arrowroot has importance for the local diet. In most cases, the consumption of arrowroot is reduced to emergencies: it ranks as a “typhoon food” or “cyclone food”, to fill in the gaps when little or no other food of value can be obtained.¹ On some islands in the Pacific, however, arrowroot attained the importance of a staple crop. Subsistence horticulture in an atoll environment prone to natural disasters meant that the horticulture was very diversified to meet all contingencies. On all atolls of Micronesia, including Kiribati and Tuvalu, the variety of carbohydrate sources is severely limited. Thus arrowroot, which ripens during a period when other food is scarce, attained great importance. In addition, once properly processed and dried, arrowroot starch (flour) could be stored for a considerable period of time, making a desirable staple. It also attained great importance on the atolls of Eastern Polynesia, i.e. the Cook Island, Marquesas and the Tuamotus.

In 1911, Wendler claims that the processing of arrowroot flour was not carried out in the islands neighbour-

² Wendler 1911.

³ The number of words contained in a dictionary has been computed by multiplying the total number of pages with the average entry count derived from the count of five sample pages. The index has been computed as follows: no of entries under “arrowroot” * 1000 / number of local language words contained in the dictionary.

That this is a valid measure becomes evident if one compares the representation of other food plants or names for fish in the dictionaries. See for example, the names for yams in Pohnpeian (87 entries in the English section; Rehg & Sohli 1979:253).

⁴ The prehistoric introduction — rather than natural dispersal — of the coconut (Cocos nucifera) is in doubt, although there can be no doubt that the palm was purposefully propagated.

¹ Cf. Loech (1926:6) for Niue.
Following cultivars are today found in the Marshall Islands, the introduction of which is probably or certainly the result of European import in the last century: *Dioscorea alata* and *Di. bulbifera* (yams); *Ipomea batatas* (sweet potato); *Carica papaya* (papaya).

Table 6. Comparative table of the representation of terms for arrowroot plants and products in modern dictionaries in Micronesia and northwestern Polynesia.

<table>
<thead>
<tr>
<th>Language</th>
<th>Plant</th>
<th>Terms for Food</th>
<th>General Total terms</th>
<th>Total entries</th>
<th>Index (‰)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marshallese</td>
<td>3</td>
<td>4</td>
<td>10</td>
<td>17</td>
<td>8500</td>
<td>2.00</td>
</tr>
<tr>
<td>Tuvaluan</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>4000</td>
<td>0.75</td>
</tr>
<tr>
<td>Chamorro</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>8400</td>
<td>0.23</td>
</tr>
<tr>
<td>Mokilese</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>4500</td>
<td>0.22</td>
</tr>
<tr>
<td>Kiribati</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>5000</td>
<td>0.20</td>
</tr>
<tr>
<td>Yapese</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>5000</td>
<td>0.20</td>
</tr>
<tr>
<td>Kapinga</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>6000</td>
<td>0.17</td>
</tr>
<tr>
<td>Palauan</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>12000</td>
<td>0.17</td>
</tr>
<tr>
<td>Woleaian</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>6200</td>
<td>0.16</td>
</tr>
<tr>
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<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>6750</td>
<td>0.15</td>
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<td>-</td>
<td>-</td>
<td>1</td>
<td>7650</td>
<td>0.13</td>
</tr>
<tr>
<td>Nukuoro</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>14500</td>
<td>0.07</td>
</tr>
</tbody>
</table>

The main food plants at the turn of the century were taro, breadfruit and *Pandanus*, while arrowroot, ti-root and other plants were typhoon food or winter food. 1 There is some seasonality in the food supply. In traditional atoll horticulture, the food supply is not even throughout the year. Seasonal are breadfruit (*Artocarpus* sp.), *Pandanus* and to a lesser extend arrowroot.

In assessing the horticulture of the Marshall Islands a whole, Krämer gives arrowroot the status of the second most important food after *Pandanus*. 2 This assessment, it seems, is largely based on the geographical distribution and thus availability of the plant throughout the Marshalls.

Table 8 shows the seasons of various Marshallese cultigens. During the off-season, that is between December and February, many islands regularly experienced annually recurrent food shortages. 3 In times like these stored food preserves were used, such as *bwiro*, 4 *mogan* 5 and *jāñwin*. 6 In addition, the atoll subsistence economy then relied on other less common food sources, such as arrowroot, and overall physical activity was reduced.

Natural disasters, such as typhoons, would bring about a very short period of over-abundance of food followed by a much longer period of severe starvation, as all fruits are blown off the trees.

Both *taro* and arrowroot horticulture was seen as men's work in the traditional system of the Marshall Islands. 7

---

1 Anonymous 1895; Stone 1951:25.
2 Krämer 1906:428.

3 See also Alkire (1978:106) for Tuamotus.
4 Made from breadfruit: Krämer & Neverymann 1938: 135
5 Made from Pandanus: Krämer & Neverymann 1938: 135.
6 *jāñwin in bob* (from Pandanus): Krämer & Neverymann 1938: 134; Wendler 1911; *jāñwin in me* (from breadfruit): Krämer & Neverymann 1938: 135. Even though these two are preferably voyaging foods.
7 Krämer & Neverymann 1938:111.
Figure 32. Traditional vegetation zonation pattern of an inhabited large, leeward atoll islet.

Figure 33. Typical modern vegetation zonation pattern of a leeward atoll islet.
### Table 7. Marshallese cultigens

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Edible parts</th>
<th>Normal times</th>
<th>Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alocasia macrohiza</td>
<td>Giant taro</td>
<td>Tubers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artocarpus mariannensis</td>
<td>Breadfruit (w/ seeds)</td>
<td>Fruit, Seeds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artocarpus altilis</td>
<td>Breadfruit (no seeds)</td>
<td>Fruit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocos nucifera</td>
<td>Coconut</td>
<td>Nuts, Sap, old wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colocasia esculenta</td>
<td>Dry-land taro</td>
<td>Tubers, Leaves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cordyline fruticosa</td>
<td>Ti-root</td>
<td>Roots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crinum bakeri</td>
<td>Spider lily</td>
<td>Roots, Stem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cytosperma chamissonis</td>
<td>Swamp taro</td>
<td>Tubers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fvora case</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Musa sapientum</td>
<td>Banana</td>
<td>Fruit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandanus tectorius</td>
<td>Pandanus</td>
<td>Keys (Pulp), Keys (Seeds), Roots, Bark</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tacca leontopetaloides</td>
<td>Arrowroot</td>
<td>Tubers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truncetella procumbens</td>
<td></td>
<td>Leaves, grated wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wedelia bifora</td>
<td></td>
<td>Leaves, grated wood</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 8. Seasonality of Marshallese food plants (Harvestable: • in full season

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alocasia macrohiza</td>
<td></td>
<td></td>
<td>•</td>
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<tr>
<td>Artocarpus mariannensis</td>
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<td>Artocarpus altilis</td>
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<td>Cocos nucifera</td>
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<td>Colocasia esculenta</td>
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<td>Cordyline fruticosa</td>
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<tr>
<td>Crinum bakeri</td>
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<tr>
<td>Cytosperma chamissonis</td>
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<tr>
<td>Fvora case</td>
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<tr>
<td>Musa sapientum</td>
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<tr>
<td>Pandanus tectorius</td>
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<td>Tacca leontopetaloides</td>
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</tbody>
</table>

1: 2-3 months
2: 4-6 months
3: 6-9 months
Chamisso, who visited the Marshall Islands in 1816 an 1817 as a member of of the Russian exploring expedition under command of Otto von Kotzebue mentions that *Taccia leontopetalooides* is used to make a nourishing flour, but that it appeared to him on the islands they visited (Wotje, Mejit and Ailuk) that arrowroot was only rarely produced and used. Kotzebue himself was given arrowroot dish.\(^2\)

Mason in his economic assessment of the Marshall Islands immediately after World War II states that arrowroot “assures, with Pandanus, a season of plenty comparable to that enjoyed by the natives when breadfruit is available. The members of a community cooperate in the preparation of arrowroot meal under the expert guidance of a few older men and women.”\(^3\)

Arrowroot formed an welcomed addition to the other cultivated plants, especially since it did not compete with taro or breadfruit for prime gardening space. In the traditional way of setting out the land, a household would own a land allotment (wato) running from the lagoon to the ocean shore, thus having access to a variety of resources, because the vegetation pattern itself would show a clear zonation from the lagoon to the ocean shore (figure 32). The vegetation on the oceanside commonly consisted of a mixed broadleaf, consisting of a few tree species and a number of shrubs, usually *Guettardia speciosa*, *Tournefortia argentea*, *Pisonia grandis*, *Pandanus tectorius*, *Cordia subcordata*, *Hernandia sonora*, *Scaevola sericea* and *Surina maritima*. These plants would be very resistant to salt-laden air the constant wind would bring in from the breaker zone at the reef. The soil at the ocean shore is also very gravelly with little humus content.

Going inland, the soil would gradually become finer, and the humus content would increase. In this zone an abundance of breadfruit trees would have been planted, providing food. In the very centre of the island, there where the underlying ground water lens (Ghyben-Herzberg lens) would be the thickest, taro patches, artificial depressions in the ground, would be present. These taro patches, in which swamp taro (*Cyrtosperma chamissonis*) would be grown, were surrounded by *Pandanus* trees, preferable the low growing variety, not used for food but for mat weaving. These *Pandanus* would act as a windbreak for the large taro leaves, and would also act as screen to filter out any salt spray the winds may bring.\(^4\)

Going further towards the lagoonal shore the vegetation zonation would once again show a series of breadfruit trees which would make way to utility and ornamental shrubs along the rear side of the household units. Next would come the houses and coral gravel spreads themselves. Towards the lagoonal shore there would be a sand-covered road or track, and then a low shrub or weed zone with some coconut. This zone provided access to the lagoon and allowed canoes to be dragged above the high-tide mark. The uninhabited and uncleared stretches of the lagoonal shores would show a coconut shrubland with an abundance of *Scaevola sericea* and *Tournefortia argentea*.\(^5\) Coconut palms, today an

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1 *Taccia pinnatifida* in his account (Chamisso 1910:167).
3 Mason 1947:70.

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4 Hiyane 1971; Krämer & Nevermann 1938.
5 This general vegetation pattern exists since several million years: The analysis of pollen grains in the deep cores drilled at Enewetak Atoll (Emery et al. 1954; Tracey
ubiquitous plant throughout the islands, as well as along the lagoonal shores and inland, would have been distributed only along the immediate lagoonal area, such as the zone of the houses and their backyards.1

Every piece of ground in the centre would have been taken up by taro patches, *Pandanus* plantations and roads/tracks. *Tacca* could not grow in the dense canopy of the breadfruit zone. Therefore arrowroot would have to be grown in the more open spaces, on more sandy ground. Thus the typical arrowroot planting zone would have been between the houses and lagoon, as well as between the houses and the onset of the breadfruit forest. Furthermore, arrowroot could also be grown on the smaller islands, where traditionally breadfruit would not thrive because of the lacking ground water lens, and where permanent human habitation would have been out of the question.

With the Europeanisation of the Marshallese agroforestry and the systematic replacement of breadfruit forests by coconut plantations for copra production (figure 33), the habitat for arrowroot has changed. The German and Japanese wide spaced coconut plantations penetrating far inland, provide an ideal semi-shaded habitat for *Tacca* if the soils are not too humic. Thus *Tacca*, a plant preferring open spaces traditionally only found in the nearshore areas, has come to be an inland plant as well.

**PLANTING AND TENDING ARROWROOT**

In traditional Oceanic horticulture we have to distinguish between planting and tending of crops. Some crops, such as *Cytosperma* or *Alocasia* are planted, tended and harvested, whereby a harvest without planting is not possible. This planting occurs on a regular basis, for some plants even during a specific period in the year, and in a regular laid out fashion, with fertiliser and soil improvements added to the process. Traditionally leaves or pumice were used as a fertiliser in taro patches, the latter either unmodified or in pounded form.4

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2 Or *agroforestry* as proposed by Thaman (1988).
3 Krämer & Nevermann 1938:111.

In the literature, pumice is reported for a number of atolls in the Marshall Islands. Wotje Atoll (Stone 1951:10; Wells 1950:3); Taroa, Maloelap Atoll (Spennemann 1899a); Majuro (Spennemann unpubl.). Mile Atoll (Spennemann unpublished) and Ujue Atoll (Fosberg & Carroll 1965:Plate 23c) and for Arno Atoll (Stone 1951:10) where pumice, however, is more prominent. First observation of pumice in the Marshall Islands was made by Chamisso (1821:156; cited after 1910:186), possibly on Ailuk Atoll. The occurrence of pumice appears to be temporal, dependent on volcanic eruptions in nearby areas. Grundemann (1887:442) mentions large ice beds for Ailuk. Steinbach (1894) mentions that an especially large number of pumice were washed ashore in Jaluit and other parts of the Marshall Islands in September 1894. At the time, ships are said to have driven/sailed through large fields of drifting pumice stone. Fosberg (1955; Sachet 1955:2) lists occurrence of pumice for Bokak, Utirik, Ailuk, Jemo, Kwajalein, Ujue, Wotho, and Ujelang. Chemical analyses are given for Bokak, Jemo, Ujue, Wotho, and Ujelang (Sachet 1955:21).

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1 Coconut palms cannot grow in the heavily bushed central areas of the islands, as the dense canopy of the central hardwood and breadfruit forests would prohibit the growth of young coconut.
Figure 34. Organisational flow-chart of traditional (19th century) arrowroot horticulture in the Marshall Islands
Tending, however, is restricted to a planted crop, keeping it free from competing vegetation ("weeding"), parasites and the like. While arrowroot definitely was not planted in the strict sense, and can be regarded as a volunteer crop which will re-occur every year, it was tended.

Starting at the beginning of a planting cycle, the crop of the previous year is harvested. Only the large tubers of the female plant are taken, its small ones, as well as the tubers of the male plant are not. The small tubers left behind, often up to 20 in number, were called *lep in μakμak* or "eggs of arrowroot" since they acted as seedlings for next year's crop. The hole from which the plant was procured was then commonly refilled with loose soil, although there are some reports that the hole was left to be filled in by nature. As far as can be made out, no systematic, spaced-out planting of the small tubers occurred in the Marshall Islands.

In Chuuk arrowroot was intentionally planted out. The planting occurred at periods on new moon or full moon. The land was carefully cleared before planting and the cleared weeds collected in a pile and burnt. One or two small tubers of less than 1 inch in diameter were placed in a small hole, which was on average 2 inches deep. The hole was filled with loosened soil.

No fertiliser was added. The planting occurs in a rough grid, every plant spaced some 2 1/2 feet apart. In Hawaii *Tacca* was either left to grow "wild" or was intentionally planted along the ridges of taro patches.

On Namoluk Atoll, Western Carolines, *Tacca* had been "partially cultivated,"

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1 Either they were not dug up at all or those dug up were thrown back into the hole.
2 Wendler 1911; Erdland 1914:38 both: *ib in mokem.ik*.
4 Paul 1965.
5 Handy 1940:299.
vated”, and “now grows wild in relatively open coconut groves near the beach”.1

Informants to the present author mentioned that sometimes Marshallese children would be tasked with spreading out small tubers in the bush if there was an abundance of small ones recovered from a bunch.2

*Tacca* can also be propagated by seeds,3 but this was apparently never practiced in traditional Marshallese horticulture.4 One of the reasons advanced for the diminishment of *Tacca* in the atolls was the fact that children no longer use the leaf stalks to use them as spears and to play with them. It is possible that this practice added to the dissemination of *Tacca*, but this time through seeds.5

No further care of the plants is taken, such as preparing a plant bed or providing mulching or organic fertiliser, and the plant spreads like a weed. According to Wendler6 it is not possible to make out where the previous year’s arrowroot harvest had been obtained.

However, traditionally the arrowroot area was weeded regularly, and competing vegetation was pulled out.7 *Tacca* was “spared when other vegetation was slashed in the [coconut] groves, and it clearly benefitted from this weeding.”8

Polynesian arrowroot is a very hardy plant, which can withstand droughts relatively well. In case of a severe drought the top leafy part of the plant may die off, but the tubers survive and send up new shoots with the return of moisture.9

Since the end of the 19th and beginning of the 20th century, when coconut plantations became more common, arrowroot is “traditionally” grown in coconut groves, often inter-cropped with papaya (*Carica papaya*), banana, breadfruit and Pandanus. Mixed stands of coconut, *Tacca* and wild vegetation are very common, especially on the smaller, not permanently inhabited islands of atolls.

Burning the underbrush seems to be a new practice, possibly introduced as late as the post-World War II period, and is damaging to coconut palms and breadfruit trees.10

Burning, however, more thoroughly than any weeding can achieve, destroys the shallow roots of competitor plants, while it leaves the deeper rest-

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3 In fact this is the sole means of reproduction for some *Tacca* species, such as *Tacca chantrieri* (Winters 1952:83).
4 This is well in keeping with the pan-Pacific horticultural tradition, where tuber- or shoot-propagated plants dominate, while seed-propagated plants are all but absent.
5 Pers. comm. Carmen Bigler.
6 Wendler 1911.
7 Kubary (189:173), when discussing arrowroot in Belau, mentions that it is not too common there because of the lack of tending.
8 Stone 1951:24. Sproat (1968:66) mentions that *Tacca* benefits from slashing and or burning the underbrush, that it will quickly resprout and, apparently as a faster growing plant, will predominate until the other plants have gradually recovered and begin crowding in.
9 Soucie 1983:197.
10 Hiyane 1967.
ing tubers of the arrowroot intact. Thus arrowroot can regrow without any competition.

Sproat, conducting research on local subsistence agriculture in Micronesia, notes that “in the atolls of the Marshall islands arrowroot is considered as a ‘volunteer’ subsistence crop which is allowed to grow under coconuts, breadfruit and Pandanus trees. It grows with other plants such as banana and papaya. Often times large areas of underbrush are burnt out under the coconut groves in the dry season. The bush plants are killed and the Tacca plants immediately re-sprout and predominate.”

HARVESTING

By the time the plant is matured, the leaves turn yellow and the plant dies back. This commonly occurs between end of November and the beginning of December in the northern, and between January and February in the southern atolls, and indicates the time for harvesting the crop. The tubers are dug up, the larger ones taken, and some smaller ones, often 10-20, left behind to produce new plants.

The Marshallese could easily decide which of the plants would bear many tubers, for every leaf stem corresponds to one root, at the end of which is a tuber. Furthermore, there is a gender difference between among the plants, where the female plants produce substantially larger tubers than the male plants. Thus, in time of relative affluence, only female plants are dug up, male plants and plants located on stony ground are spared.

Traditionally the digging up of the tubers occurred with sharpened sticks (kūbwij). Since the turn of the century spades, shovels, crowbars and pick-axes have become the sole means for excavation, both in soft sands and in rubbley ground.

One source based on evidence presented during a training workshop, claims that “in the Marshalls, to make harvesting easier, the entire area is burned. Usually the entire family joins in the harvesting.”

The burning appears rather unlikely as a precursor to harvesting as this makes the selection of female vs. male plants impossible, thus requiring the excavation of the root systems of all plants which are still recognisable as arrowroot. It is more likely that the area was torched as a shortcut to weeding and clearing well after harvesting, sometime in January or February, when arrowroot plant growth is revitalised and competitor plants could be wiped out.

The collected tubers were placed in a flat coconut leaf basket with two handles (banoonoor) for transport to the processing site. A good-sized tuber may weigh up to 500g.

5 Which is more effort to dig up and search for the tubers.
6 kūbwij; Abo et al. 1976:170 transitive form of kōb - to dig. Term after Grösser 1902 (kabji).
7 Soucie 1983:199.
9 There are some data collected from Tarawa, Kiribati: the total weights of all tubers collected from four plants were: 2 lbs., 2.6, 1.9, 3.3 lbs. The largest tubers on one plant weighed: 8.7, 5, 4.5 and 4 ounces. Catala 1957:109.
Some informants indicated that arrowroot harvesting did not necessarily occur as an all out action, but that over the harvest months people could and would go out to harvest arrowroot as needed. Planting and harvesting was and still is men’s work.\footnote{Krämer & Nevermann 1938:111.}

**Northern atolls, traditional to 1910.**\footnote{The main description follows Wendler (1911) with additions from other sources of the 1910 Hamburg South Sea Expedition. Ermland’s description (1914:38-39) is basically similar.}

The collected arrowroot tubers are brought to the processing site, poured into a wide-meshed sack made of plaited coconut (sennit), which resembles a fishing net (mādo, do).\footnote{mādo (pronounced mero), a variant form of do, is the term for a large-meshed, bag-shaped net to wash arrowroot or to soak breadfruit.}

The sack is tied on the top with a string and carried into the lagoon where the tubers are cleaned of earth and sand by pushing the sack around with the feet.

After this cleaning process the sack is pulled out of the water and carried to the location where the rubbing takes place. Individually, every single tuber is rubbed on or with a rough but soft coral (pukor)\footnote{Beachrock or coral (Feeney [1952:251]:bukor; Krämer (1905:142; 1906:429): bjogor; Hersheim: bōgor; Erdland: bigur; Ermland (1906:93): bōgor; Krämer & Nevermann 1938:131: bjogor (Ratak dialect), buigor (Ralik dialect), Abo et al. [1976:56, 200, 248]: pukor. Krämer (1906:429) describes the pukor as a “triangular, sharp stone.” Krämer & Nevermann (1938:131) describe it as an approximately rectangular piece of coral of about 20-25cm length. According to Krämer (ibid) the pukor also appears as a weaving motif on Marshallese mats (see list or ornaments in Krämer & Nevermann 1938:161). The rubbing process itself is called irir (Wendler [1911]: irir; Abo et al. 1976:78). (Two other sources provide another term, liklik: Krämer & Nevermann [1938:136] liklik; Erdland [1906]: liklik. There seems to be some mix up in the tradition of words, as in modern Marshallese liklik means “to sift; to strain” (Abo et al. 1976:180).} until it is reduced to a reddish

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**Extraction Of The Starch**

Traditionally there were a number of slightly variant techniques to make starch.\footnote{Described in Krämer 1906:428-429; Krämer & Nevermann 1938:110; Murai et al. 1958:102; Wendler 1911.} The extraction of starch always followed the same general principles, although the extraction techniques obviously vary over time, especially as other, modern appliances and contraptions become available. In the following several descriptions of arrowroot starch extraction will be repeated here, which document the gradual changes over time.
mass ("ne rup"), not unsimilar in consistency and appearance to grated potatoes. This mass is collected in large leaves or on old mats (ko ed in liklik) and placed into the processing unit.

Chain the washed tubers were commonly rubbed/grated with their skins.

The men who perform the task of processing arrowroot usually sit in a circle around a pit measuring 1 to 2m in diameter and about 0.5 to 0.75 m deep. The sides and bottom of the pit are lined with leaves or coconut fronds. A large, strongly plaited mat (ko ed in liklik) is placed on top of these leaves, and its edges protrude a good distance over the edge of the pit. This mat serves as a trough on which to catch the strained arrowroot flour.

Resting on the orifice of the pit and supported by four branches, is a rectangular container woven from Pandanus roots or from young shoots of the mangrove Bruguiera gymnorn-

1 Hiyane 1967.
rhiza, supported by four crooked legs (figure 37). In order to prevent any large pieces of the üne rup as well as any foreign material from falling into the mat, the coconut mesh is covered with (the rind of [?]) a sticky flexible creeping root (kil-in-kaönön).

In more recent time this has been replaced by a wooden box (waliklik), which acts as a strainer (figure 38), and whose lower part is open and only covered with a mesh made from coconut coir (ekkwal).

An alternative set-up dispenses with the need for a pit altogether and suspends the mat catching the water and washed-out starch on four sturdy stakes. This set-up allows the men (washers) to place the entire sifting unit on the beach, within easy access to ample fresh sea-water. In another alternative, also mentioned by Krämer the waliklik is held up by two men.

The red mass is then wrapped in the net-like wrapper of young coconut leaves, which acts as the real filtering cloth. This is placed in the box and watered with sea-water and continuously kneaded with the hands. While one man kneads, the other from time to time sprinkles the mass with sea water from a canoe bailer (lem).

The water runs off carrying with it the dissolved arrowroot starch into the trough-like mat underneath. This water mixed with arrowroot (üne) stays in the mat for one to two hours, the starch gradually settling to the bottom. After that the water, which has not yet dissipated through the mat and leaves into the ground is skimmed off. The material left over from the kneading (bue), leached out of its starch content is thrown away.

After two or even three hours the sifted starch is sifted in the same manner for a second time (epta) and if there is large amount of flour processed, even for a third time. Commonly, but apparently not as a rule, the last washing occurred with fresh water, rather than sea water. During this pounding and leaching process, the arrowroot loses its bitterness. When all the water is skimmed off or has dissipated, the flour is scraped together and hung up in the wrapping of a young coconut leaf, thus allowing the water to run off and drip out of the starch (bobo en Ujilan).

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1 **Bruguiera gymnorrhiza** (Marshallese: jon), is a mangrove commonly growing in depressions close to the shore lines. The young saplings are used for a variety of purposes, among them the weaving of fish traps (see compilation on the plant in Spennemann & Lajan 1991).

2 Wendler (1911): kilka; not listed in plant list by Krämer & Nevermann 1938:291-293. Kilin kau "Skin of a cow" = leather (Abo et al. 1976:140); Kil-in-kaönön, means the skin of the kaönön plant (*Cassytha filiformis L.*) (LAURACEAE). This is a leafless, green or brown twining parasite, which is common on most atolls of the Marshall Islands (Abo et al. 1976:132; Fosberg 1990).

3 Wendler (1911): *wa in likilik*; Krämer (1905): *wunikikelik*; Curtis (1986): jirrok or waliklik *makmok*; Abo et al. (1976:279): waliklik; Entomology: wa "boat", "canoe"; liklik - "to strain"; "to sift".

4 Informants on Enajet, Mile Atoll, mentioned in June 1991 that *Tacca* starch is still being produced. The waliklik is made for each occasion, but not kept.

5 Krämer 1905:143.


7 Wendler (1911): ünu; Abo et al. (1976:232): *sn* "nourishing; substance; vitamin; nutrition.

8 Sometimes 3-4 hours (Hiyane 1967) or even overnight (pers. comm. Liki Jacklick).

9 Wendler (1911): wo; Abo et al. (1976:46).


11 In modern days commonly substituted by a cloth.

12 Wendler (1911): *bobo in Ulilan*. This drying method has been given this term because the people of Ujelang prepared arrowroot starch this way. *bobo* "to make balls" (Abo et al. 1976:33).
Figure 39. Schematic view of the arrowroot sifting process. 1-Mat with ground arrowroot tubers; 2-Mat with cleaned arrowroot tubers; 3-Pit excavated into the sand; 4-Coarse mat used as lining of the pit place above a layer of coconut leaves (not shown); 5-Heap of sifted arrowroot starch in the pit; 6-Arrowroot strainer (walikilik); 7-Ground arrowroot ready for washing with sea water.; 8-The excess water dissipates into the ground.

Another way of getting the starch lump to dry is to excavate a small hole, line it with leaves and place the starch lump wrapped in young coconut leaves into the hole in which the excess water will run off (likatöttö). In order to expedite the process, some people beat the suspended starch ball with a stick, although most are satisfied to let gravity do the work. This is the preferred method in the rest of the Marshall Islands, especially inLikiep and Utirik.

As soon as all the water has dropped out, the hardened, rounded lump of arrowroot starch (jibwil) is placed in a shady place, usually a hut, so that it can dry and harden still more. After about two or three days it is crushed on a mat and placed in the sun to dry out thoroughly. This process, in which the flour is frequently turned and powdered, takes about two to four days.

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1 Wendler (1911): likadeddekk; probably from likatøttøt “stay where one is at patiently”; “stay put” (Abo et al. 1976:180).

Figure 40. Arrowroot making on Likiep Atoll at the turn of the century
(Photos: Joachim deBrum, Courtesy deBrum Collection, Alele Museum. Negatives B-228; B-281)
About seven baskets of unprocessed tubers result in one basket of processed dried flour.²

Krämer also mentions that a thoroughly dried *jibwil* may be kept as such and may not be broken up. The drying process creates an hourglass-shaped object. From this lump then arrowroot flour is broken off as needed (figure 42).³

*Ujae Atoll 1880s.* A contemporary source of the mid 1880s, O.J. Humphrey⁴ mentions that “arrowroot grew in abundance all over the island. This was obtained by burning over the land, and was dug up, then dried and pounded up fine and put into mat bags to sell [sic] traders that called at the island for cobra [copra].”

Humphrey’s description appears a bit shortened, containing a number of points, some of which need clarification. It seems that the vegetation was burned, probably to allow arrowroot to sprout and dominate, rather than during the land to harvest it. It is rather interesting to note that Humphrey omits the laborious detoxication and starch extraction process, and simply states that the tubers were dried and pounded up for trade. It is unclear whether this is actually true, and some traders obtained dried and pounded arrowroot for further process-

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1 Wendler (1911): *bojo*; Grösser (1902): *bojo*; Bartels in Krämer (1905): *pojo*; (Krämer 1905): *bojo*; Krämer & Neumann (1938:136): *bojo*; Erdland (1906): *buajo*; Abo et al. (1976:37): *bojo*, hand basket of a fine weave; The basket is described in Krämer & Neumann (1938:133; 153-154). It is made of fine Pandanus strips and may have a plaited part to strengthen the bottom; it is commonly closed by sowing a string of *ekkwa* in a zigzag manner across the top.

2 Wendler 1911.


4 Humphrey was shipwrecked in the Rainier on Ujae in 1884 and stayed there for several months (Humphrey 1887:88). See also Hezel 1979:140 for other sources on the incident.
ing elsewhere or whether he simply did not get all the details involved.

Figure 43. Woven Pandanus bag used for trading of arrowroot flour (from Krämer & Neve-ermann 1938:Plate 6).

**Likiep 1907.** A major technological innovation was introduced on Likiep in 1907: a hand-driven arrowroot grating machine, similar to a potato grating-machine. This alleviated the laborious task of grinding the tubers to mash.¹

**Arno 1950.** As a variation of the previously mentioned techniques, the grated tubers are placed "in a clean coarse cloth bag. Water is poured through, as the mixture is stirred [in the bag], thus washing out the starch and leaving the fibre in the bag. The starch is collected and dried, yielding a white high quality product that can be stored."²

**Likiep 1951.** The onset of other available material brought about other technological change. Feeney de-

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1 Wendler 1911.
2 Stone 1951:25.

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3 Feeney 1952:251.
After thorough stirring, the starch was allowed to settle and the salt water was decanted. This washing process removes the bitter taste and produces a relatively pure starch. The wet starch was placed in a cloth and hung from the ceiling to drip. When the starch had hardened, it was spread outside to dry in the sun until powdery. The mokmok was scraped from the cloth
and stored in a woven basket for use as needed.”

Lae 1970s. The arrowroot tubers are grated on handheld potato graters. The mash is placed in the arrowroot strainer (jirrok or wali̱lik makm̈ok) and buckets of ocean water are poured over it. As the starch is washed out, it is caught in a pit laid out with mats underneath the jirrok. The water gradually runs off or dissipates. After two or three washings a smooth white starch remains, which is formed into a round ball (jibwil) and left to dry until it is much like like flour in substance. The jirrok is describes as a four sided box with the sides made from sticks or wood. Ekkwal is woven in a criss-cross pattern along the bottom to provide strength for the layer of coconut cloth (inpel) which acts as the strainer, keeping out the larger pieces of arrowroot and letting starch and water through.

**TIME EXPENDITURE**

The process of arrowroot starch production as outlined above is time consuming. All time estimates are based on the volume of two 100lb. copra bags, which are estimated to hold about 125lb. of arrowroot tubers and which are said to produce between 25 and 30lb. of pure starch/flour. The excavation of the tubers to fill both bags is said to have taken about 2 days. Over half a day was spent with cleaning the tubers in the lagoon and rubbing and grating them into a mash. The first sifting usually occurred before the day was over, and the starch was allowed to settle over night. The second and third sifting of the starch took up one further day, after which the starch ball was suspended to dry. Over the next three days, on and off, the pre-dried starch ball would be broken up and sun-dried.

**EXTRACTION OF STARCH IN OTHER PARTS OF MICRONESIA**

There are several more detailed accounts on the extraction of starch in other part of greater Micronesia, such as from Chuuk, and Kiribati. Descriptions from the Philippines, Guam, Fiji, and Hawaii are also available.

The Chuukese process is basically the same as in the Marshalls, except that in the high islands of Chuuk (but not on the atolls) the tuber is skinned and then grated/rubbed. The Chuukese let the sifted starch settle for four to five hours before repeating the sifting for a second and third time. The first sifting occurs with sea water, while the second and third sifting occur with freshwater.

Yet another starch extraction technique is described for Tarawa, Kiribati, where the introduction of arrowroot was said to be recent and from the Marshalls. The technique is reported as follows: “[The tubers] are washed in salt water and the outer skin scraped off. The tubers are grated with a stick tightly bound with coconut rope [coir] and the grated pulp tied in a cloth and placed in a basin with sea water. The starch is forced out by pressing the cloth, and left to settle for three hours. Then the sea water is replaced and the starch settled again for

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2 Curtis 1986:68.

3 The time expenditure costs have been estimated based on interviews with numerous Marshallese who have at one point or another actively made arrowroot starch.


5 Safford 1905:380.

6 Safford 1905:380.

7 Handy 1940:299; Ihara 1971.

8 Paul 1965.
three hours. Finally fresh well water is used and once the starch has settled, it is spread out to dry in the sun.¹

**STORAGE OF ARROWROOT**

There are two options to store arrowroot for some time. One is to store it in processed form, the other is to store it unprocessed. In *unprocessed form*, arrowroot is stored in a cool, dark and dry place, such as pits along the beach, for up to six months, after which the tubers begin to sprout.²

Arrowroot tubers can also be ground to pulp and stored in underground, leaf-lined pits, where the pulp is left to ferment in the manner of breadfruit or *Pandanus*. This process was common in Fiji³ but apparently was never exercised in the Marshall Islands, although fermentation processes were well understood and breadfruit fermentation is even today still popular.⁴

A mat basket or mat bag (*bojo*)⁵ made from strips of Pandanus leaves was used to store the processed, *dried arrowroot flour* (figure 41).

**STARCH TRADE**

A finer woven Pandanus bag (figure 43) served as a trade package to trade arrowroot to Jaluit, the German trading port of the Marshall Islands.⁶ The Rongelapese used a coconut shell with the top taken off as a container for the starch and shipped it in this form.⁷

Figure 45. A coconut shell serving as a trade container for arrowroot starch from Rongelap. (After Krämer & Nevermann 1938:137).

It is unclear from the descriptions whether the trade to the southern atolls was created by European trading interests⁸ or whether traditionally a north-south trade in starch existed.⁹ Pollock¹⁰ mentions that production of arrowroot flour for trade traditionally occurred in January, in order to have a supply ready when the voyaging season of calm seas began in May (to September). The northern atolls were the major arrowroot exporters. According to her informants, arrowroot was traditionally traded for other food stuffs in the southern atolls. Woven Pandanus bags being used as receptacles and trade containers.

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¹ Tarawa (Kiribati) 1950s.: Catala 1957:109.
³ Safford 1905:380.
⁴ For *biwo* (fermented breadfruit) production and its importance see Erdland 1914; Krämer & Nevermann 1938; Spech 1949; Pollock 1970, Poyer 1990.
⁶ Hernshein 1886:306; Krämer & Nevermann 1938:108; 138; German trade name: “Takkamehl”.
⁷ Krämer & Nevermann 1938:131; 138 Figure 28.
⁸ To ship the starch to China where it could be sold at some profit.
⁹ There was no trade in arrowroot in the 1960s in Chuuk (Paul 1965).
Table 9: Documented late 19th and 20th century arrowroot flour production in the Marshall Islands by decade. Codes: ■ - documented; □ - uncertain.

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Table 10. Occurrence (Occ.) of food plants and their importance (Imp.) in the late 19th century diet on the atolls of the Marshall Islands. Atolls shown in italics were traditionally uninhabited.

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Measurement of importance: No symbol - unimportant, • - rarely utilised, ○ - utilised, ◯ - important, ○ - very important
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Measurement of importance: no symbol = unimportant, • = rarely utilised, ● = utilised, ○ = important, ○○ = very important
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The Pacific Islands starch trade developed at the end of last century and European traders added arrowroot starch to their list of sought after trade items. The starch trade for the European and Asian markets also brought about changes in the local production techniques: In the Philippines the rubbing of the arrowroot tuber occurred under water, thereby avoiding that the tuber turned brown, thus discouraging the starch. In Fiji traditionally a "grater of mushroom coral (Fungia) was used and the colour of the arrowroot was grey since the tubers were not properly washed." When the starch became an export commodity, the starch was prepared more carefully.

Provided it is kept dry and away from weevils, ants, cockroaches and the like, the starch will keep indefinitely.

REGIONAL DISTRIBUTION OF ARROWROOT PRODUCTION IN THE MARSHALL ISLANDS

The extraction of arrowroot starch was predominantly exercised in the northern atolls of the Marshall Islands. In the accessible literature arrowroot starch production in general, and the process in particular has been documented for the following atolls: Ailinglaplap,3 Ailuk,4 Arno,5 Aur,6 Bikini,7 Ebon,8 Enewetak,9 Jabat,10

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2 See also Kotzebue 1821: II26.
3 1879 (Finsch 1893); 1910s (Wendler 1911)
4 1951 (Murai et al. 1958:102).
5 1950 (Stone 1951:25).
6 1910s (Krämer & Nevermann 1938:137).
7 1912 (Merz to Imp.GermGov. see footnote 6 on page 47); late 1800s and early 1900s (Lamberson 1987); 1940s (Kiste 1968:37).
8 Warren 1866.
9 late 1800s and early 1900s (Lamberson 1987).
Traditional Utilisation of Arrowroot

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Measurement of importance: no symbol = unimportant; □ = rarely utilised; □ = utilised; □ = important; □ = very important.

Jaluit,1 Kili,2 Kwajalein,3 Lae,4 Likiep,5 Majuro,6 Maloelap,7 Mejit,8 Mile,9 Namu,10 Rongelap,11 Rongerik,12 Ujae,13 Ujelang,14 Uterik,15 and Wotje,16

European visitors report for the 1880s17 as well as for the 1910s that arrowroot flour is only produced on eight northern atolls and that Aur and Mejit are main producers and make it for trade.18 Thus, the heavy emphasis on arrowroot production and utilisation in the Marshall Islands is confined to the northern atolls, where other staple starches, especially taro are less common or thrive less well. If we go even further north, to Bikar, Bokak and Eneen-Kio, the area becomes too dry for arrowroot to exist.

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2 It appears that no (more) arrowroot grew on Kili in the 1940s, before the Bikinians were settled there (Kiste 1968:71-74); 1956 (MacKenzie 1956).
3 1879 (Finsch 1893); 1910s (Wendler 1911); 1912 (Merz to Imp.GermGov. see footnote 6 on page 47); 1912 (Merz to Imp.GermGov. see footnote 6 on page 47); 1970s (Curtis 1986).
4 1912 (Merz to Imp.GermGov. see footnote 6 on page 47); 1970s (Curtis 1986).
5 1879 (Finsch 1893); 1910 (Wendler); 1920s (deBrum photographs in Alele Museum, Neg. Nos. B-81; 89; 157; 228, 229; 281); 1930s pers. comm. Revd. Kanki Amlej; 1951 (Feeney 1952:201).
8 1879 (Finsch 1893); 1910s (Wendler 1911; Krämer & Nevermann 1938:137); 1930s pers. comm. Revd. Kanki Amlej.
11 1910 (Krämer & Nevermann 1938:137).
12 1940s (Taylor 1950:17); 1950s (Kiste 1968:51); 1931 (Murai et al. 1958:102).
13 1884 (Humphrey 1887:88).
14 1910 (Wendler 1911).
15 1879 (Finsch 1893); 1910 (Wendler 1991).
17 Hershein 1886.
18 Krämer & Nevermann 1938:137.

63
Traditional Marshallese Utilisation of Arrowroot

The occurrence of food plants and their importance in the diet on the atolls of the Marshall Islands at the beginning of the century and today is shown in tables 10 and 11. On the whole it is not easy to measure the importance of crop, as it depends on the observer’s point of view. A good example is the account of the German trader Hager, who does not refer to arrowroot at all in his treatment of local food plants and gardening. Goetz, one of the oldest treatises on human settlement patterns on coral atolls, mentions that arrowroot is only important in the Marshalls and the Caroline Islands.

In traditional Marshallese culture arrowroot was mainly utilised as a food item, although tubers and other parts of the plant also found a number of other uses. These will be discussed in this section.

Foods Prepared from Arrowroot

Traditionally, as well as today, flour (starch) is the most common form in which arrowroot is used as a food (solids). Only one source, post World War II, mentions that arrowroot tubers are “cooked like a potato and eaten at meals with other foods.” This may be a more recent development. It has been mentioned that if arrowroot is cooked for a long time, the acrid taste will disappear. Another modern development seems to be the method to “grate arrowroot and boil it in water into a spongy ball, which then is covered with freshly grated coconut meat.” Today, where prepared and present, arrowroot starch is used as a thickener in numerous dishes.

Foods Prepared from Flour

Traditionally, as well as today, there are a number of Marshallese dishes which have been prepared solely from or with the addition of arrowroot starch (flour). The addition of arrowroot starch gives many dishes a gelatinous, brain-like appearance; for this reason these dishes are called in Marshallese Kōmālīj. All dishes are solids, unlike the Tuamotus, where Tacca starch is also used to make (alcoholic?) beverages.

The boat-shaped leaves of the coconut palms served as receptacles and cooking vessels for arrow root and as a storage device for water. The canoe-shaped wooden food bowls (Jāpe)

5 MacKenzie 1961:60. This seems to be a modern version of Benben-in-moknok (see below).
6 Poyer 1990:64.
7 In Kiribati, Tacca is also eaten mixed with fresh toddy (jekaro) into a very thick pancake mix which can be fried. Butaro (Kiribati term) is made up of arrowroot flour, grated taro (Kiribati: babai) and coconut syrup (jekemai). Finally it is used to make fritters called te tonai (Kiribati term); here the flower is mixed with sugar and baking powder, or if the latter is unavailable, with fermented toddy (jekaro). Small amounts of the paste are deep fried in coconut oil or lard (Catala 1957:109). For other Kiribati dishes see footnotes to Marshallese dishes.

In Tahiti it was used to make poi (starch mixed with pulp of bananas, and other fruit), in Hawaii it was mixed with coconut milk, wrapped in ti leaves (Cordyline terminalis) and baked/steamed in the earth-oven (Soucie 1983:198).

In Guam Tacca flour was used for sweet meals called buñelos (Safford 1905:380).

9 Doty 1953:34.
10 Krämer & Nevermann (1938:1333; 138): wudak
were serving vessels and in their round form were used as eating dishes (figure 46). In addition, arrowroot was cooked in large coconuts with their tops taken off, similar in appearance to the coconut trade containers used for arrowroot starch (figure 45).

**Aujik**: Meal prepared from arrowroot flour boiled with (rolled in?) grated coconut.

**Benben in mokmok**: The most common way to use arrowroot flour was to boil it in water and to add coconut sap (*jekarō*) until it attained a thick jelly-like consistency. The matter would then be shaped into small balls or patties and rolled in grated coconut.

**Beru**: Soft pulp from the ends of boiled *Pandanus* keys (*mokwan*) combined with arrowroot flour, poured into a cone-shaped or triangular receptacle made of two fresh breadfruit leaves; cooked together as a dessert. Coconut cream (*el*) may be added for taste. According to Pollock **beru** is commonly cooked in the earth oven (*um*).

**Bobo**: Arrowroot flour mixed with coconut water and cooked in co-

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Figure 46. Wooden food preparation and serving vessels. 1—collected on Majuro; 2-4—collected on Lae (all after Krämer & Neumann 1938:112-113).

Often the arrowroot flour was mixed with water to a thin paste, *lagalba*, which was then used to be mixed with other dishes. These dishes are:

**Aiku**: A soup made from *iu* (spongy coconut) and arrowroot flour.

5 Krämer & Neermann (1938:139): aujik; Steinbach-Grösser quoted in Krämer 1905:144. See also the dish called wagagak.

6 Murai 1954:2; Murai et al. 1958:102. Also spelled as: *jabjen*; According to Hiyane (1967) this way of serving arrowroot is preferred in the northern Marshalls. See also Kotzebue (1821:II 26) who was the first European to describe this dish. See further MacKenzie (1960:60) for a modern version of the dish (see above).


conut shells. This food is mainly used for sick and old people (and infants?). 1 Pollock describes the dish with some sugar added. When jelled and cooled down, the jelly is cut into squares and rolled in grated coconut. 2

Buiabui 3: An emergency and starvation ("typhoon") food could be made by pounding the internal part of a driftwood tree 4 to pulp and then mixing it with arrowroot flour and water. A variation of this seems to be to pound the internal wood of an old coconut palm and mix it with water and with arrowroot flour. 5

Bwiro iiek: Preserved breadfruit (bwiro) mixed with arrowroot flour and coconut sap (jekaro), wrapped in breadfruit leaves and baked. 6

Iek: Bwiro mixed with arrowroot flour, kneaded and shaped into a ball. It is then sun dried and can be stored for a limited period of time. When it is to be eaten, the ball is immersed in water and allowed to soak for an hour. At

meal time the water is poured out and the ball is mashed with a Tridacna pounder. Grated coconut is added to the mixture when pounded. 7

Jabjen: Arrowroot starch boiled in water with coconut sap (jekaro) added. Allowed to cooled, formed into a ball and rolled in grated coconut . 8

Jamok(ok): Arrowroot flour with grated coconut meat from semi-ripe coconuts and baked. 9

Jinkap: Arrowroot flour mixed with coconut water and cooked in coconut shells. This food is solely used for women who gave birth. 10

Jokwob: Boiled arrowroot flour with fish added. A soup-like dish. 11

Jup in mokmok: Arrowroot flour, iu (coconut embryo), fish and coconut milk. 12

Karek: Preserved breadfruit (bwiro) mixed with arrowroot starch. 13

Kebjeltak: Arrowroot flour, crackers and jekaro. 14

Likobla: Arrowroot flour and jekaro or arrowroot and water mixed together at a ratio of three to one. The starch is

1 Krämer 1905:144; Krämer & Nevermann (1938:139): bobo. See also below for dish jinkap.
4 The buiabui tree, which looks similar to a coconut palm is said to be a driftwood tree (Krämer & Nevermann 1938:140); not as such mentioned in Wendler 1911). Humphrey (1887:87) describing his involuntary stay on Ujia mentions that another “principal article of food, called perue, was made from rotten wood. Where the wood was obstained we could not find out, but we saw large pieces in the houses light as cork. The wood was pounded up fine and mixed with brackish water in a trough and when mixed resembled thick mud, but was much more dirty looking, it being of black colour. It was then made into little rolls and rolled in grated coconut, wrapped in leaves, and baked on hot stones. This dish was hard to relish, but when hungry it tasted good and helped to fill up.”
5 Wendler (1911) mentions that in his time there were still some people who had eaten it and who described it as quite delicious.
6 Abo et al. 1976:297. Krämer & Nevermann (1938:139) describe the receipt as for managedjen with the addition of grated coconut. In their version the food is not baked.
7 Krämer 1905:144. The dish is called fish (iek). It is very similar to the dish Managedjen (see below). Krämer & Nevermann 1938:139 (see previous footnote).
10 Krämer 1905:144. Krämer quotes Steinbach-Grösser as a source. This dish sounds very similar to bobo. It is possible that it has the same receipe but a different name because the people fed with it belong to a different category.
12 Murai 1954:2; Murai et al. 1958:103; Erdland 1914:221.
13 Krämer 1905:144.
14 Murai 1954:2; Murai et al. 1958:103.
first mixed with water, sugared water or *jekaro* into a watery consistency. Then the mixture is slowly poured into a pot of boiling water and stirred until a soft, sticky substance is obtained.\(^1\)

**Managedjen:** Bwiro mixed with arrowroot flour, kneaded and shaped into a ball. It is then sun dried and can be stored for a limited period of time. When it is to be eaten, the ball is immersed in water and allowed to soak for an hour. At meal time the water is poured out and the ball is mashed with a *Tridacna* pounder.\(^2\)

**Pesut:** In cooked with water or coconut milk and arrowroot flour.\(^3\)

**Wagakgak:** Meal prepared from arrowroot flour boiled with grated coconut.\(^4\)

no name. An innovative dish, apparently introduced by the UNDP Integrated Atoll Project was reported for Taroa, Maloeap Atoll, where Papaya (*Carica papaya*) and arrowroot are mixed with water,\(^5\) apparently to make a *poi*-like dish.

In addition to the dishes, arrowroot flour was sometimes added to dried and preserved *mogan* during the production process, thus prolonging the preserve and adding further starch.\(^6\)

**Utilisation of the unprocessed tuber**

Stone, in his treatment of the agriculture of Arno Atoll\(^7\) mentions that “it is possible to eat them [arrowroot tubers] baked.” According to some sources\(^8\) the bitter taste attributed to arrowroot will disappear when cooked.\(^9\) Raw tubers, however, not only have a bitter taste, but are also credited with being mildly poisonous.\(^10\)

**Utilisation of other parts of the plant**

As far as can be made out, apart from the tubers no other parts of the plant were used for food.

**NON-FOOD USES OF ARROWROOT**

Apart from the pre-dominant use of the plant as a source of carbohydrates, the plant was also used for other purposes.

**Manufacture**

The up to 2m long green stalks supporting the flower and the seeds of the plants (*aetöktök*)\(^11\) serve the village kids as spear-like projectiles.\(^12\)

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A variation of this receipt, consisting of arrowroot, water and coconut syrup (Marshallese: *jekamai*) is the main dish of arrowroot in Belau (Kubary 1895:173).

In Kiribati, *Tacca* is eaten cooked as a porridge with coconut syrup (*jekamai*; Kiribati: *kamaimai*; Catala 1957:109).


\(^3\) Abo et al. 1976:297. According to Hiyane (1967) this way of serving arrowroot is preferred in the southern Marshalls, especially Mile and Namorik.


\(^5\) Poyer 1990:64.

\(^6\) Hiyane 1971b:14. *Mogan* is made from the pulp of cooked or raw pandanus keys. This pulp, which is sometimes prolonged with arrowroot flour and sugar, is then dried in the sun or over hot stones until a thick firm cake is obtained. The cake is then wrapped in pandanus leaves and secured with coconut coir for storage.

\(^7\) Stone 1951:24-25.

\(^8\) Merrill 1945:185.

\(^9\) In Hawaii fresh, non-dried *Tacca* was mixed with coconut milk, wrapped in *ti* leaves (*Cordyline terminalis*) and baked in the earth-oven (Hiroa 1957:11; Handy 1940:299; Ilhara 1971).

\(^10\) Murai et al. 1958:100.


\(^12\) According to Erdland (1906:127) playing spears were called *Kajeörlok*. 
Hats

When the stems, especially those of the flower stalks, are broken up they provide thin fibres, which can be woven into hats. Because of the great amount of labour involved in manufacturing these hats, their were property of only the chiefs.¹

In Kiribati arrowroot stems are also used to gain fibres for the manufacture of hats.² In Tahiti straw hats were made by splitting the flower stalks and the petioles into narrow strips, curing and drying them. The material was then woven into white and glossy hats of little weight.³

Cigarette holders

In the modern Marshall Islands Tacca stems are also used as cigarette holders mainly during those frequently recurrent times when there is little tobacco on the islands.⁴ A medium-sized Tacca stem is chosen, pulled out and cut to a length of about 15cm. A cut piece of a cigarette or a cigarette stub is inserted in the end and smoked. This holder allows to smoke the cigarette until virtually no tobacco is left. These arrowroot cigarette holders, when no longer useable, are carefully kept and dried. When the tobacco shortage has become so severe that there are no stubs left to smoke, the nicotin-drenched tips of the dried arrowroot cigarette holders are chopped up fine and smoked in fresh holders.⁵

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¹ Wendler 1911.
² Catala 1957:77; 109.
³ Safford 1905:380.
⁴ In times of abundance of cigarettes the cigarette stubs are not discarded but kept for times of cigarette/tobacco shortages.
⁵ See also Pollock 1970:250.

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Glue

In Samoa the freshly made arrowroot starch was used as glue in pasting together the thin layers of broken bark of the paper mulberry tree (Broussonetia papyfera) in making tapa (bark cloth).⁶

Medicine

Mason, in his study of the economic organisation of the Marshall Islands states that arrowroot flour is used as a medicine, but does not further specify its use.⁷

On Namoluk Atoll, the seeds (fruits) are collected and used in leis, while the leaves are considered to be essential in the treatment of persons thought to have been bitten by a sea ghost; the stem has other medicinal uses.⁸

In the Pacific the plant has a varied range of medicinal uses; in Hawaii it was used raw, grated, and mixed with water to treat diarrhoea and mixed with red-coloured high-iron content clay for dysentery.⁹
Table 12 Utilisation of parts of the arrowroot plant in Greater Micronesia.²

<table>
<thead>
<tr>
<th>Locality</th>
<th>Food</th>
<th>Starch for clothes</th>
<th>Hat Weaving</th>
<th>Medicine</th>
<th>Psych. Medicine</th>
<th>Leis</th>
<th>Barkcloth Glue</th>
<th>Cigarette holder</th>
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A common use for the starch developed with the Christianisation of the islands and the increased introduction of European clothing. These clothes, especially those white dresses worn for Sunday church services had to be well starched. *Tacca* starch was used in the Marshall Islands for that purpose.¹


Arrowroot in Marshallese Folk Tales

Arrowroot appears in a few Marshallese folk tales, but in all occasions arrowroot is only of minor importance. The general scarcity of such stories indicates the limited spiritual importance afforded to the plant.

One version of the Marshallese creation myth describes how two ancestral beings, Wullep and Limjjuanij were born out of a boil on the leg of Lowa, the first being on earth. Limjuaninij, later on had two children, Laniij and Lowej. In order to get into the sky, Wullep and (his two sons?) Lowej and Laniij, sat themselves on a flower stalk of an arrowroot plant, which then grew into the sky, lifting them up.\(^1\) This tale, which is reminiscent of Jacob's ladder, also occurs in Tongan mythology\(^2\) and elsewhere in Polynesia.

In another tale, also involving Letao, the trickster orders an earth-oven to be prepared, climbs in and asks to be covered with earth. When he reappears from the ocean shore, and the oven is uncovered, it contains a large amount of cooked bwiro, arrowroot starch, fishes and the like, feeding a large number of people.\(^3\)

The fact that arrowroot tubers are very bitter, and that the bitterness needs to be removed before the starch is palatable gave rise to stories explaining this bitterness.

One legend deals with the fact that unprocessed arrowroot tubers have a very bitter taste. According to this leg-

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\(^1\)Erdland 1914: 309.

\(^2\)Gifford 1929.

\(^3\)Neervenmann 1938:242.

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\(^4\)Wendler 1911; Erdland 1906.

\(^5\)Wendler 1911.
Modern utilisation of Arrowroot

ROLE OF ARROWROOT IN LATE 19TH AND EARLY 20TH CENTURY

The middle and end of the 19th century saw a dramatic influx of European traders into the Pacific. A number of trade routes were set up as various trade goods were developed. Although only a minor item on the overall shopping list, trade in arrowroot flour attained a high level in Eastern Polynesia. Arrowroot, because of its easy digestibility and perfect starch was sought after in China. It appears that arrowroot was not a major export item in the Marshall Islands, although Wendler mentions that arrowroot was prepared for sale in Jaluit, the trading centre and sole port of entry-exit for the German Protectorate over the Marshall Islands. A 20 pound sack of arrowroot flour could be obtained for four Imperial German Marks.

ROLE OF ARROWROOT DURING THE JAPANESE PERIOD (1914-1945)

It is known that the Japanese developed agricultural and horticultural production in the Mandated Territories and even set up an agricultural research station in Koror, with experimental gardens in Pohnpei, Jaluit and Wotje. It has been reported that the Japanese developed tapioca flour production.

ROLE OF ARROWROOT DURING THE POST-WORLD WAR II PERIOD (1945-1955)

At the end of World War II arrowroot starch still played a major role in the subsistence economy of the Marshallese, especially of the more northern atolls.

The diminished role arrowroot plays in modern Pacific nutrition is exemplified by...

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4 Wotje Atoll, for example has a track record of having a series of experimental gardens. The first such garden was set up by the Russian Exploring Expedition in 1817. Another garden was operated by the Japanese military garrison and third garden was established at Wotje School by the Civic Action Detachment team in 1972 (Porter 1972b:5-4). Yet another garden was established by a village co-operative in 1988 and is still producing vegetables for sale to Majuro Atoll. Wotje was one of the islands where substantial numbers of plants were introduced. The Russians planted a vegetable garden on Wotje Island and introduced the following plants to Wotje, several of which were obtained on other Pacific Islands: sweet potato (Ipomoea batatas), yams (Dioscorea alata), melons, watermelons, gourds, both for food and for water containers, sugar cane, grapevines, pineapple, the Hawaiian apple, the ti-root (Cordyline terminalis), the lanten tree (limetree), candle nut (Aleurites moluccana) and two species of trees whose bark is used for bark cloth manufacture. During the war, the Japanese maintained an extensive vegetable garden plot east of the northern turning circle of the NNSSE runway.

Soil was imported from high islands to Jaluit Atoll, mainly to run the experimental garden. Import was conducted by both by the Germans and the Japanese (Fosberg & Sachet 1962:1). Import to Jaluit is also reported by Stevenson (1914:150). German soil is also reported to have been imported to Japton Island, Enuwai Atoll (Lamberson 1987b:24). Imports of soil to the atolls of the Marshall Islands seems to have occurred mainly in the form of ship's ballast, brought by copra trading vessels returning largely empty from the volcanic high islands in the Carolines (such as Ponape) (cf. Fosberg 1961).

5 Tapioka = Manioc (Manihot esculenta), an American starch cultigen, which when introduced by Europeans, became rapidly established in the Pacific in the 19th century.

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1 Oliver 1975:105; 207.
2 Wendler 1911.

3 In 1912 four marks was equivalent to 44 pounds of copra at the then valid rate 0.20 marks per kilogramme (1 kg=2.2 English pounds). Source: German District Administrator Jaluit District Mr. Merz, 1912, Vergleichende Übersicht der steuerpflichtigen Bevölkerung zur Produktion und die Aufwendung für geplante und bisherige Steuer. Ms., contained in German Colonial Archives from Rabaul, New Britain, Papua New Guinea, Record Series G2, Record Group H34; Australian Archives, A.C.T. Records Depository, Canberra (Australia).
ed by the fact that its not included in a 1981 nutrition manual for Micronesia.¹

A nutrition survey trip undertaken during the early 1950s to the northern atolls of the Marshall Islands showed that "arrowroot flour was used extensively where imported goods were not available" and where the breadfruit season had not yet begun.²

Previous botanical and agriculturally oriented studies³ had shown that arrowroot does well under coconut, provided that competing vegetation is kept away. This finding, then, was applied in the recommendations of an agriculture survey of Kili Island and islands in Jaluit Atoll. In order to maximise production to feed the dislocated Bikini people it was proposed to clear all coconut scrubland on the islets with the exception of Jabwor, and to interplant Tacca as a starch supplier.⁴

The decline in arrowroot starch production can be directly related to the increasing imports of rice and flour to the outer islands.

ROLE OF ARROWROOT DURING THE TRUSTEESHIP PERIOD (MID-1950S TO 1970S)

In 1967 the subsistence patterns of some families on Laura, Majuro Atoll, were investigated.⁵ At the time, Laura (~700 persons) was by far not as urbanised as it is today (1988: 1575 persons).⁶ The assessment found that none of the nine households analysed utilised arrowroot starch. That may be a result of the particular time of the year when the study was conducted, but the omission of arrowroot in the introduction and discussion of food items indicates that it had lost its importance altogether.

This contrasts to some degree with the experience on the outer islands, where arrowroot production was still practised, although gradually declining.

In a 1968 assessment of the nutrition on Namu Atoll, Pollock states that in "November when arrowroot corms should have been ready to dig up, there were only barely enough to make starch for clothes, let alone for food."⁷ At the time, arrowroot cultivation—like taro cultivation—had almost died out since seed corms were no longer planted to ensure supply for the following year.⁸ The sequence in which the use of arrowroot starch is mentioned, first starch for clothes, then food, indicates that the starch has lost its role as a major food supplier.

ROLE OF ARROWROOT IN CONTEMPORARY MARSHALLESE SOCIETY (1980S AND 1990S)

The role of arrowroot starch in the modern Marshall Islands economy is hard to ascertain. While the starch is virtually impossible to obtain in the urban atolls Majuro and Kwajalein, it is also very rare in the outer islands.⁹ From what transpires from inter-

¹ Rody 1981.
² Murai et al. 1951:102.
³ Especially Hatheway 1953.
⁴ MacKenzie 1956:3; 4; 8; 20.
⁵ June-August 1967; Domnick & Seeleye 1967.
⁸ According to Namu informants it is easier to gather coconuts for copra to sell and to but rice, than to grow taro and arrowroot as staple foods. Also, pigs were seen as a major pest uprooting the plants.
⁹ Informants on Enajet, Mile Atoll, mentioned in June 1991 that Tacca starch is still being produced, though in very small quantities. The harvest time is in February.
views, arrowroot starch is still produced, though not in very large quantities, and when the starch is available it is almost inevitably quickly exhausted for daily consumption, rather than stored and used over a greater period of time. Quantitative data, however, cannot be provided.

A number of nutritional surveys have been conducted in the Marshall Islands, none of which assessed the importance of traditional food in the communities.¹

Table 13 Results of a questionnaire submitted to the mayors of Local Government Councils. Ranking of the importance attached to custom, traditional culture and items of traditional material culture (N=14).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Issue</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowing the old way to navigate</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>Knowing how to fish in the old way</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>Knowing the legends of the atoll</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Knowing how to weave an old mat</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>Building more tipnols</td>
<td>26</td>
</tr>
<tr>
<td>6</td>
<td>Knowing to build a traditional Marshallese house</td>
<td>23</td>
</tr>
<tr>
<td>7</td>
<td>Preserving archaeological sites</td>
<td>22</td>
</tr>
<tr>
<td>7</td>
<td>Knowing how to build a tipnol</td>
<td>22</td>
</tr>
<tr>
<td>9</td>
<td>Knowing how to use fishtraps</td>
<td>21</td>
</tr>
<tr>
<td>9</td>
<td>Knowing traditional ways to improve the land</td>
<td>21</td>
</tr>
<tr>
<td>11</td>
<td>Knowing the varieties of Pandanus</td>
<td>18</td>
</tr>
<tr>
<td>12</td>
<td>Knowing how to plant taro</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td><strong>Knowing how to make mokmok</strong></td>
<td><strong>11</strong></td>
</tr>
<tr>
<td>14</td>
<td>Growing less taro</td>
<td>-5</td>
</tr>
<tr>
<td>15</td>
<td>Knowing the different types of cars</td>
<td>-12</td>
</tr>
</tbody>
</table>

Today, in the 1990s, one can purchase corn starch, as well as potato starch in the retail stores of Majuro Atoll, although the trade volume is small. It is of interest to note that the modern starches are called mokmok, an incidence of the term surviving the item itself.

But what is the prevailing perception in the islands? A survey of the opinions of the mayors of the 24 certified Local Government Councils of the Republic of the Marshall Islands was conducted for purposes of Historic Preservation Planning. The participants were asked to rank the importance of several individual aspects of the traditional material culture and traditional food production. A couple of verification questions to catch serial checking of answer boxes were also included. The responses were then ranked.² Slightly more than half the respondents (57%) thought it to be very important for a young person to know these skills, and another 14.5% thought it important. On the other hand, almost 30% (29%) thought it to be

² Open criticism is not a trait in the Marshall Islands' society, especially not in front of real or perceived authorities. Thus there is little avenue to express disagreement or negative feelings, except by avoidance of the subject and topic. The underlying psychology of the common perception of custom in the Marshall Islands is that custom is necessary to be preserved. Even individuals disagreeing with this are caught up in it and find no avenue to express their disagreement. Thus, based on the concept of avoidance of an unpleasant issue, we have to group the lacking answer with the negative category. To express one's opinion by explaining one doesn't have one can - in the context of the Marshall Islands - also be seen as a trait of moderate criticism. Since the preservation issues discussed show different responses, it seemed advisable to grade them. Based on the above, the following grading system was employed: very important +2, important +1, don't know -1, unimportant/not answered -2. Based on this grading, then, the following ranking could be developed, where a total of 28 points (14 x +2) constituted the maximum.

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unimportant in one way or the other.

The importance of the knowledge how to prepare arrowroot ranked at the bottom of the list, only surpassed by the importance to grow less taro, and to know modern car makes, both catch questions. In view of the overall trend of the outer islands mayors to show that they are rooted in traditional culture, this low rating of the popularity of arrowroot is probably even an exaggeration of the real importance.

![Republic of the Marshall Islands Map](image)

Figure 48. Spatial distribution of the answers of those mayors of the Local Governments regarding the knowledge on the preparation of arrowroot starch (*mokmok*) to be very important.

**"Mokmok does not grow large anymore"**

In the Marshall Islands there is today a common notion that arrowroot does not grow very large any longer, "only this high" with informants pointing to the level of their knees. The other notion, either offered unprompted or as an answer if the writer claimed to have seen arrowroot standing 3 feet tall, is that there are no longer any large tubers on the plants.

The following statements are in the published record. In 1977, on the occasion of a sub-regional training course on atoll cultivation in Tarawa, Kiribati, the delegates from the Marshall Islands explained that arrowroot suffered from a "root dis-
ease”, which resulted in diseased tubers which were poisonous to pigs. The delegates explained

“that the people attribute the disease to radioactivity from the nuclear testings on Bikini and Enewetak during the 1950’s.”

In 1989, on Taroa Island, Maloelap Atoll, the following claim went on record:

“Taroa people consistently describe recent reduction in the amount of arrowroot growing on the island. The plants continue to grow, but the tubers are small or non-existent. Although statements about when the decrease in arrowroot viability occurred are imprecise, informants agreed that it occurred after World War II (that is, rather than being a result of wartime destruction of Taroa’s productivity). People agree that there is significantly less usable arrowroot on the island than there was some twenty years ago; most dated the change to the 1960s (this despite the very few people living on Taroa then). The common explanation for the change is atomic bomb tests in the northern Marshall Islands.”

Doubtlessly, today this notion, in one shading or the other, is believed throughout the Marshall Islands and is likely to pose major feeling of opposition to any attempt to re-introduce arrowroot as a staple crop.

During a 1991 survey of Mile Atoll, people accompanying part of the team, also mentioned and continuously maintained the common story that arrowroot no longer grows well and this despite being shown the contrary.

ENTYMOLOGY OF A MYTH

The “entymology” of this entire notion is very hard to trace. According to one informant the beginning of the story was related to the actual tests in Bikini and Enewetak and the subsequent assessment of vegetation, which showed that arrowroot had a substantially raised level of radioactivity in its tubers, taken up from the soil. According to the informant, the U.S. authorities declared arrowroot unsafe to eat for the northern atolls. This information, then, gradually filtered south and was generalised.

This notion seems to have become a well established popular belief which simply has to be true, even in view of evidence to the contrary. To check up on this issue, a repeated test was run when someone mentioned the popular story: Once an informant claimed that there was no longer any large arrowroot around, the informant was shown some large plants which had been previously observed by the author. The informant then commonly switched to the explanation that there were no large tubers on these plants. When the informants were shown large tubers collected previously, or when they were shown the then dug up tubers of the disputed plants, they were literally left speechless.

An informant on Nalu I., Mile Atoll, when challenged, finally mentioned a completely different story. He stated that although the tubers were as large as before, substantially less starch could be extracted from them than in previous decades.

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1 Soucie 1983:200.
2 Poyer 1990:60.
3 Pers. comm. Queenie Ria (Alele Museum) for Meji; Alik Alik (Public Defender) for Jaluit Atoll;
4 See below for economic calculations
5 Pers. comm. Liki Jacklick.
6 It was not possible to determine whether the (claimed) starch extraction technique used by the informant had changed over time. This change was dated to the mid- to late 1970s according to the informant.
On Mile Atoll a large variation in peoples attitudes towards arrowroot could be observed.\(^1\) In the more populous areas in the northwest and west of the atoll, namely Tokowa, Nalu and Mile I., where about 70% of the population lives, the people on the whole were not making arrowroot starch at all. Some informants mentioned that they had not made starch since 15 years of age. In these areas, there was also a concentration of notions that arrowroot does not grow large any longer, that the tubers are small and the like. On the other hand, in the somewhat less populous areas of the southern and southwestern part of the atoll there was a great interest in arrowroot production, and an absence of people's notions that the root does not grow large any longer.

The varied frequency of arrowroot starch production seems to be directly correlated with the fluctuating abundance of other foods, such as breadfruit and taro, or of imported foods. Where there was sufficient other food, imported or homegrown, arrowroot was not cultivated and utilised; where these food sources were scarcer, and where there was less money around to be spent on imported food, arrowroot attained a greater role.

Based on the Mile experience, then, it appears as if a rationalisation has set in to argue that arrowroot does not grow large any longer and therefore one does not have to go to the effort to dig it up and extract starch from it. This rationalisation, in turn, is likely to be based on a bad conscience, a fact which may be utilised in the future (see below).

Numerous informants mentioned that the main harvesting season for Mile was between January and February. Thus, inquiries during early June should in fact produce some stored starch. It was noted, however, that arrowroot starch was apparently used up as quickly as it became available. Rather than storing the extracted, dried starch, it was immediately put to use in various dishes aikuiu (arrowroot and iu) being the most popular.

The majority of the arrowroot tubers seen by the author had a skin of brownish to yellowish colour, with a white interior. On Mile only one island, Lukunor, located at the southwestern part of the atoll, is said to have another variety, which has reddish to purplish skin. This variety, according to an informant from there, is said to have been brought from Ponape, possibly during the Japanese Period.

According to an informant from Anewa I., Mile Atoll, arrowroot starch is regularly extracted today during the harvesting season in January of February. It is said to take two to three men two days to extract the starch from a copra bag full of arrowroot tubers, using a traditional pikor stone. A semi-coarse piece of cloth, such as a well washed bed sheet, is used as the filter. The amount to starch extracted is said to be “a bucket full.”

On the whole a large variation in plant growth was observed among arrowroot.

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\(^1\) It should be noted that the following is not based on a representative poll, but on the impressions gained by the author by talking to Mile people in different parts of the atoll during an archaeological reconnaissance survey carried out in June 1991.
"The Disappearing Arrowroot" — Myth and Reality

In the previous sections I have laid out all the available information on arrowroot, its biology, its occurrence in the Marshall Islands, and its traditional cultivation and use.

Modern oral traditions have it that arrowroot does not grow any longer because of radiation effects originated by the nuclear testing on the northern atolls.

From the above discussion, then, a number of points emerge, which need attention:

1) Along with other traditional food plants, such as taro, arrowroot is no longer a staple crop utilised by the Marshallese on a regular basis. It has been replaced by flour and rice, which are easier to acquire and to prepare. Arrowroot is occasionally still used, however, and the technology is still available.

2) Arrowroot was traditionally very common, planted and grown at a number of locations. It was traditionally cultivated on a low level, tended to keep weeds and other plants away.

3) Today arrowroot is still abundant on most atolls and can be found in many open semi-shaded areas.

4) Arrowroot if untended and not looked after, tends to come under pressure from competitor plants for space, nutrients and air. The main competitor plants are Wedelia biflora and Vigna marina.

Following from this, it appears that the decline of arrowroot in the Marshall Islands has little to do with the radiation effects, but is a result of the synchronistically occurring diminishment of the importance of traditional food items. With the lack of tending of the plants, arrowroot plants become crowded by competitor plants and eventually choked. The fact that the plants have to put all their energies into leaf growth, in order to keep up with the competition, rather than producing a seed stalk and then reproducing a large tuber, lead to the fact that the tubers recovered from modern arrowroot plants are only small. Where the competitive leaf growth does not occur, the arrowroot plants produced larger tubers.

Is there a future for arrowroot production?

One major issue remains to be discussed: Whether there is a future for arrowroot production in the Marshall Islands.

If we sum up the previous discussion then it has become apparent that arrowroot has lost its importance. In fact, throughout the Pacific Region the role of arrowroot in the local subsistence economy has seen a down turn. Colonial interference was limited during the first half of this century, and the limited amount of money circulating in the islands made subsistence agroforestry a necessity on the atolls. In the immediate post-World War II period a great amount of traditional subsistence systems still existed, although in a phase of transition. Arrowroot was still a staple crop, used on some atolls, although it had become a source to rely on in times of restricted food availability only. Over time, arrowroot starch was then made not for
eating purposes, but to use it for starch in cloth washing. Finally, with the advent of washing powder—as opposed to bar soap—and the general decline of the habit of wearing starched clothes brought about the decline of arrowroot starch altogether. This is true for the Tuamotus¹ as it is true for Palau² and for the Marshall Islands.

One of the major reasons was that the cash economy brought upon the islanders by the burgeoning Pacific trade and by the high prices which copra, the staple export crop for most atolls, could fetch, changed the produced food items for purchased ones. It became easier to produce copra and to purchase staple foods from the proceeds. This was even more compelling since the modern introduced foods could be cooked with less preparation time that the traditional foods.

This has pointedly been called the "copra-tin can economy" and has been observed on numerous atoll groups.³

While this made economic sense in the heyday's of copra production and the days of high copra prices of the 1970s and 1980s, this makes little economic sense in the days of low copra prices in the 1990s.

The modern economy of the Republic of the Marshall Islands is heavily supported by outside funding. The balance of payment figures available show a trend of increasing imports, while the exports remain stagnating or at best increase only negligibly. The balance of payments is highly negative, and exports need to be raised by 1500% to level out the balance of payments.⁴

Copra is for most outer islanders still the sole means of a cash income apart from handicraft production, but it has become a less and less lucrative commodity.

A Recourse to History

Let us go back into history for a moment and compare the proceeds of arrowroot flour in the 1910. A contemporary source states that a twenty pound bag of arrowroot flour could be obtained for four Imperial German Marks,⁵ or if we use the copra equivalent, at the cost of 44 pounds of copra.⁶ Today, 44 lbs of copra bring about $3.08, which allows a Marshallese on an outer island to purchase about 8.6 lbs of wheat flour or 2.6 lb of corn starch.

Towards Feasibility - The Parameters of Economic Reality

In order to assess the economic viability of a rekindled arrowroot production, we have to assess a number of parameters, namely:

- productivity and yield of arrowroot
- practicalities of growing arrowroot
- time expenditure required in growing and processing arrowroot
- losses on other productivity because of time expended on arrowroot production
- market and demand for flour and starch on the outer islands

Productivity and Yield of Arrowroot

Unfortunately no one has conducted any quantitative studies in the Mar-

export was $2,108,000, resulting in a trade deficit of $31,656,000.

5 Wendler 1911

6 At the rate of 0.20 Marks per kilogramme (22 pounds) pound of copra (German District Administrator Jaluit District Mr. Merz, 1912, Vergleichende Übersicht der steuerpflichtigen Bevölkerung zur Produktion und die Aufwendung für geplante und bisherige Steuer.

³ Cf. Doty (1954:13) for the Tuamotu;
⁴ OPS 1989a: 138. In the year 1988 the total amount of imports was $33,764,000, while the total amount of
shall Islands of well tended arrowroot plants to determine the yields. Comparative data are available from Kiribati (Catala 1957:109), where four plants produced in total 2, 2.6, 1.9, and 3.3 pounds of tubers each, equalling an average yield of 2.54 pounds. Assuming that a quarter of the tubers (by weight) is used as reseed stock, then 1.8 pounds (813g) of harvestable tubers remain. Using Wendler's ratio of 7:1, i.e. seven baskets of unprocessed tubers resulting in one basket of processed arrowroot starch/flour, the average starch yield per plant would somewhere near 0.25 pounds (113g).

In order to arrive at a even more conservative estimate, which can be used as the basis of calculation, we will employ Hiyane's figure of only 10% extractable starch content in any given tuber. Following from this, the approximately 800g of harvested tubers per plant yield some 80g of pure starch.

Using the planting grid shown to be effective in Chuuk with Tacca spaced at 2.5 feet (~0.75m), then one acre (0.405 ha) of coconut grove, with coconut palms spaced at 20 feet (6m) intervals, results in the potential seeding and stocking of 6860 arrowroot plants. Even assuming a 20% crop failure due to unknown causes, one weed-free acre could yield almost 5500 harvestable arrowroot plants, which represents the staggering amount of 439kg (965lb) of arrowroot starch. If we widen the grid spacing to three feet, and again assume a 20% crop failure, the acre would yield almost 3800 harvestable plants, or 303 kg (666lb) of arrowroot starch.

### Practicalities of growing arrowroot

As should have become self-evident during the previous discussion, arrowroot grows, in fact thrives well with very little human input, provided that the area around the plants is kept reasonable free of competitive weeds and scrubs. After an initial clearing, it is estimated that clearing the area once a month is sufficient. If this clearing is done on a regular basis, the clearing of an acre will not take more than half a day. This clearing can be undertaken on the fly during the collection of coconuts for copra making, whenever a competitor plant is considered to have become too big.

It has been suggested in the mid-1950s to systematically intercrop arrowroot and coconuts. The effects, apart from an increased arrowroot production are that the coconut groves can be easier managed and most nuts can be collected for copra before they sprout.

### Time costs for growing and processing arrowroot starch

Based on the previous descriptions of arrowroot tending, production and starch extraction, the following time calculation has been drawn up:

The time expenditure costs have been estimated based on interviews with numerous Marshallese who have at one point or another actively made arrowroot starch. The calculations are based on the requirements of a household comprising two able-bodied males (15-64 years of age), and two male minors. Female labour input, which would speed up the process, has not been taken into account as this is not traditional “custom”. All time estimates are based on the volume of two 100lb. copra bags, which are estimated to hold (only) 125lb. of arrowroot tubers and which are said to produce between 25 and 30lb. of flour.

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1 Hiyane 1967; Rather than Wendler's ratio, which is equivalent of 14.2% starch.
It is assumed that one acre is weeded monthly for a whole day on each occasion; hence with the low yield of 666lb/acre 125lb. of tubers are equivalent of about 2 days of weeding.

Table 13. Time expenditure in arrowroot production (for 25lb of pure starch)

<table>
<thead>
<tr>
<th>Task</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeding etc.</td>
<td>2 days</td>
</tr>
<tr>
<td>Excavation of roots</td>
<td>2 days</td>
</tr>
<tr>
<td>Cleaning grating and 1st sifting</td>
<td>1 day</td>
</tr>
<tr>
<td>2nd (and 3rd sifting)</td>
<td>1 day</td>
</tr>
<tr>
<td>Drying (spreading &amp; turning)</td>
<td>1 day</td>
</tr>
<tr>
<td>Total</td>
<td>7 days</td>
</tr>
</tbody>
</table>

This calculation is somewhat biased, as a) weeding is largely women’s and children’s work and would therefore not figure in adult male time expenditure figures, and b) the drying process, although taking a day or two in the sun, does not occupy the male members of the entire household for the day, and again is a task performed by subsadults. Thus the “real” time expenditure figure may be as low as 4 days. However, to be conservative, the seven-day figure shall be used.

Based on the above time calculation, the entire acre’s worth of arrowroot can, depending on the yield, be processed in three or four consecutive weeks, or, since arrowroot once harvested can be stored for up to six months, in three or four separate 1-week sessions.

Costs of the arrowroot flour

Today the sole means of cash income on most outer islands is copra, and this at a time when copra prices worldwide are running low, and the Marshall Islands coconut mill offers less and less per pound.

Based on the copra-income loss figures presented elsewhere\(^1\) the seven days of labour invested in the production of 25lb. arrowroot starch are equivalent of $21.00. Therefore, one pound of arrowroot starch costs the producer and self-consumer $0.84. In view of the fact that both the copra income loss figures, as well as the labour investment figures have been rather conservatively calculated, the actual cost of one pound of arrowroot starch is very likely substantially less than the calculated $0.84.\(^2\)

This cost of $0.84 per pound needs to be compared with the costs of flour and starch purchased in outer island retail stores. Given the remote location of the Republic of the Marshall Islands all imported foods are expensive due to transportation costs and mark-ups along the way.

At the time of writing (December 1991) the outer island cost for a pound of starch is $1.50-1.70, that is ~180-200% the cost of arrowroot starch. Ex-Majuro costs are between $1.15 and $1.60 for one pound of starch (corn and potato).

Dimensions of trade: flour imports to the outer islands

There are few reliable figures on starch and flour imports to the outer islands.

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1 Income loss of $3.00 per day and household: Spennemann 1991.

2 For example, assuming that the weeding of the acre, as well as the drying of the extracted starch are done by children not involved in copra making, the labour investment is reduced to four days, resulting in a cost of only $0.48 per pound of arrowroot starch. Alternatively, by exchanging the figure for the maximum recorded daily copra income (as recommended to be used by Spennemann [1991a]), with the average daily income loss in copra making ($1.34), the cost per pound of arrowroot starch is reduced to $0.37 using a 7-day labour figure, and to only $0.21 when using the 4-day labour investment figure.
As calculated above, one acre could produce between 300 and 440kg (660-960lb.) of pure arrowroot starch. Based on the above cost figures for starch imported from Majuro the total starch production of an acre would thus be equivalent of $990-1600.

**BENEFITS OF ARROWROOT PRODUCTION - MEASURABLE AND UNMEASURABLE**

The measurable benefits of renewed arrowroot starch production is that additional food sources become available to a household at comparatively little expense in terms of time or capital outlay. There are also unmeasurable benefits to be taken into account. Self-sufficiency raises the spiritual well-being of an individual, as well as the well-being of an entire outer islands community.
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82
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Appendices
Appendix A:
Glossary of Marshallese terms connected with Arrowroot Production and Consumption

**aetôktôk** Male arrowroot, no food value.

**aetôktôk** Stalk of arrowroot plant.

**aiiku** A soup made from *iu* (spongy coconut) and arrowroot flour.

**anônean** Harvest time for arrowroot.

**aujik** Meal prepared from arrowroot flour boiled with (rolled in?) grated coconut.

**benben in makmôk** Arrowroot flour boiled in water with *jekaro* added until it attained a thick jelly-like consistency. The matter would then be shaped into small balls or patties and rolled in grated coconut.

**Beru** *Mokwan* combined with arrowroot flour, poured into a cone-shaped or triangular receptacle made of two fresh breadfruit leaves; cooked together as a dessert. Coconut cream (*el*) may be added for taste. *Beru* is commonly cooked in the earth oven (*um*).

**bobo** Arrowroot flour mixed with coconut water and cooked in coconut shells. This food is mainly used for sick and old people (and infants?). Pollock describes the dish with some sugar added. When jelled and cooled down, the jelly is cut into squares and rolled in grated coconut.

**bôjo** *Pandanus* mat bag in which the dry, snow-white arrowroot flour is stored.

**bôjo en Ujla** A way of getting the starch to dry. The fresh arrowroot flour is scraped together and hung up in the wrapping of a young coconut leaf, thus allowing the water to run off and drip out of the starch.

**buiabui** An emergency and starvation ("typhoon") food made by pounding the internal part of a driftwood tree to pulp and mixing it with arrowroot flour and water. A variation of this seems to be to pound the internal wood of an old coconut palm and mix it water and with arrowroot flour.

**bwe** The material left over from the kneading leached out of its starch content.

**bwiro** Preserved fermented breadfruit paste.

**bwiro iiôk** *Bwiro* mixed with arrowroot flour and coconut sap (*jekaro*), wrapped in breadfruit leaves and baked.

**do** Large-meshed, bag-shaped net used for washing arrowroot and soaking breadfruit.

**ekkwal** Coconut coir.

**el** Coconut cream

**epta** To sieve arrowroot.
| iek | *Bwiro* mixed with arrowroot flour, kneaded and shaped into a ball. It is then sun dried and can be stored for a limited period of time. When it is to be eaten, the ball is immersed in water and allowed to soak for an hour. At meal time the water is poured out and the ball is mashed with a *Tridacna* pounder. Grated coconut is added to the mixture when pounded. |
| jelkut | Arrowroot flour, crackers and *jekaro*. |
| ko ed in liklik | Old mat placed underneath the *waliklik* during the sifting process. Cathces the arrowroot starch. |
| jinapen | See *benben in mokmok*. |
| jepettap | Wooden bowl, canoe-shaped, used to prepare as ands to serve them. |
| jibwil | Coconut sap. |
| jëmak | Molded lump of arrowroot starch. |
| jëmak(ek) | Arrowroot flour with grated coconut meat from semi-ripe coconuts and baked. |
| jëmakap | Arrowroot flour mixed with coconut water and cooked in coconut shells. This food is solely used for women who gave birth. |
| jëroko | Strainer for arrowroot starch extraction made from a wooden box with a meshed bottom of coconut sennit. |
| jëkob | Boiled arrowroot flour with fish added. A soup-like dish. |
| jëp in | Arrowroot flour, *iu*, fish and coconut milk. |
| jëp in | Preserved breadfruit (*bwiro*) mixed with arrowroot starch. |
| jëp in | Literally “eggs of arrowroot”; term for those small tubers left behind after harvesting as seedlings for next year’s crop. |
likötöt

A way of getting the starch lump to dry. A small hole is excavated, lined with leaves and the starch lump wrapped in young coconut leaves is placed into the hole in which the excess water will run off.

liköbla

Arrowroot flour and jekaro or arrowroot and water mixed together at a ratio of three to one. The starch is first mixed with water, sugared water or jekaro unto a watery consistency. Then the mixture is slowly poured into a pot of boiling water and stirred until a soft, sticky substance is obtained.

managedjen

Bwiro mixed with arrowroot flour, kneaded and shaped into a ball. It is then sun dried and can be stored for a limited period of time. When it is to be eaten, the ball is immersed in water and allowed to soak for an hour. At meal time the water is poured out and the ball is mashed with a Tridacna pounder.

mádo

Large-meshed, bag-shaped net used for washing arrowroot and soaking breadfruit.

mokwan

Soft pulp from the ends of boiled Pandanus keys.

makmök

Plant, arrowroot (Tacca leontopetaloides).

nuknuk in ni

Other term for inpel, the cloth-like spathe that grows around the base of coconut fronds, used as a filtercloth for the waliklik.

peaut

Iu cooked with water and arrowroot flour.

peru

Pandanus and arrowroot flour cooked together as a dessert.

pukor

Stone (coral) used for grinding arrowroot.

pål

Arrowroot dying back.

pål

Arrowroot season.

um

Earth oven.

üne rup

Reddish mass of rubbed arrowroot tubers, not unsimilar in consistency and appearance to grated potatoes.

wagakgak

Meal prepared from arrowroot flour boiled with grated coconut.

waliklik

Net made from sennit used for sifting arrowroot starch.

waliklik makmök

Strainer for arrowroot starch extraction made from a wooden box with a meshed bottom of coconut sennit.
# Appendix B: Regional terminology for Arrowroot

Arrowroot is distributed throughout the Oceanic region, being present on most island groups. Thus a vast variety of names could be expected. Interestingly enough, however, the names for arrowroot are very restricted, mainly variations of a common root word. This indicates that the plant was introduced by the original settlers and then propagated. In the Pacific Region, which is commonly split into Micronesia, Polynesia and Melanesia, the following names have been used.

**Micronesia**

<table>
<thead>
<tr>
<th>Location</th>
<th>Term</th>
<th>Applies to</th>
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<tbody>
<tr>
<td>Belau</td>
<td>seboseb</td>
<td>plant</td>
<td>McManus &amp; Josephs 1977</td>
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<tr>
<td></td>
<td>sebosob</td>
<td>plant</td>
<td>Müller 1917</td>
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<td></td>
<td>sobosob</td>
<td>plant</td>
<td>Kubary 1895</td>
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<tr>
<td>Bur/Bunaj</td>
<td>nogonok</td>
<td>plant</td>
<td>Kubary 1895</td>
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<td>Chamorro/Marianas</td>
<td>aruru</td>
<td>plant</td>
<td>Topping et al. 1975</td>
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<td></td>
<td>arrowroo</td>
<td>plant</td>
<td>Villagomez 1965</td>
</tr>
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<td></td>
<td>gapgap</td>
<td>plant</td>
<td>Topping et al. 1975</td>
</tr>
<tr>
<td>Chuuk (Udot)</td>
<td>mokmok</td>
<td>plant</td>
<td>Murai 1954</td>
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<tr>
<td>Chuuk</td>
<td>ngunu</td>
<td>dried starch</td>
<td>Paul 1965</td>
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<tr>
<td></td>
<td>mokmok</td>
<td>plant</td>
<td>Paul 1965</td>
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<td></td>
<td>mokemok</td>
<td>plant</td>
<td>Krämer 1932</td>
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<td>Ifaluk</td>
<td>mogumog</td>
<td>plant</td>
<td>Damm 1938</td>
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<tr>
<td>Kiribati (Tarawa)</td>
<td>te makamaka</td>
<td>plant</td>
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<td></td>
<td>te makenmake</td>
<td>plant</td>
<td>Thaman 1987</td>
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<td>Kosrae</td>
<td>mokmok</td>
<td>plant</td>
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<tr>
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<td>makmōk</td>
<td>plant</td>
<td>Abo et al. 1976</td>
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<tr>
<td></td>
<td>aetōktōk</td>
<td>Male plant, no food value</td>
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<td>mwoakmwoak</td>
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<td>mōkumōk</td>
<td>plant</td>
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<tr>
<td>Satawal</td>
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**Dirk H.R. Spennemann**, Notes on Polynesian Arrowroot in the Marshall Islands

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<td>mwegiumweg</td>
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<td>Yap</td>
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### POLYNESIA

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<td>Futuna</td>
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<tr>
<td>Hawaii</td>
<td>pia</td>
<td>plant</td>
<td>Handy 1940</td>
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<td>Kapingamarangi</td>
<td>mee-ladilegu</td>
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<td>Niue</td>
<td>pia</td>
<td>plant</td>
<td>Smith 1983</td>
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<td>teve</td>
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<td>Smith 1983</td>
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<td>bie</td>
<td>plant</td>
<td>Carroll &amp; Soulik 1973</td>
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<td></td>
<td>pie</td>
<td>plant</td>
<td>Stone 1966</td>
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<td>Proto-Polynesian</td>
<td>*pia (?)</td>
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<td>Tonga</td>
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### MELANESIA

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<td>haclan (?)</td>
<td>plant</td>
<td>Soucie 1981</td>
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In the Philippines the terms are kanubong (Bisaya), panarren (Iloko), tambobomn (Sambali), tayobong (Bisaya), yabyaban (Tagalog) (Brown 1954:383).

If we look at the formation of the names for arrowroot, four major groupings can be distinguished: the mokmok group of Central and Eastern Micronesia and Kiribati, the chabchab/yabyaban group of Western Micronesia and the Philippines, the pia group of western and eastern Polynesia with the exception of Samoa, and the masua group of north-western Polynesia, comprising Samoa, Tokelau and part of Tuvalu. The Melanesian area is characterised a plethora of different names, indicating that no common ancestor for the plant dispersal can be found.

Figure 49. Distribution local names for Tacca leontopetaloides in Micronesia and the Western Pacific. 1 - Phillipine languages; 2 - mokmok Group; 3 - tia/pia Group; 4 - masua Group.