

## Two Species of Mangrove Trees Previously Unrecorded in the Marshall Islands Found in Jaluit Atoll

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**Abstract**—Jaluit Atoll, in the Republic of the Marshall Islands, has long been noted for its extensive mangrove wetlands. It has generally been held that the tree species to be found in these wetlands were predominately *Bruguiera gymnorrhiza* and *Pemphis acidula*, with a lesser amount of *Sonneratia alba* and *Lumnitzera littorea*, and a limited number of *Rhizophora mucronata*. However, recently two additional mangrove tree species were found, *Xylocarpus* cf. *rumphii* and *Rhizophora apiculata*, well established in the wetlands of Jaluit Atoll. The aboriginal inhabitants of the Marshall Islands were skilled sailors who traveled throughout Micronesia. Many plant species were introduced prehistorically from other areas and these had an impact on the terrestrial flora. Linguistic similarities with other regions, and related anthropological evidence may give evidence as to whether these recently documented mangrove species were introduced through human activity.

### Introduction

The Republic of the Marshall Islands is the eastern most of the Micronesian islands. The Marshall Islands are all atolls, with the exception of five flat isolated coral islands. They are spread out in approximately two archipelagos—the Eastern Branch or “Ratak”, and the Western Branch or “Rālik”, lying approximately between 160° and 173° longitude east and 4° and 14° latitude north (NBTRMI 2000).

Jaluit Atoll, one of the southern Rālik atolls, lying at about 6° north and 160° 35' east, has long played a significant part in the cultural and political history of the Marshall Islands. Many of the tribal chiefs and lords hail from Jaluit Atoll and there are many legends recounting their activities (Deunert et al. 1999, Tobin 2002). In the late nineteenth century, Germany made claim to the Marshall Islands and established their trading center, and then later their capital, on Jabwor Island, Jaluit Atoll. When World War I began, Germany sold its rights in Micronesia to Japan, which maintained Jabwor as their capital and trading center (Hezel 1983). New species of plants were introduced during the administration of these two foreign powers with the intent of making the area agriculturally self-sufficient

(Okabe 1952a, b). To help increase the chances of survival of the introduced plants, soil was brought in from Pohnpei by both the Germans and Japanese (Fosberg 1961a). Nevertheless, most foreign plants did not survive (Fosberg & Sachet 1962, Vander Velde & Vander Velde, in prep).

When the Americans took over the administration of the Marshall Islands after World War II, they established their center on Majuro Atoll, which eventually became of the capital atoll when the newly formed nation began in 1972 (Hezel 1995). During the days of the Trust Territory of the Pacific, an experimental agricultural station was still maintained on Jabwor, Jaluit (Fosberg & Sachet 1962).

Several typhoons have ravaged Jaluit Atoll within recorded history. In 1905, a devastating typhoon passed close to Jaluit and did extensive damage to the atoll. In late 1957, Typhoon Lola, then Mamie, swept through the vicinity of Jaluit Atoll. Typhoon Ophelia (which would have more than likely been classified as a supertyphoon according to more recent figuring) passed directly over Jaluit Atoll in January 1958, killing at least 14 people, destroying villages and devastating the plants. A botanical survey was conducted soon thereafter to determine the after-effects on all plant species known at that time (Fosberg 1961b).

So, although the flora of Jaluit Atoll has been recorded since the late 1800s and is considered to be the most extensively botanized of all the Marshall Islands, almost all of those records are obsolete and very little has been done after the post-typhoon work of Fosberg.

In 1999, the Jaluit Atoll Conservation Area was established through sponsorship of the South Pacific Regional Environmental Programme. Attention has been given to a relatively large mangrove pond of Jaluit Island, Jaluit Atoll. Nature trails have been built and very small numbers of tourists visit (Aiello 2001).

### Previous Mangrove Records

When Fosberg (1961b) conducted his post typhoon survey, he noted four ecologically distinct mangrove tree species: *Bruguiera gymnorrhiza* ("Dominant tree in most mangrove depressions"), *Sonneratia alba*, *Lumnitzera litorea* and *Pemphis acidula*. However, Fosberg did not seem to have personally surveyed the mangrove pond of Jaluit Island at that time.

A subsequent review of the vascular plants of the atoll by Fosberg & Sachet (1962) made mention of *Rhizophora mucronata*, citing an old Japanese work, but indicating that it was no longer present on Jaluit Atoll. However in his later work on Micronesian mangroves, Fosberg (1975), regarding *R. mucronata*, says that: "In the Marshalls it occurs on Jaluit and Ailinglapi Atolls."

*Rhizophora mucronata* is listed for Jaluit in the exhaustive dicot listing of Fosberg et al. (1979). However, neither *R. apiculata* nor *Xylocarpus* of any species is listed for any of the Marshall Islands.

### Recent Finds—*Xylocarpus*

In connection with the Jaluit Atoll Conservation Area and the RMI Environmental Program, the authors visited the inland mangrove pond of Ae Island, Jaluit Atoll in April 2003. A legend told of a mangrove-associated tree that was found nowhere else in the Marshall Islands.

The legend tells of “*Lokobar*” who was a very handsome, popular—and vain—man who lived on Ae Island. While he was able to have his way with all the women, there was one—*Linintok*—who totally ignored him. To try to win her over, *Lokobar* would show off whenever she was around, but to no avail. Eventually, *Linintok* became a rock near Mājrwirōk, the island next to Ae, across the channel. *Lokobar* became a tree bearing his name. Every July, supposedly still in an attempt to show off to *Linintok*, *Lokobar* puts on a showy display, with all his leaves turning bright red, then they fall off. The *lokobar* tree is reportedly found only on Ae Island, if seedlings are transplanted, these do not survive (pers. comm. A. Jamodre, Deunert et al. 1999).

While the legend tells of only one tree, a well-established stand of a *Xylocarpus* was found at the site. One tree is clearly much older than the rest and is said to be the original *lokobar* tree (Figure 1). Other, younger trees, were found in the pond, evidently offspring of the original (Figure 2).

Specimens of leaves and seeds (Figures 3 and 4) were photographed and collected for identification. Unfortunately, *Xylocarpus* is evidently one of the more difficult of mangrove genera to specify, and names have been greatly confused in much literature (pers. comm. D. Mabberley, P. Tomlinson). There are currently three recognized species—*X. granatum*, *X. moluccensis* (=mekongensis) and *X. rumphii* (Kitamura et al. 1988, Mabberley et al. 1995,) “*Lokobar*” is almost certainly not *X. granatum* as many of the characteristic features of that species, such as the buttressing roots and large fruit, are clearly lacking. The most likely candidate seems to be *X. rumphii*, but it may also be *X. moluccensis*. *Xylocarpus moluccensis* is the much better known of the two species, and often any non-*granatum* *Xylocarpus* just assumed to be this species, sometimes causing a misidentification of *X. rumphii* (Jayatissa et al. 2002).

### Recent Finds—*Rhizophora*

For a number of years, the authors have made visits to Jaluit Atoll, each time visiting the extensive mangrove ponds of Jaluit Island. During almost every visit, they have been to the small stand of *Rhizophora* near the east-end of the mangroves. Based on earlier reports by Fosberg and others, the logical conclusion was that these trees were *R. mucronata*. However, after collecting specimens of leaves and hypocotyls, and examining the prop roots (Figures 5, 6) indications were that the species of Jaluit was not *R. mucronata* after all (pers. comm. N. Duke). This was finally confirmed in July 2003, when specimens of the flowers and buds were collected. The characteristics of the flowers and their arrangement “in pairs on a



Figure 1. Original “lokobar” tree of Ae Island, Jaluit Atoll



Figure 2. Younger “lokobar” trees from Ae Island (photo: RMIEPA)



Figure 3. *Xylocarpus* leaves and flowers (photo: RMIEPA)

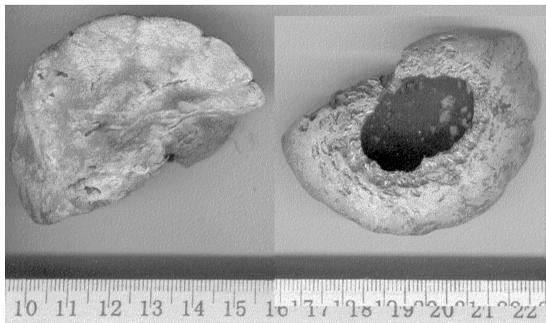


Figure 4. *Xylocarpus* seeds from Ae Island

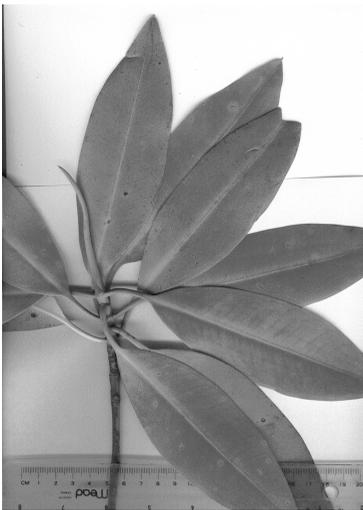


Figure 5. Jaluit *Rhizophora* leaves



Figure 6. hypocotyl



Figure 7. *Rhizophora* flowers from Jaluit.



Figure 8. *Xylocarpus* drift seed from Majuro, infested with shipworms.

stubby axis" (Tomlinson 1999) made it clear that species must be *R. apiculata* (Figure 7).

### Possible Mode of Introduction—*Xylocarpus*

It seems that the "lokobar" *Xylocarpus* from Ae Island, Jaluit Atoll is a well-established species. It is closely associated with a legendary man and has a local name that does not appear to have a readily apparent meaning in Marshallese. It seems to be just one of the serendipitous flukes of botanical research that caused it to be unrecorded for over a century of extensive scientific investigation.

Since the introduction evidently took place in prehistoric times, it is not really possible to know how the initial introduction of the parent tree took place. *Xylocarpus* seeds float extremely well, having a thick corky testa or seed coat (A. C. Smith 1985, Tomlinson 1999). Jeremy Smith (1999) commented that there is "local seed dispersal... this apparently does not extend to long distances, and seeds from remote places with mature *Xylocarpus* trees are invariable dead."

One reason that "long range drifting of live seeds apparently does not occur" (Gunn & Dennis 1999) is probably the fact that *Xylocarpus* seeds are highly susceptible to attack by crabs and insects. Allen, Krause & Hauff (2003) found during their recent research of *Xylocarpus granatum* on Kosrae, the Federated States of Micronesia, that: "Virtually 100% of the seeds had some evidence of crab (91.0%) and/or insect (66.7%) damage after 34 days".

An unusual amount of long-distance drift material washed ashore on Majuro Atoll in late 2001, early 2002, evidently associated with cyclonic activity to the west of the Marshall Islands. Collections were made from dozens of sites, both from ocean and lagoon beaches, some sites being collected repeatedly over the weeks. *Xylocarpus* seeds or seed fragments were the most commonly encountered drift seed or drift fruit collected. On one stretch of ocean beach of less than a kilometer in length, 25 *Xylocarpus* seeds or seed fragments were found. Altogether, 130 were collected from all sites (Vander Velde & Vander Velde, in prep). None was viable. A few were only slightly damaged, but others were just remnants. Many were infested with mangrove shipworm shells (pers. comm. R. Kawagia) (Figure 8). A few that were whole and appeared not to be penetrated, were fermenting internally. Even when badly damaged, those found on the beaches of Majuro Atoll were often crawling with hermit crabs feeding on any remnant of the endosperm that was left.

There are no reported *X. rumphii* or *X. moluccensis* in the nearby islands of Kosrae, Pohnpei or Chuuk, nor in Kiribati (Fosberg et al. 1979). The nearest known stands of *X. moluccensis* are on Guam, Palau, Samoa and Fiji; and for *X. rumphii*, Tonga and the Philippines (Mabberley et al. 1995, Stemmermann 1981). And while confusion in identification between species is possible, it would seem unlikely that a viable seed of either of these species would have survived the arduous journey of thousands of kilometers across the open ocean, then be cast ashore,

washing over the rubble ridge of the beach and then into an inland pond of a little islet of the Marshall Islands.

The ancient inhabitants of the Pacific were extremely capable sailors. According to Carter (1963): "It was the Pacific people who earliest developed the most advanced watercraft." The Marshallese evidently transported mangroves (Hatheway 1953). Fosberg (1953) said "that the mangroves, at least *Bruguiera*, found in landlocked pools and muddy depressions have been deliberately introduced and planted by the Marshallese."

The names in Marshallese and Kosraean for the mangrove *Sonneratia alba* strongly suggest an ancient introduction. The name is "bulabol" in Marshallese, "fulohfohl" or "folofol" in Kosraean, the same name if allowance is made for phonemic shift (Marshallese does not have an "f" sound, but when such a sound is encountered, it is included in either "b" or "p") (Abo et al. 1985, Falanruw et al. 1990, Lee 1976). In neither of these languages does the name for *Sonneratia alba* have any root that the authors have been able to detect. The name may, however, have a root from the areas of Chuuk, "pwulopwul" in Pulawat, "pwunapwun" from the Lagoon, apparently meaning "popping" or "crackling," the name for *Xylocarpus granatum* (Davis 1999, Goodenough & Sugita 1990). However, the name seems to shift in the middle of the lagoon to apply to *Sonneratia alba* (pers. comm. with several Chuukese people).

No nearby vernacular name for any *Xylocarpus* species, though, seems even close to that of the Marshallese "lokobar." However, the Palauan name is "meduulokebóng" (Falanruw et al. 1990, Josephs 1990). When spoken, the latter part of this name sounds remarkably similar to "lokobar" (pers. comm., H. Francisco). Some Marshallese plant names are simply the shortened form of names derived from other languages, such as "meria" for the English "plumeria" and "limpok" often used as a shortened form of "kõtōmānlimpok" for bouganvillea, from the Pohnpeian "kataman limpoak", meaning "reminder of love." (Abo et al. 1985, Rehg & Sohl 1983, Thaman & Vander Velde 2004)

Assuming that an aboriginal introduction from Palau occurred (which would seem much more probable than a natural introduction), "meduulokebóng" well could have been shortened to "lokobar."

*Xylocarpus* wood from all species is attractively colored, with red highlights, being hard but quite workable (Mabberley et al. 1995). Wood from the "lokobar" grove of Ae Island is often harvested and carved to make the forms for weaving hats and other useful tools. Those who have used it say it is superior to the exceptionally hard wood from *Pemphis acidula* as it is less likely to crack. The usefulness of the wood could have been one reason for an aboriginal introduction. In other areas of the Pacific, *Xylocarpus* is also used for glue and medicine (per. comm. S. Lanwi; Raulerson & Rinehart 1991, Whistler 1992), and while these were not mentioned by the people of Jaluit, these still may have been reasons for an introduction.

### **Possible Mode of Introduction—*Rhizophora***

The presence of *R. apiculata* also raises some questions as to how it would have been introduced, but these seem less formidable. *Rhizophora* seeds are capable of drifting for significant distances in the ocean and sprouting in areas distant to their point of origin. Hypocotyls from the Atlantic species *R. mangle* have been known to travel from Florida to Bermuda, where they were able to take root and grow (Gunn & Dennis 1999, Perry & Dennis 2003). During great influxes of drift material into Majuro in 2001/2002, and 2003/2004, the authors found only a few *Rhizophora* hypocotyls washed ashore. Four that came with the latter drift were transferred to a nursery setting and did sprout. But even though such a hypocotyl may be viable when it drifts in, it is highly unlikely that any would have survived on the beaches they were found, and getting from a beach into an inland pond would still entail human intervention.

There is the possibility, of course, that there was of simply misidentification of the species decades ago, and what was reported to be *R. mucronata* on Jaluit Atoll was in fact *R. apiculata*. The authors have yet to find *R. mucronata* on Jaluit Atoll.

The size of the current stand of *Rhizophora* trees of Jaluit Atoll would suggest that they probably grew after Typhoon Ophelia (pers. comm., N. Duke). So again, it could have been there all along but due to damage and debris, was simply missed in the post-typhoon survey.

Fosberg & Sachet (1962) and Fosberg et al. (1979) considered *R. mucronata* to be indigenous on Jaluit Atoll. The brief notation of only the collector and year by Fosberg & Sachet (1962) and nothing further, gives no insight as to whether the Germans or Japanese might have actually introduced this species. The Marshallese name for *Rhizophora* spp. is “eoeak.” It is quite different from most other Micronesian names for this species, but similar to the Pohnpeian “aak” for *R. apiculata* (Falanruw et al. 1990, Stemmermann 1981). Some Marshallese people, who do not know the word “eoeak” as being a tree, are familiar with the term pole for poling a canoe or boat (pers. comm. B. Kiotak). The species certainly could have been introduced for this and other purposes, as traditional sailing canoe travel between the Marshalls and Pohnpei, even in fairly recent times, has been documented (Tobin 2002).

### **Conclusion**

Many feel that because the Marshall Islands are low lying coral atolls, their flora must be well documented and stable. While it is true that many of the islands do not yield much beyond the usual native and well-established plant species, the possibility of previously undocumented species should not be dismissed. The reasons are: 1) many more new exotic species are constantly being introduced by people (Thaman & Vander Velde 2004); 2) not all of the atolls, much less the over twelve hundred islands have been scientifically investigated; 3) the two mangrove

tree species recently found on Jaluit Atoll both extend the known range of these species—in the case of the *Xylocarpus*, by thousands of kilometers—indicating that there are still significant gaps in the biological knowledge of the region; 4) both of these tree species were well-known to the local people and are of cultural importance, showing the value of biologists being cognisant of the history, culture and language of the area where they work.

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