RMAP WORKING PAPERS

Resource Management in Asia-Pacific

Working Paper No. 49

Palm Sago: Further Thoughts on a Tropical Starch from Marginal Lands

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The correct citation for this publication is:

Author: Patricia K. Townsend
Year of Publication: 2003
Title: Palm Sago: Further Thoughts on a Tropical Starch from Marginal Lands
Series: Resource Management in Asia-Pacific Working Paper No. 49
Publisher: Resource Management in Asia-Pacific Program
Research School of Pacific and Asian Studies
The Australian National University
Place of Publication: Canberra
ISSN – 1444-187X

Resource Management in Asia-Pacific

Working Papers

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Palm Sago: Further Thoughts on a Tropical Starch from Marginal Lands

Introduction

Sago is a topic that I have balked at considering as my specialization. My resistance stems from more than one quarter. The main source of resistance is that sago swamps are miserable places to tramp around. I have been there, done that, back in my early twenties in the Saniyo (or Saniyo-Hiyowe) language area in the upper Sepik, and had no desire to do more. Another is that I have little botanical knowledge and no hope of acquiring an appropriate level of understanding. Palms are notoriously difficult to study botanically. Sago palms, with their huge inflorescences, are difficult to collect.

And there is the "sago, what's that?" reaction of colleagues working in other areas. It is bad enough to work in a discipline often seen as exotic and irrelevant to modern life without working on "an underutilized and neglected crop," to quote the foremost agronomist who has worked with sago (Flach 1997). This last point, by itself, is less likely to deter an anthropologist or geographer. The three geographers from the University of California at Los Angeles with whom I collaborated on the 1978 book "Palm Sago" sub-titled it "a tropical starch from marginal lands." (Ruddle et al. 1978). We were all well aware of the significance of a crop ideally specialized for the wetlands in which it was grown. Among the staple food crops grown in Papua New Guinea, sago is second only to sweet potato as an energy source (though it is about to be overtaken by cassava) (Land Management Group 2002, Table 4).

The 1966-67 field research (P. Townsend 1969, 1974; Townsend et al. 1973) left several annoying loose ends that I continued to pick at over the years without success in tying them up, even after several weeks of additional fieldwork in the Sepik during 1980 to 1984. Every few years I turn from whatever else I am doing back to survey the literature on sago (Ruddle et al. 1978; Townsend 1977, 1982). Each time I hope that other researchers will have discovered the clues I need to tie up those loose ends.

The most persistent of those unresolved questions are:

1. *What is the difference between wild and domesticated with respect to sago*? Looking backward and forward, the domestication question relates to the **prehistory** of *Metroxylon sagu* Rottb. on the one hand and to the **prospects** for its industrial use and agricultural intensification on the other. In addition to the technical botanical or agronomic issues, we need ask whether gender identity, ethnic identity, or other human social relations are related to this in any way.

2. *What does it mean that many of my informants were unable to eat sago pudding*? Sago pudding was my translation of the Saniyo word *einei*, sago cooked by pouring boiling water over sago flour and stirring quickly. It could be called sago gel, or, in Tok Pisin, *hotwara*. About one out of four of the people I asked claimed that they gagged the first time they tried it as a child and thereafter never were able to eat it. Posed more generally, this leads to questions about food aversions and about the significance of cooking.

3. And, as a medical anthropologist, I wanted to know, *what are the health issues surrounding the use of sago*? This is not a new question, of course; F. W. Clements published an epidemiological study in the *Medical Journal of Australia* in 1936 in which he related the incidence of tropical ulcer in the villages of Manus to dependence on sago rather than taro. He attributed the elevated incidence in sago villages (as reflected in hospital admissions at Lorengau between 1926 and 1932) to a "partial deficiency of the vitamin B complex" and a diet relatively low in protein and fat and high in carbohydrate (Clements 1936).

Initially, my major health concerns with respect to sago, like Clements, were related to nutrition. I have previously discussed my concerns about the nutritional implications of the high carbohydrate diet of sago peoples (Townsend 1971, 1982; Townsend et al. 1973). The positive side of the use of sago as energy source is that its abundance and storability assure that scarce protein is unlikely to be metabolized for energy. Most sago-using people also have access to fish or game to meet their needs for protein. A recent study of regional patterns of birth weights in PNG indicates that village dependence on sago, plantains, or taro is associated with lower birth weights, while high consumption of fresh or tinned fish is associated with higher than average birth weights. Sweet potato and yam are associated with intermediate birth weights (Müller et al. 2002).

More recently the health issue that has come to occupy me is the *risk of toxic effects of heavy metals* that may be associated with consuming sago grown on soil polluted with mining wastes, as discussed in the epilogue to this paper.

Planting, cooking, eating. Each of my questions requires help from a different set of specialists -- agronomists, botanists, geographers, archaeologists, food chemists, nutritionists, plant physiologists, hydrogeologists, and toxicologists. What can a mere anthropologist bring to such questions? Only, I think, two things: our holism and our persistence. By holism, I mean the willingness to try to bridge these disparate technical specialties in order to gain a broad bio-cultural understanding of a topic like sago. By persistence, I refer to the fact that our initiation rite of fieldwork, experienced in our youth with a certain amount of pain, engenders a lifetime of commitment to try to understand those things that affect the well-being of the people with whom we did that initial research (and others living in similar situations). Hence, we do keep worrying away at these questions which any reasonable person would have given up by now.

Sago and the Intensification of Production

I came to Canberra in April/May 2002 at the invitation of the Department of Human Geography to continue working on those loose ends. I was inspired by a reading of Mike Bourke's paper on agricultural intensification (Bourke 2001) to set aside for the moment the question of domesticated vs. wild and instead to look more broadly at the process of intensification as it relates to sago.

Subsequently, my reading of the literature on domesticated palms, particularly *pejibaye*, the peach palm (*Bactris gasipaes* Kunth) of Amazonia, has confirmed the usefulness of this approach, since it is becoming increasingly clear that palm domestication is an extremely complex question and is one that needs to be tackled anew for each species (Clement 1992). It is far more useful for an anthropologist to describe, as best as possible, some of the complex human/plant interactions on the continuum from use to management to cultivation to domestication in a particular place than to speculate about the genetic responses of the plant.

In this paper I shall continue to use the term "domesticated" to refer to *nau* and the term "wild" to refer to *yapai*, but it should be understood that these are used merely as the most intelligible glosses for the indigenous terms in the Saniyo language spoken by a few hundred people in the upper Sepik. I do not imply that a specialist would draw the line in this way; indeed both *nau* and *yapai* are quite possibly best seen as **semi-domesticates** located at different points on a continuum of domestication.

When we speak of intensification in PNG agriculture, we normally have in mind a process related to the more than doubling of the PNG population between the first census, from 2.2 million in 1966, the year I began my fieldwork, to 5.1 million in the 2000 Census. Under pressure of population growth, farmers have made changes in crops, fallow periods, and farming practices.

However, my fieldwork has been in an area where there has not been this kind of population growth. In fact my study population declined slightly between my 1966 fieldwork and the 1980 census (from 234 to 217). A few of the young men who signed on for contract labour failed to return from East New Britain, and infant mortality remained shockingly high, some 400 per thousand (Townsend 1985).

It was therefore not self-evident that I should be looking at intensification. Intensification does become relevant when you consider that during this period there were pushes and pulls that led to moving and consolidating settlements. Fewer and larger villages were located in places accessible by river or located at the airstrip opened at Mapisi in 1981. Old stands of sago fell into disuse and there was new pressure on areas relatively lacking in sago. Furthermore, the introduction of steel tools in the mid-1960s (W. Townsend 1969) reduced the effort required to clear trees and manage sago stands.

Most of the procedures that constitute intensification with respect to other crops scarcely apply to the sago palm. What might intensification mean with respect to sago? In this paper I will examine several such possibilities:

1. Planting more sago, instead of depending on suckers grown up from wild or previously planted palms.

2. Choosing more productive varieties for planting or harvesting.

3. Managing stands of sago by clearing and thinning.

4. Making decisions during harvesting and processing to optimize for increased starch return at the cost of greater labour time.

Planting

One step in intensification would be to plant sago. This can only be a very long-term step, as it will be on the order of 15 to 20 years before the first palm would be ready for harvest. In 1966-67, my informants at Yareno insisted that they were aware that sago could be planted but nobody ever had any reason to do so. The sago that they were using had been there since time immemorial. They were not aware who, if anyone, planted it.

Each mature palm is surrounded by its suckers, referred to according to size as the first-born, second-born... (*Poto, Pafei* ...) of the mother palm. After a palm is harvested (or flowers and dies) it opens up a space in the canopy and one of the suckers grows up and replaces it. Hence, the sago plantation may be self-perpetuating (even though all of the named varieties of *nau* are said not to produce seeds.)

Ownership of *nau* was established by one's father or mother showing his or her sons and daughters his or her sago palms as an inheritance. (The need to be "shown" the sago palms meant that claims were allowed to lapse when a person had not resided in the area for part of his or her younger years, spending some time in the swamp where sago was being worked. While claims to palms are bilateral they do not ramify indefinitely.) In contrast with *nau,* tracts of *yapai*, also called *asaye*, 'grubs, beetle larvae' are held collectively by patrilineages.

At Yapatawi in the 1980s I did see a young man plant one sago sucker near a waterhole not far from a house and another was pointed out to me as having been planted. (We are obviously not talking about vast plantations.) People who had visited another tributary of the Wogamus River, the Mapuwei, said that 'a lot' of sago had been planted there, but I do not imagine that this amounted to much either. The local approach to all horticulture is that some men have a few plants, and I do not know of any women gardening at all.

Selection of Varieties

In addition to simply planting more sago, another step in intensification would be to select for planting those varieties that are faster maturing or higher yielding. The Baroi of Gulf Province, for example, have discarded many of their cultivated varieties of sago in recent times. They now cultivate three varieties at most in any garden. The cultivars that have been retained are those they believe to be higher yielding and easier to work (Ulijaszek and Poraituk 1993).

One of the questions that remained for me from the dissertation research was the question of the significance of the several locally-recognized varieties of sago that I had earlier recorded. Therefore I focused in the re-study on re-confirming the Saniyo-language terms and looking at the morphological features upon which they were based (see Table 1). In the course of this work I also recorded a few additional varieties but made less progress than I might have hoped in differentiating all of them. Beyond height at maturity and the length and number of spines, which are the primary defining characteristics, the descriptions of crown shape and leaf color were difficult to sort out. The varieties were not all found in one place and not everyone was familiar with the same ones.

Table 1: Varieties of sago.

	Height	**Spines (length, number)**	**Other traits**
Yapai	some tall, some short	long, many	produces seeds
Nau tavariyo	very tall	long, not many[1]	
Nau piyarei	tall	short, not many	
Nau tarei	short	short	
Nau wa'aro	short	short	big crown
Nau wopi	short	short	like *tarei* except leaves droop
Nau wourei	short	short	small crown
Nau iyou	short	long, many	fat trunk
Nau te'erei	short	very short, many	
Nau meri	short	short	erect petiole
Nau sa'i apou	tall	short	erect petiole

Rare (not seen, not worked by informants during any periods of fieldwork):

Nau siye	tall	none	
Nau pavi nau	tall	?, few	
Nau saperi	short	none	
Nau yapuwei	very tall	short, few	

All are presumed to be varieties of the single species, *Metroxylon sagu* Rottb. Recent botanical research on the morphology and genetics of sago specimens collected from seven localities throughout the country confirms the taxonomy of Rauwerdink, who recognized only one species of Metroxylon in Papua New Guinea (Kjær et al. 2003; Rauwerdink 1986).

The most commonly worked varieties in the villages where I have lived (Yareno in 1966-67 and Yapatawi in 1982-84) were *nau tavariyo* and *nau tarei*. For example, at Yapatawi in the three weeks between 28 Dec 1982 and 17 Jan 1983, 12 different women (working usually in pairs) started work on 13 newly cut logs of 3 varieties, growing in 4 different named tracts (*pani*): 6 *nau tavariyo*, 5 *nau tarei*, and 1 *nau wa'aro*.

Some additional varieties were newly planted close to the waterhole just below the houses. These included a sucker of *nau piyarei* and one of *nau siye*. The man who planted these said he also brought a sucker of *nau sa'i apou* from Maprik and planted it here. A sweet potato cutting was also supposed to have been introduced from Maprik, where several young men have attended Bible School.

What is the local rationale behind planting sago? It is to get another variety started that is not available nearby. The reason that people give to need more than one variety is to provide for people who are unable to eat the locally dominant variety because they are in mourning. Out of grief, the chief mourners will avoid eating the variety of sago that they were eating when their loved one became ill and died. A new widow does not eat sago at all, going hungry or eating bitter wild yams for some days. When resuming sago she will avoid the variety that she had been eating when her husband died. Five years after the death of her teenaged daughter, Keiko was still not eating sago of the memory-evoking variety (though she was now working it and giving it to others and eating sago that someone else provided for her). In other

[1] "not many" means no spines on upper petiole and widely spaced on the base of the petiole.

words, the rationale for planting new varieties is not agricultural but cultural. Most sites of present and past settlement seem to have no more than three or four varieties of *nau* nearby.

One of the biggest puzzles left from my 1966-67 fieldwork was the status of the palm called *yapai*. It was perplexing that *yapai* (translated as *wail saksak* by speakers of Tok Pisin) is called simply *yapai* and never **nau yapai*. I worried that it might be a different species. I was told repeatedly that no one planted it, that it was always there, and that (unlike the varieties of *nau*, which generally are said to <u>not</u> produce seeds) *yapai* does produce seeds. We had seen a good deal of *yapai* in the 1966-67 fieldwork for it dominates the more flooded parts of the swamp forest. Because sago does not grow beyond the rosette stage under heavily flooded conditions, we had not, however, seen *yapai* with a trunk formed or flowering and fruiting. Therefore one of the first things that it seemed important to do was to find a *yapai* that had gone to seed and collect the seeds. We did this in January 1981 between Wourei and Nakek. Its seeds indicated that was indeed *Metroxylon sagu*. The men who located it and cut it for us notched it in order that beetles could colonize it for a later harvest of grubs.

The other question about *yapai* was whether it was used to produce sago starch. People had insisted that it could, but we had not heard of anyone doing it in 1966-67. Asking more explicitly this time, I spoke with five women who had worked it at least once, another five who never had. It was explained that *yapai*, unlike *nau*, will grow in very wet places, but to get *yapai* that forms a trunk it needs to be a better drained area. There seem to be relatively few places where this is the case.

Men had also insisted that they were capable and willing to work sago, which is normally women's work. So our friend Aymawei and a younger man demonstrated that both of these claims were based in reality by pounding and washing the starch from a *yapai* log. They dragged/floated it to do the work near the riverside village. (It was not an all-male effort, as Aymawei let his wife build the washing apparatus and work one of three sections of the log.)

Several other married men indicated that they had learned to work sago from their mothers and had done so either alongside their wife or alone when she was burdened by caring for a sick child. (This flexibility about gender roles, which contrasts with relative rigidity on the part of speakers of the eastern dialect of Saniyo, is something that I have addressed elsewhere (Townsend 1989).

The trunk was quite small, with a girth of only 98 cm. The pith was described as soft and easy to pulverize. They planned to work the trunk in three sections in three days of which the first two days' yield was observed and measured. Two men worked the first day to produce 12.4 kg of moist starch. A woman worked the second day, producing an additional 4.8 kg. The average yield was 37 kg/m^3 of pith, less than half the yield per volume of pith of the varieties of *nau* that I had previously recorded (P. Townsend 1969:39).

Starch density is not a property on which the Saniyo comment much unless a log disappoints by containing "only water, no starch." In the case of this *yapai* log, the low starch density was offset by the ease with which the soft pith could be pulverized. With larger *nau* logs, they may leave the stump or low-yielding bottom several feet of the trunk unworked as food for beetle larvae, this being the normal use of whole *yapai* palms.

Data on starch density from several studies are presented in Table 2. When one considers the small sample sizes, inter-observer variability, differences between varieties, the cutting of some palms at less than optimal timing, and differences in the thoroughness and care of extraction, it is surprising that any pattern emerges from the data. Instead there is an obvious gradient from the wild/unmanaged sago through varying degrees of cultivation intensity in various regions in New Guinea to the monocrop plantations in Malaysia.

Table 2: Starch density of sampled sago palms.

Location	Sago starch, kg/m3 of pith	N	Source
Malaysia, plantation	300	?	Flach 1997
Abelam, E. Sepik, PNG	235, 249	2	Lea in Schindlbeck 1980
Sawos, E. Sepik, PNG	7-323, mdn 187	13	Schindlbeck 1980
Bedamuni, Western, PNG	166	6	Minnegal & Dwyer 1998
Kikori, Gulf, PNG	114, 130	2	Rhoads 1980
Kubo, Western, PNG	119	13	Dwyer & Minnegal 1994
Saniyo, E. Sepik, PNG, nau	55-147, mdn 98	7	Townsend 1969
Yafar, W. Sepik, PNG	64-92, mdn 78	?	Juillerat 1984
Waropen, West Papua, Indon.	50-100	?	Flach 1997
Saniyo, E. Sepik, PNG, yapai	37	1	Townsend, 1983 data

It is not possible to know the extent to which the differences revealed in Table 2 are the result of selection for higher starch content, better management, more thorough extraction, regional variations in annual solar radiation, or some combination of these factors. Although possible genetic differences are obscured by other sources of variation, there are undoubtedly differences in starch yield among land races of *Metroxylon sagu* in addition to the differences between wild and domesticated. People are quite likely to have pragmatically selected for higher yields when planting sago cuttings. Nonetheless, it remains striking that the Saniyo, at least, attempt to maintain diversity for the sake of diversity. They do this in order to have alternate varieties of sago for mourners as part of a larger pattern of sympathetic kinsfolk providing alternative foods, such as rats or tinned fish for mourners unable to eat pork. The preservation of biodiversity, perhaps someday critical to protecting this staple from introduced diseases or pests, thus rests on a set of cultural values other than straightforward productivity.

Management of Sago Stands

As Flach has demonstrated (Flach 1977), even wild and semi-wild sago compares favorably with typical world yields of cereal and tubers, as measured in kcal/hectare/year. Another form that intensification may take is investing labour in the improvement of these naturally regenerating sago stands. In my dissertation I indicated that a number of common practices would have the unintended effect of managing sago stands for better productivity. These include cutting trees and brush to improve paths by bridging wet places and cutting young sago for grubs or palm cabbage.

I also noted in the dissertation that the higher-yielding varieties of sago were found at the better drained higher margins of the swamp, sloping up on to the margins of the hills upon which the houses are built and fruit trees and bananas are planted. What only became clear from the follow-up research in 1983 is the extent to which forest succession is intentionally and actively managed at the margin of rain forest and swamp forest.

In January 1983, Bill Townsend, with local assistants, surveyed two 10-meter wide transects through currently exploited sago stands, each running from the lower slopes of Yapatawi hill out toward the permanently flooded swamp. Here, and elsewhere in actively used sago tracts, Yapatawi men had cut trees for the express purpose of opening up the canopy to allow sunlight to reach sago suckers and improve their growth. The findings are illustrated in Figures 1 and 2. Trees larger than 10 cm. in diameter were plotted. *Metroxylon* were recorded by variety and size classification, and the height of all trunks determined by triangulation. The categories in the Saniyo language for the developmental stages of sago palms are as follows:

unei	small shoot
to'out	large sucker or seedling
tarowei	trunk just beginning, cabbage can be harvested

to'asei	palm with small trunk
simenise	"with a trunk" (adjectival form)
towapi	palm with trunk that can be processed for starch

Transect 1 is in the area known as *Hare Yamehe*, generally northward from Yapatawi, toward the Hewei River and Mapisi. The word *hare* means 'fish' or 'stream,' and the stand is named for the small stream that crosses this transect three times, at the 25-, 45- and 105-meter points. At the 125-meter point is the corner of a 5m x 6m bush house used for resting and occasional overnights while working the sago owned by a group of brothers who belong to the sub-clan *Arasu nikiyei*. The sago is of three locally-recognized varieties, *nau tavariyo, nau tarei,* and *nau wa'aro*. The other trees were of several locally named taxa that had not been collected and taxonomically identified in the earlier research and the following previously collected taxa: *mei utai* (Burseraceae, *Canarium*)*, mei turei* (Euphorbiaceae, *Mucaranga, Mallobus*), *mei iruwapavi* (Aquifoliaceae, *Ilex*)*, mei tuwai* (Anacardiaceae, *Campnospermum brevipetiolata*)*, mei yawmei* (Myrtaceae, *Eugenia*), *mei yo'o* (Moraceae, *Ficus*) and *mei umei* (Moraceae, *Ficus*) (P. Townsend 1969, Appendix I).

Transect 2 traverses a sago tract belonging to the sub-clan *Iya na'asu,* lying east of Yaputawi, downstream and on the right bank of the Miwei, or Wogamus. With no living members in the male line, the *Iya na'asu* sago is owned by two brothers who inherited it from their mother. They have a bush house 10 m off of the transect between the 20- and 30-meter stations. Most of the sago is of the variety *nau tavariyo,* with some *nau wopi*. At the 75-meter station the ground drops off abruptly to soft mud and from 120 meters is sufficiently inundated that it only produces *asaye*, grub sago. Few trees of other species are found in the transect. They include the palm, *sarowei*, the wood of which is used for making bows and arrow foreshafts and barbed points. Other trees included *mei po'aru* (Euphorbiaceae, *Endospermum*), *mei aipo'u* (Leguminoseae, *Pithecellobium*), and *mei re'i* (Moraceae, *Ficus*).

Comparing the two transects, the second, while small, is more productive, with few competing trees and the equivalent of 130 mature palms per hectare, comparable to Oboro, the most intensely managed of the four stands of planted sago in Kikori, Gulf Province, studied by Rhoads (Rhoads 1980, Vol. 2, Table 2.2). The Hare Yamehe transect has only half the number of mature palms. This is roughly equivalent to Rhoads' Poialaviti swamp, an older established, less recently exploited stand. The Hare Yamehe stand had recently been improved through the cutting of several trees along the stream, near the 20-m station, with the stated rationale of making the sago suckers grow large. Other trees were cleared in a brushy area that lacked sago (between the 80- and 90- m stations) with the intention of helping suckers from the adjacent palms to become established.

Summing up, the Saniyo exploit stands of sago that, if not exactly "wild" were not planted within either memory or legendary time. Even so, their stands of sago are managed, through clearing and pruning, to attain much the same result as stands of planted sago in Gulf Province.

Harvest

Given that a sago palm may require as much as twenty years to come to maturity, the strategies for managing sago that have been discussed so far require thinking in the very long range. The most immediate way to get more food energy from a given sago palm is through more thorough and timely extraction of the starch. We turn then to harvesting, or processing, sago starch, as a form of intensification.

Ethnographers have been making comparisons of labour time in extraction of sago at least since in my dissertation I compared my 1966 data with David Lea's Abelam data from his 1964 ANU dissertation (Lea 1964:122). The return per hour of sago harvesting is so readily measurable that it warms the hearts of all of us who seek relatively painless quantification in our studies of subsistence systems. I found that my yields per hour worked (averaged over seven palms) were virtually identical to Abelam yields (P. Townsend 1969:38-40). The division of labour (women doing sago work) and the technology were similar in the two areas. There was, however, a striking difference: the Abelam were only processing half the volume of pith in an hour to extract an equal amount of starch as the Saniyo. They were also obtaining more starch from each palm. In other words, the Abelam might have possessed a better-yielding variety of sago, but they seemed to be offsetting this advantage by expending more effort to extract starch more thoroughly—another type of intensification. The Abelam, in a densely populated part of the Sepik, produce sago to tide people over the lean period between yam harvests, while the low-population-density, low-intensity Saniyo live on it year-round.

The penalty of taking the lead in sago studies in the Sepik was that the generation of fieldworkers to follow had read my dissertation and felt obliged to do the same, though methods were hardly standardized and samples are small.

The Yafar of the Border Mountains produce sago starch with approximately the same efficiency as the Saniyo, in both kg/hour and kg/m^3 of pith (Juillerat 1984).

The Sawos of the Middle Sepik (Schindlbeck 1980:87-92) produce far more starch per hour and per cubic meter of pith, giving nearly double the amount (per unit of labour and pith) produced by the Saniyo and Yafar. However, for three of 13 palms Schindlbeck recorded extraordinarily poor yields—a high degree of variability in all of our small samples makes precise comparison inappropriate.

The Gadio Enga provide yet other difficulties in comparison, for they have men doing the pounding, and they are also extracting sago starch from only a short length of each trunk, using raw pith as pig food. Nonetheless their production per hour is not much greater than either the Saniyo or Yafar, about 3 kg / hour of work, exclusive of walking time (Dornstreich 1973:211).

My initial interest in making these measurements of labour time and starch yield was to compare sago work with tropical horticulture in respect of the labour input needed to feed a household. For this purpose, I found Robert Carneiro's measure useful, the number of hours of work to produce the calories required for one adult for a year (P. Townsend 1969). Sago work came out as less labour intensive than other subsistence activities with which data were then available for comparison.

Subsequently, those working with systems approaches were more interested in measuring flows of energy in and energy out. Such studies of energetics continue to be of interest in human biology: for example, Ulijaszek's research on the energetics of sago work in the Purari Delta (Ulijaszek 1997). Ulijaszek suggests that the Baroi of Gulf Province gain an energy return from an hour of sago work similar to the Saniyo and Abelam, but double that of the Gidra of Western Province studied by Ohtsuka.

Another direction that one might go with this subject is to compare the varying technologies of sago extraction throughout PNG. The extra step of beating the pulverized pith with a stick while it is in the washing trough should lead to more thorough extraction. Minnegal and Dwyer claim that the beating of the pith is what differentiates the more intensive sago extraction of the Bedamuni from the less thorough extraction of sago practiced by the Kubo (Dwyer and Minnegal 1994; Minnegal and Dwyer 1998:384, 2001:273). The Bedamuni pay the price by producing only 0.85 kg of sago flour per hour to the Kubo l.46 kg/hour. (It can be noted that <u>both</u> of these values are lower than the Sepik and Gulf production figures quoted above.)

I do not think that this step of beating the pith would be as helpful where a flaked-stone hammer/scraper like the Saniyo sago pounder is used. The worker may use it as a hammer to break up the pith and loosen the starch granules after using its cutting edge to scrape the pith, before carrying it to the washing trough. In areas where workers use open-ended bamboo or pipe sago tools, I assume that these would be more effective for cutting than pounding. Beating the sago in the trough with a stick might make up for this. Extracting every last bit of starch is probably not a high priority for Saniyo women, who allow their young pigs to feed in the spent pith they have tossed to the ground.

The flaked stone sago pounder (*fiyasei*) remained in use in the 1980s as the sole tool for its purpose. Indeed I was given a newly made *fiyasei*, now in the National Museum, as my farewell gift in 1984. In contrast, the polished stone tool (*ipei*) used for cutting the palm was already disappearing in 1967 (W. Townsend 1969). By 1980 it had been completely displaced by the steel axe.

For maximum yield, it is generally agreed that a sago palm should be cut just before flowering or in the early stages of flowering. Yet this is not always done, and it is my sense that with the Saniyo, at least, population pressure, such as it is, leads to bad decisions, cutting palms that yield a poor return of starch for the labour involved. Mostly this means cutting them too soon: too short in terms of the full height and total starch content that they might have achieved. But it might mean working a palm they might otherwise have passed over. This happened more than once in 1980-84, though it was not mentioned to me in the earlier fieldwork.

The village of Wourei was built on the banks of the Miwei River to take advantage of access to missionaries, traders, and government officers arriving by river, despite the inadequate sago stands nearby. In December 1980, women were complaining about the *nau tare* they were working at some distance from the village. In full flower when cut, it had very dark, reddish gray pith and was not yielding much starch. At Mapisi, adjacent to the new airstrip, people complained of a sago palm that when cut produced "only water, no starch."

Pressure to use the entire palm might also mean using the whole length of the trunk, including the lower-yielding lower portion, from which the starch has already begun to migrate up the trunk in preparation for fruiting (Van Kraalingen in Flach 1997). With plenty of sago palms around for the cutting, Saniyo will leave unworked at least a portion of the base (the cut stump) and sometimes also another section of the bole as much as 1 to 3 metres in length if they deem it low in starch. (Unworked portions of the trunk are revisited several weeks later to harvest the grubs that have colonized them.)

Conclusions

I have attempted to suggest what we might mean by "intensification" with respect to sago, with respect to planting, selection of varieties, managing stands, and harvesting. I should make it clear at this point that I am not retracting my long-standing contention that the Saniyo are most usefully seen as hunter-gatherers rather than farmers, particularly when attempting to understand their society and culture and to make relevant comparisons with other parts of the world. But over the years I have laboured that point in a variety of venues. More recently, Jim Roscoe has argued it even more convincingly (Roscoe 2002). I think it is now safe to suggest that even these most **un**-intensive of sago gatherers engage in varied management practices in their agro-forestry.

As they moved into new situations, such as the larger and more permanent settlements at riverside or airstrip locations, these techniques of intensification that were already known to them became more conspicuous in practice. While total population had not increased, pressure on sago resources near new settlements had increased. Even so, in the upper Sepik during the early 1980s, the practices related to intensification were only slight. Planting a cutting of sago was still a rare event, and it was practiced to diversify the varieties available for cultural reasons. Thinning and pruning to manage sago stands for better yields, using newly available metal bush knives and axes, was more noticeable after two decades of post-contact change, but the technology of sago pounding and washing had not changed significantly.

Epilogue: Sago Downstream of Large Mining Projects

Sago stands are a natural resource that has been taken for granted. Men from sago areas who are in salaried employment, when joking about what they would do if no longer employed, say, "Well, I could go back to eating sago." It is unthinkable that sago might not always be available. Yet insofar as sago stands require management to stay productive, neglected sago would become less available. And the alterations in flood plains of rivers downstream of large mining projects practicing riverine disposal of tailings and waste rock already may have irretrievably damaged large areas of sago palms. Downstream of Freeport's Ertsberg/Grasberg mine, the Kamoro (Mimika) have lost their most extensive sago stands to the Tailings Impoundment area (Harple 2000).

Monitoring these stands has not been part of the environmental research program of these mines, so we do not know the extent of such damage. Ok Tedi does monitor the extent of forest dieback adjacent to the river, which may include some sago palms, but that does not tell us whether changes in drainage patterns have reduced the starch yields of surviving palms that were not suffocated and killed outright by tailings. Already, people downstream as far as the Gogodala of the Lower Fly are concerned about sago palms that are not maturing to produce normal amounts of starch (Dundon, personal communication, 15 October 2003).

Even if sago palms survive and mature normally, is it possible that the starch may be contaminated by heavy metals? I first raised my concern about the possibility of heavy metal contamination of sago grown on soil polluted with mine wastes at a paper for the meetings of the European Society of Oceanists at Copenhagen in 1996 (Townsend and Townsend 1996). The paper was placed on the Internet without my knowledge and came to the attention of Robert Goodland at the World Bank. This led to an invitation to me to present a brownbag seminar at the World Bank in 1997 that was attended by both the PNG country director and the head of the mining department at the Bank. In those presentations I was careful to indicate that I had no way of knowing whether sago in the watershed of the Ok Tedi or Fly Rivers had been affected by heavy metals. Indeed, the central point that I was making was that, as far as I knew, there were no data to answer this question (and still to this day are not). The study of sago and other land-based subsistence was not part of the scientific program attached to the Ok Tedi mine because it had been assumed from the outset that only the river and fish needed to be monitored.

Of the metals that are present in Ok Tedi mine wastes, copper has received the most attention. Copper, particularly the occasional pulses of copper that reach high concentrations, is damaging to fish and the invertebrates on which the fish feed. The mining company has preferred to emphasize average levels of copper and to treat occasional high readings as errors or chance fluctuations. However, in the site of my most recent fieldwork, the Clark Fork River of western Montana, downstream of the copper mines at Butte, the occasional pulse of copper is considered to be the cause of fish kills. Copper and other metals build up on the surface of "slickens" (riverside deposits of tailings) and dry out. Then, when a sudden downpour comes they are washed into the river all at once, creating a pulse of dissolved copper to which the fish are very vulnerable.

At the levels reported in the Ok Tedi and Fly, copper is not dangerous to humans, however. It is cadmium that is my main concern with respect to human health in the long term. I am concerned both because it is reported at fairly high levels in the water monitoring data reported by Ok Tedi Mining Ltd. and because it has the potential to be taken up into plant tissues and affect humans who eat the plants.

I cannot emphasize sufficiently that **we do not know how much cadmium is taken up into sago palms**, or if so in what part of the plant it accumulates. Japanese were affected by eating rice that contained cadmium taken up in irrigated fields. (The comparison with occasional flooding of sago swamps with river water is suggestive.) In Europe, of the plants tested, the highest levels of cadmium are reported from potatoes and leafy green vegetables. The concentration of cadmium in plant tissues is something that differs among species.

The toxic effects of cadmium are well known through studies of occupational exposure, particularly in workers in Belgium and Japan (Nordberg et al. 1992). Both in Europe and in Japan persons eating foods grown on cadmium-polluted soils or living in communities where they breathe air or drink water polluted with cadmium have also developed symptoms of cadmium exposure (Meulenbelt et al. 2001). The details of toxicology are outside my area of expertise, but the bottom line is that chronic low-level exposure to cadmium is likely to show up as kidney damage and fragile, demineralized bones, particularly in older women. A more severe form of cadmium intoxication with bone pain is known from Japan as *itai itai* disease, 'ouch ouch' disease.

Persons with iron deficiency are especially vulnerable to damage from cadmium. Iron deficiency anemia is very common in women in lowland Papua New Guinea, especially those who have had many pregnancies and who live in areas with malaria. Cigarette smokers take in cadmium with tobacco smoke, and are therefore more at risk if they consume additional cadmium from food or water. Tobacco smoking is also very common in Papua New Guinea.

Because cadmium is eliminated slowly from the body, the concentration of cadmium in the kidney and liver increases with age. This means that damage to human health, if it does occur in the Fly River watershed, is likely to be a slowly developing problem. Add to this the slow development of the sago palm (compared to a rice plant or a head of lettuce), we are talking of something that is only likely to emerge as a health problem decades from now, long after OTML is gone, if it ever emerges at all.

Cadmium and other heavy metals can be studied in humans by analyzing hair samples. Although there are some problems in interpreting them, they have the advantage that, unlike blood samples, they reflect intake over a period of some months. The baseline survey prior to mining was conducted in villages near the mine during 1982-1983 before production began (Jones et al. 1987). Of the metals measured, cadmium was considerably higher than in other populations, suggesting that high levels of cadmium in the water and soil in the region of the mine had affected Ok Tedi residents prior to mining. The 1982-1983 baseline medical survey did not include downriver populations from the Middle and Lower Fly. A subsequent medical survey by the mining company's medical officer found cadmium levels in hair samples from the Middle Fly and Fly estuary to be within normal reference values (Flew and Taufa 1999:47). It is unclear whether peer review of this work and further monitoring are planned.

Short term epidemiological studies or spot checks of sago purchased in the market are unlikely to reveal the full scope of the problem. One such study compared the 1987 and 1990 incidence of fractures and nephrosis and nephritis reported at health centers in the Fly River area. Although the author claims that the changes over time are in the direction to be expected from the consumption of fish increasingly contaminated with cadmium (Vinit 1999:112), the analysis is not persuasive. In addition to problems of poor reporting and small sample size, the study is difficult to interpret for various reasons. One can only wonder whether the rarity of fractures in elderly women, for example, merely reflects the improbability that they will be transported to a health centre and the increase between 1987 to 1990 an increase in the availability of such transport.

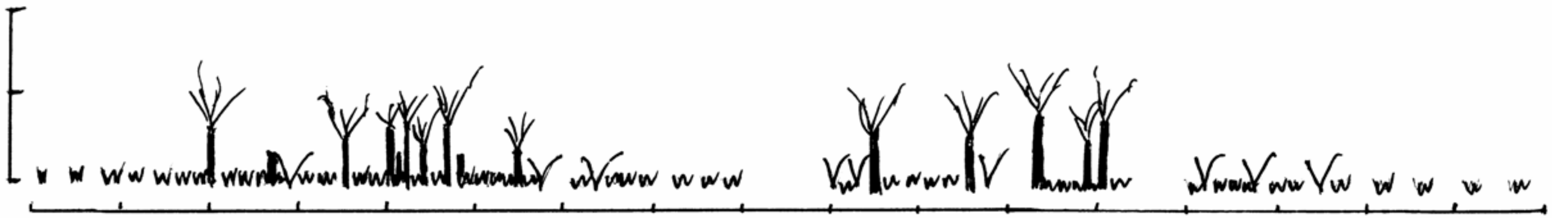
It is difficult to raise the issue of heavy metal toxicity without unduly alarming people and causing them to lose confidence in their food supply, yet it is necessary to do so in order to insist that appropriate research and monitoring take place. Now that other researchers have reported that people downstream of the mines are already worried about the safety of their sago (Dundon 2002), I am less reluctant to publicize my concerns.

Acknowledgements

For my dissertation fieldwork of 1966-67 in the Wogamus River area (a tributary of the Sepik in the Ambunti District, East Sepik Province) we lived in the hamlet of Yareno, which no longer exists. Its former residents scattered to Wourei, Mapisi, and Yapatawi. When we revisited the area for several short periods between 1980 and 1984, Ron and Sandy Lewis of the Summer Institute of Linguistics graciously offered us the hospitality of their houses in Wourei and, later, Mapisi, before we built our own in Yapatawi. This latter fieldwork was done partly in relationship to a study of maternal and child health at the PNG Institute of Applied Social and Economic Research (now the National Research Institute). The additional data on sago is largely the contribution of William Townsend, who generously gave his vacation time to tramping around the sago swamps. I am grateful for the encouragement that the Department of Human Geography and the Resource Management in Asia-Pacific Program in the Research School of Pacific and Asian Studies at the Australian National University have given me to dig out these aging field notes, publish the additional data, and rethink the topic in the light of research done by others in the past two decades. For comments on an earlier version I am grateful to Mike Bourke, Robin Hide, Jean Kennedy and Bill Townsend, none of whom bears responsibility for its remaining defects.

Figure 1: Hare Yamehe transect.

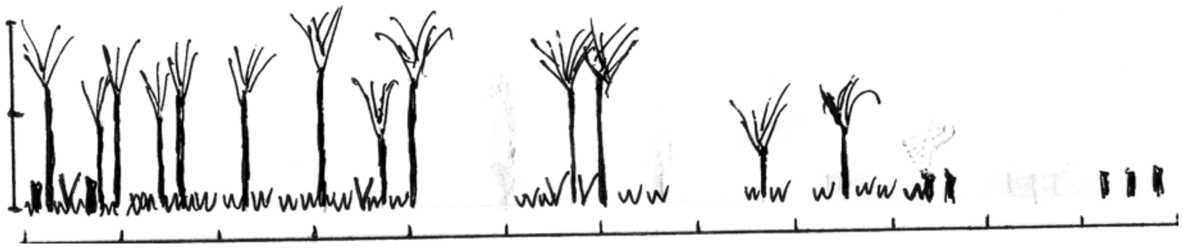
Sago palms are illustrated in the diagram, other trees are enumerated below. Note the inverse relationship between the density of mature sago palms and the number of other trees in the canopy at each station. Recently felled sago palms are shown as stumps on the diagram, recently felled trees are indicated in parentheses, following the number of standing trees. The stream crosses the transect at the 25-, 45- and 105-meter points.



m	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
No. of Trees > 10 cm dia.	3	5(1)	1(3)	2(1)	0	2	3	0	5(1)	0	1	1	0	2	5	8	8	

Figure 2: Iya Na'asu transect.

Sago palms are illustrated, other trees are enumerated below. Recently felled palms are shown as stumps, including 3 *nau tavariyo* between the 110 and 120 meter stations and two between 90 and 100 meters. At 76 meters, firm ground drops off abruptly to soft mud. After 120 meters the swamp is *asaye,* grub sago, which does not form a trunk.



m 0 10 20 30 40 50 60 70 80 90 100 110 120

No. of Trees > 10 cm dia. 1 0 0 2 1 2 2 3 0 0 0 0

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