Sago Research in Pacific Island Countries and Southeast Asia - A Review

Review

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Abstract

This is a review that critiques sago research and provides some reflections on Papua New Guinea, of which its thesis has applications and implications for PICs and Southeast Asia. These reflections are based on an eclectic review of the literature on previous and current sago palm research carried out in some SUAS in PNG, with some case references drawn from that of Malaysia, Philippines and Indonesia. Two broad aims are pursued in the present study. Firstly, the empiricism of sago research is classified into three categories and critically examined. The first category covers studies on agronomics of the sago palm (*Metroxylon* spp.); the second category focuses on ethnological studies, providing comparative studies of SUAS from a multitude of views. Issues cover thematic and development-related studies such as poverty-focused, gender-focused, nutrition-focused and socio-economic surveys. The third category explores teleological studies and briefly covers sago palm starch extraction methods, biotechnology, food technology and food security. Secondly, this study reviews two main leading theoretical assumptions pertinent with sago palm research with respect to the Headland/Bailey food scarcity thesis and the sago palm's centre of diversity thesis.

Key words: International Sago Symposium (ISS), Pacific Island Countries (PICs), sago palm, sago using agrarian societies (SUAS), Southeast Asia, sago palm (*Metroxylon sagu* Rottb.)

Introduction

A critique of the past and recent sago research in PICs and Southeast Asian countries is provided to draw on some of the informational perspectives and trend of the species of sago palm genus *Metroxylon* for comparative purposes. The literature on past sago palm studies find eloquent expressions, relevant data and information in academic journals such as, *Human Ecology; Anthropology in Oceania; Journal of the Polynesian Society; Economic Botany; Canberra Anthropology; Tropical Science; Principes; Sago Communication; Sago Palm* (Journal of the Society of Sago Palm); *People* [*Mankind*] *and Culture in Oceania; Ecology of Food and Nutrition; Japanese Journal of Tropical Agriculture; Contemporary PNG Studies: DWU Research Journal*, among others.

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Burgeoning literature on the various aspects of the sago palm are also found in the published proceedings of the last eight international sago symposia (ISS), in Kuching Sarawak, Malaysia (1976); in Kuala Lumpur, Malaysia (1979); in Tokyo, Japan (1985); in Kuching, Sarawak in Malaysia (1990); in Hat Yai, Songkhla in Thailand (1994); in Riau, Pekanbaru in Indonesia (1996) and in Port Moresby, PNG (2001), which came under the auspices of the International Sago Network. The eight ISS was held in Jayapura, Papua in Indonesia (2005). The ninth ISS was held in Baybay, Leyte in Philippines (2007); however, the conference proceedings have not been published yet. Eight years ago, the Society of Sago Palm Studies held its international symposium on sago from October 15 to 17, 2001 in Tsukuba City, Japan, which culminated in the published proceedings of the conference entitled, *New Frontiers of Sago Palm Studies*. Described as an authoritative account, the proceedings encapsulate major scientific advances made and provide useful up-to-date information and data on sago palm. The conference proceedings serve as a timely forum for mutual exchange of ideas pertinent with sago palm for sago eaters, development practitioners and for the literary scholars of sago palm.

Other sago research works have been commissioned by entities such as the United Nations organisations: Food and Agriculture Organisation (FAO) and United Nations Educational, Scientific and Cultural Organisation (UNESCO) as well as another leading research institute, International Plant and Genetic Research Institute (IPGRI), and perhaps a leading university in scientific and social science-focused studies on sago palm is that of Waginengen Agricultural University (WAU), The Netherlands, which has a sago archive located in the Agronomy department. This sago archive at WAU, let alone the commissioned studies, to a larger extent, have all produced well-documented studies on sago palm from various standpoints and provide useful sources of reference for intellectual cogitation *per se*. A case in point in WAU would be found in the work of JONG (1995) on the research for the development of sago palm (*Metroxylon sagu* Rottb.) cultivation in deep peat in Sarawak.

Viewing it from more detailed sago research done in PNG, the then Department of Minerals and Energy in collaborative research works, with the Office of Environment and Conservation in the 1970s and early 1980s were tasked to make preliminary assessments on the viability of promoting sago palm as a commercially managed crop on a larger scale. The main motivations behind active interest in sago palm research can be associated with two main possible reasons. Firstly, because of the oil crises, these caused havoc for petroleum-dependent industries and consumers, not only in PNG, but were experienced world wide then. During the height of the oil crises then, it was perceived that PNG so as to offset the sudden dramatic price increases in petroleum-based products; should explore the possibility of deriving ethanol fuel from fermenting sago palm starch as a reliable fuel substitute. The pilot project was proposed to be established in East Sepik Province to achieve this end (NEWCOMBE *et al*. 1980).

Secondly, to provide hydroelectric power scheme for many rural dwellers throughout the country, the Purari River delta in Kikori in Gulf Province was proposed as an ideal candidate for the scheme. Purari River's latent potential came under the scrutiny of energy

development prospects for a growing population. Feasibility studies covered the ecology of the Purari River delta, which is a vast natural area under sago palm; likewise, the salinity levels of the water to be dammed, let alone how a dam was to affect the delicate ecosystem of the sago palm were reported. Though the two highly valued national development interests; an ethanol fuel project in East Sepik Province and the Purari River delta hydroelectric power scheme in Gulf Province never reached any greater heights thereafter, as interest waned after fuel prices dropped, nevertheless it was perceived as showing one of the key initial interest for sago palm studies.

Because of the large volume of literature from previous sago palm studies, the author proceeds to briefly highlight a few of the studies drawn from some of the sources of literature mentioned herein. TOWNSEND (1982) points out that the first and second National Food Conferences held in 1975 and 1980 respectively prompted the other key reason for the upsurge in developing significant interest in sago palm in PNG. The conferences were held to review existing traditional management systems in production of existing staple food crops in the country in the midst of catering for the demands of a growing population (BOURKE 1980).

Materials and Methods

Materials obtained for the study extensively reviewed and analysed from wide-ranging sources of literature, which provided the basis for critiquing some of the past and present sago research in PICs, comparing these with some of the works covering the Southeast Asia region. Two methodological perspectives are pursued, of which the first method delineates the practicalities associated with sago research from three standpoints: (1) Agronomics of the sago palm [species of sago palm (*Metroxylon* palms): palms in the genus *Metroxylon* sections *Metroxylon (Eumetroxylon)* and *Coelococcus*], (2) Ethnological studies of the sago palm and (3) Teleological studies of the sago palm, which briefly extends to food technology, biotechnology and food security issues as well. The second methodology applies a theoretical approach to discussing issues pertinent with two leading theories, of which its underlying assumptions in sago research are critically examined.

Results and Discussion

Empiricism of Sago Palm Research

I. Agronomics of the sago palm [species of sago palm (*Metroxylon* palms): palms in the genus *Metroxylon* sections *Metroxylon (Eumetroxylon)* and *Coelococcus*]

There has been a general consensus among sago palm scholars and researchers (BECCARI 1918, BARRAU 1959, FLACH 1993, 1997, HISAJIMA 1995, HASSAN 2001, JONG and FLACH 1995, JONG 1995, 2002), especially, those with a background in botany, agronomy and other tropical crop-related agricultural studies that sago palm (*Metroxylon*

spp.) is a palm species and belongs to the order Arecales, family Palmae, subfamily Calameae, subtribe Metroxylinae and genus *Metroxylon*. Sago palm is a huge hapaxantic (once-flowering) and soboliferous (tillering) tropical palm. Sago palms had generally been classified into two species, based on morphological characters, namely: non-spiny type (*Metroxylon sagu* Rottb.) and spiny type (*Metroxylon rumphii* Mart.) in the past; however this agronomic view had changed after the 8th ISS in Jayapura, Indonesia (2005). Now, sago palm is only one species (*M. sagu* Rottb.) after RAUWERDINK 1986; EHARA *et al*. 2003a, KJÆR *et al*. 2004). John DRANSFIELD of Royal Botanic Gardens, Kew, UK also recognises both the spineless and spiny sago palm as (*M. sagu* Rottb.).

Earlier reported and published works on sago agronomy are found in the seminal works of BECCARI (1918), BARRAU (1959) and RUDDLE *et al*. (1978), though there were others who did ecological studies well before those cited works (see Table 1) in different parts of the world; however, contemporary intellectual culture uses these studies as points of references for the most part. Other works in the past are equally important; however, this study merely attempts to contextually situate current developments in sago agronomy. Arguably the three works cited have attempted to classify sago palm species and local varieties and came up with lists that other scholars have attempted to reclassify, based on collaborative, extensive and more focused research into various general, let alone specific properties and the characteristics of the sago palm in different localities. Sago researchers identify variation of sago palm as "folk variety" after the 8th ISS held in Jayapura, Indonesia (2005). Whilst doing a much needed review and research on sago palm studies in PNG, TOWNSEND (1982: 30) recommended further studies on taxonomy and physiology of sago and its varieties. FLACH (1981), by then, had already begun doing a taxonomic study on different varieties of the sago palm in the Sepik area of PNG.

Interest in sago taxonomy and physiology grew in leaps and bounds thereafter, and became a preoccupation of most sago palm agronomists, even today. Taxonomic studies have been based on morphological characteristics (*cf*. EHARA *et al*. 2000, RAUWERDINK 1986). Morphological characteristics of the sago palm revolve very much around *Metroxylon sagu* Rottb which includes both the (spineless type) and the (spiny type) after the ISS in Jayapura, Indonesia (2005). Determination of the sizes of the circumference or girth of the sago palm trunk; height of the trunk at various stages of growth; number of leaf scars at different intervals on the trunk; pith dry matter to ascertain the amount of starch content and other variances inherent in sago palm growth in different localities, using sophisticated techniques such as the amplified fragment length polymorphism (AFLP), or the random amplified polymorphic DNA (RAPD) analysis (e.g. EHARA *et al*. 2001, KJÆR 2001), have been quite useful in broadening and deepening the research and reporting on the genetics of the sago palm further. Using the AFLP method, KJÆR (2001) attempted to determine the genetic (DNA material) and morphological varieties of young sago palm leaves from a sample of one hundred and thirty two palms sampled at seven different localities in Western, Milne Bay, Morobe, East Sepik and Sandaun Provinces of PNG and concluded that New Guinea is the centre of morphological variability.

EHARA *et al*. (2000) also did an agronomic study on the Eastern archipelago of

Indonesia to clarify the variation in sago palm growth and production and its related environmental factors in southeast, north Sulawesi and northern Maluku. Combining folklore taxonomy of the Tolakinese people of Southeast Sulawesi of Indonesia with internationally accepted taxonomic classifications of the sago palm, NISHIMURA *et al*. (1994) identified two main types of sago growing in Southeast Sulawesi. They are: (1) *"Runggumanu" (spiny type)* and *"Roe" (spineless type)* according to BECCARI (1918) classification. Six years ago, it was pointed out that the Tolakinese of Southeast Sulawesi classify sago palms into four types, as is noted in a study by PASOLON *et al*. (2002), of which the two main types were mentioned earlier in a study investigated and reported by NISHIMURA *et al*. (1994), while the other two as reported by PASOLON *et al*. (2002), according to BECCARI's classification are: *"Rui"* (*Metroxylon micracanthum* Mart.) and *"Baruwilla"* (namely white sago).

In the Oceania region, more biogeographically oriented studies related to taxonomy of various cultivars of the sago palm for PICs such as Solomon Islands and Vanuatu have been reported by DOWE (2001, 2002); MCCLATCHEY (2002); EHARA *et al*. (2003a, b). DOWE (2002), in particular has investigated the uses of *Metroxylon* (Arecaceae) in Vanuatu and concluded that much of it is now utilized for thatch for building houses. DOWE (2002: 229) reports that much of the thatch for roof making is obtained from the leaves of both, Solomon sago palm [*M. Salomonense* (Warb.) Becc. and *M. Warburgii* (Heim) Becc.], which is now commonly used throughout Vanuatu and Solomon Islands.

Moreover, EHARA *et al*. (2003a) investigated and reported the distribution, utilisation, morphological characteristics and production of *Metroxylon* in Vanuatu. The studies by EHARA *et al*. (2003a, b) and MCCLATCHEY (2002) both attempt to determine the essential composition, characteristics and distribution of the sago palm, especially on the *Metroxylon* section *Coelococcus* species and subsections therein, such as Fiji ivory nut [*M. vitiense* (H. Wendl.) H. Wendl. ex Hook.] and *M. paulcoxii* McClatchey and *M. warburgii* (sub-section 2). Detailed biogeographically determined studies by DOWE (2001, 2002); MCCLATCHEY (2002) and EHARA *et al*. (2003a, b) on the sago palm, have been confirmed that the distribution of *Metroxylon* section *Coeloccocus* species and its sub-sections are distributed in the following manner, Pacific ivory nut palm [*M. amicarum* (H. Wendl.) Becc.] is a species concentrated in Micronesia (Guam, Palau, Federated States of Micronesia and Marshall Islands; the *M. warburgii* is concentrated around Vanuatu and Rotuma; the *M. paulcoxii* is concentrated around Samoa; meanwhile the *M. salomonense* is clustered around the Solomon Islands.

FLACH and SCHUILING (1989), FLACH (1993, 1997), JONG and FLACH (1995), JONG (1995, 2002), RAUWERDINK (1986), among others, have all specifically advanced their methods and provide insightful analyses on sago palm cultivation on different soils in different localities, morphological characteristics of the sago palm and are now regarded as authorities on sago palm agronomy. From the viewpoint of extensive and intensive research works (EHARA *et al*. 2000, 2001, 2002, 2003a, b, c) on sago agronomy and taxonomy, have not only covered localities in Southeast Asia, but have now moved their comparative studies further to include localities within the Oceania region as well, which goes to show a more

Table 1 Some Ethnic Groups Producing Sago

Ethic Group	Locality	Palm Utilized	Status	References cited after Ruddle *et al.* (1978)
1. Abelam	East Sepik Prov., PNG	*Metroxylon* sp.	Wild	Lea 1964:122
2. Alfur	Interior Seram, Maluku, Indon.	*Metroxylon* sp. *Arenga* sp.	cultivated	Tauern 1918:102-105 Jensen 1939:342-343
3. Ambonese	Ambon Is., Maluku, Indon.	*Metroxylon* sp.	cultivated	Cooley 1962:10, 1967:138
4. Asamat	South Irian Jaya, Indon.	*Metroxylon* sp.	wil	Amelsvoort 1964:36-37
5. Bila-an	Mindanao, Philippines	*Corphya umbraculifera*	dwild ?	Grebrands 1967:29
6. Bisaya	Southwest Sabah Matto Grosso, Brazil	*Metroxylon* sp.	wild and cultivated	Ruddle (field survey)
7. Bororó	Karimata Is., Kalimantan,	not identfied	wild	Cook 1907:60
8. Dyak	Indon.	*Arenga* sp.	unknown	Bartlett 1963:208
9. Elema	Gulf Prov., PNG	*Metroxylon* sp.	wild ?	Rumens 1972:510
10. Foe (Kutubu)	Southern Highlands Prov., PNG	*Metroxylon* sp.	wild ?	Williams 1940:152-153
11. Gadio Enga	East Sepik Prov., PNG	*Metroxylon* sp.	wild	Dornstreich 1973:205-218, 331-333
12. Guayaki	Eastern Paraguay	*Arecastrum romanzoffianum*	wild	Clastres 1972:156 Metraux & Baldus 1948:436
13. Hanunóo	Mindoro, Philippines	*Arenga* sp.	unknown	Conklin 1957:87
14. Hiowe (Heve)	East Sepik Prov., PNG	*Metroxylon* sp.	wild	P. Townsend 1969
15. Hopoi	Morobe Prov., PNG	*Metroxylon* sp.	wild ?	Streicher 1934:236-237
16. Kai	Kai Is., Maluku, Indon.	*Metroxylon* sp.	cultivated ?	Geurtjens 1929:229-231 Nutz 1959:14-19
17. Kaingáng (Guarani)	South Mato Grosso, Brazil	*Arecastrum romanzoffianum*	wild	Henry 1964:163
18. Keraki	Western Prov., PNG	*Metroxylon* sp.	wild and cultivated	Williams 1936:422-424
19. Kimam	Dolak Is., Irian Jaya	*Metroxylon* sp.	wild and cultivated	Serpenti 1965:46-48
20. Kiwai	Western Prov., PNG	*Metroxylon* sp.	cultivated	Landtman 1927:101
21. Kwoma	East Sepik Prov., PNG	*Metroxylon* sp.	cultivated	Whiting and Reed 1939:178-179
22. Mailu	Central Prov., PNG	*Metroxylon* sp.	wild ?	Malinowski 1915:550-551, 598-599
23. Marind-anim	South Irian Jaya	*Metroxylon* sp.	wild	Baal 1966:484
24. Mejbrat	Ajamaru Dist., Irian Jaya	*Metroxylon* sp.	cultivated	Elmberg 1955:58
25. Melanau	Oya River, Sarawak	*Metroxylon* sp.	cultivated	Morris 1953:11
26. Mentawaians	Mentawai Is., W. Sumtra, Indon.	*Metroxylon* sp. ?	cultivated	Nooy-Palm 1968:169
27. Me'udana	Normanby Is., Milne Bay Prov., PNG	*Metroxylon* sp.	wild and cultivated	Schlesier 1965:6-15
28. Mimika	South Irian Jaya	*Metroxylon* sp.	wild and cultivated	Pouwer 1955:35-37
29. Mountain Arapesh	East Sepik Prov., PNG	not identified	unknown	Mead 1970:42, 143
30. Nimboran	Nimboran, Irian Jaya	*Metroxylon* sp.	wild	Kouwenhoven 1956:15-16
31. Nuaulu	South Seram, Maluku, Indon.	*Metroxylon* sp.	wild and cultivated	Ellen 1975:140-141
32. Orokaiva	Northern Prov., PNG	*Metroxylon* sp.	wild	Williams 1930:58-60
33. Punan	Rejang and Baram Valleys, Sarawak	*Eugeissona utilis*	wild	Beccari 1904:307
34. Siwai	North Solomons Prov., PNG	*Metroxylon* sp.	wild	Oliver 1955:29-30
35. Subanu	Mindanao, Philippines	*Corphya umbraculifera* *Metroxylon* sp.	unknown	Finley and Churchill, 1913:19
36. Tangu	Madang Prov., PNG	*Metroxylon* sp.	cultivated	Burridge 1969:41-42
37. Tanimbar	Tanimbar Is., Maluku, Indon.	*Metroxylon* sp. *Arenga* sp.	wild and cultivated	Drabbe 1940:80-84
38. Tasaday	Mindanao, Philippines	*Caroyota* sp.	wild	Fernandez and Lynch 1972
39. Tikopia	Tikopia, Solomon Is.	*Metroxylon* sp.	wild	Firth 1950:131, 133
40. Tor	Jayapura, Irian Jaya	*Metroxylon* sp. ?	wild	Oosterwal 1961:58
41. Toradja	Central Sulawesi	*Metroxylon* sp.	cultivated	Adriani and Kruyt 1951:200-207
42. Warao	Orinoco Delta, Venezuela	*Mauritia flexuosa* *Manicaria saccifera*	wild and cultivated wild	Heinen and Ruddle 1974:124 Wilbert 1976:319
43. Waropen	Teluk Sarera, Irian Jaya	*Metroxylon* sp.	wild and cultivated	Held 1957:178, 346-350
44. Wogeo Islanders	East Sepik Prov., PNG	*Metroxylon* sp.	wild	Hogbin 1939:306-308
45. Yimar	East Sepik Prov., PNG	*Metroxylon* sp.	wild and cultivated	Haberland and Seyfarth 1974:224-236

Notes: For the PNG cases, the author has inserted Prov., in lieu of Dist., for District, as these localities are now under administrative functions of Provinces, though the usage of Dist., was appropriate following the first couple of years after Political Independence in 1975. The author references cited for the forty-five (45) ethnic groups producing sago has been adopted and adapted after RUDDLE *et al*. (1978).

Source: Adapted and slightly modified where appropriate for the PNG cases from RUDDLE *et al*. (1978).

comprehensive approach to taxonomic reporting of sago palm's genetic and morphological variabilities in different SUAS. While this has been established, much more needs to be studied and reported of this generally 'underutilized' and 'neglected' food crop by synthesising local folk taxonomy [indigenous knowledge] with the conventional scientific methods for a better understanding of sago palm (FLACH 1997).

Ethnological Studies

Ethnological studies of the sago palm have been well documented and are abound in the literature (see Table 1), of which many researchers have attempted to explain the adaptive and beneficial role of sago palm in SUAS. Four main perspectives can be discussed, of which the conceptual and underlying assumptions are sometimes overlapping each other. They are: poverty-focused studies; nutritional status-focused studies; gender-focused studies and socio-economic studies. These studies, put together, are more or less thematic and development-related studies, owing to the thematic nature and intellectual quests for promoting economic development in these relatively underdeveloped SUAS studied.

In PNG, ethnological studies can be reviewed in the works of some of these researchers, who focused on these ethnic groups and localities, for instance, on the Sanio-Hiowe of East Sepik Province (TOWNSEND 1969, 1974); on the Koravake of the Purari River delta of Gulf Province (ULIJASZEK 1982, 1995, 2001); on the Oriomo Papuans of Western Province by a Japanese human ecologist, (OHTSUKA 1977, 1983); on the Siuhamason, a Kubo-speaking people of Western Province (SUDA 1995); on the Arapesh of the Abelam area of East Sepik Province (TOYODA 1995, 2001); on the Kukipi people of Gulf Province (MORAUTA 1982); on the people of Lake Kutubu and Kikori of Southern Highlands and Gulf provinces respectively (BUSSE *et al*. 1993 cited in NISHIMURA and LAUFA 2002). In Malaysia, ethnological studies have been done on the Melanaus of Sarawak (MORRIS 1953), on the Floodplain dwellers of Sungei Batu Pahat, West Malaysia (TAN 1983) and on the Penan foragers of Sarawak (BROSIUS 1991, BARKIN 1998), among others.

On the Sanio-Hiowe people of the East Sepik Province, TOWNSEND (1969, 1974) explored their subsistence behaviour and concluded that it was quite similar to other previous cited studies (e.g. LEA 1964) on the Abelam. ULIJASZEK (1982, 1995, 2001, 2002) has extensively studied SUAS for quite a long period of time in Gulf Province, focusing mainly on diets and nutritional status of sago eating Korovake people of the Purari river delta. ULIJASZEK (1995) cites the case that the 1947 Nutrition Survey Expedition (*cf*. HIPSLEY and CLEMENTS 1950) and the Tommy Kabu movement (*cf*. MAHER 1958), as the initial motivation behind the Korovake peoples' attempt to plant sago palms on new ground, so as to supposedly achieve economic growth in that period. ULIJASZEK (1982), in his earlier study attempted to measure the nutritional status and diets of the Koravake people again in 1980 and concluded that there was little impact on nutritional status, despite intensification of sago palm use.

Moreover OHTSUKA (1977, 1983) in his study of Gidra-speaking people of Oriomo Plateau, Western Province, attempted to establish the nature of their daily activities, by timing what they did during sago making expeditions and concluded that it took

approximately 2 kg of sago starch to be produced per hour (*cf*. TOWNSEND 1982: 15). SUDA (1995) also explored the scope and nature of sago palm starch productivity of Kubo-speaking Siuhamason people of Western Province and concluded that despite knowing other reliable methods to improve productivity per hour, they [Siuhamasonese] were still reluctant to change and adopt efficient means to obtain sago starch flour. Results of some of the studies investigated and reported of sago palm starch productivity are (*cf*. TOWNSEND 1982, SUDA 1995), along with those of (e.g. ULIJASZEK and PORAITUK 1993) and more recently that of (e.g. LAUFA 2004b) are provided in Table 2 below.

Table 2 Summary of studies on rate of sago extraction in selected localities in PNG

Author references	Technology of sago extraction kgh^{-1} (kg/hr)	Locality (Study sites)	Province
1. Hyndman (1979: 207)	1.90	Wopkaimin	Western
2. Ohtsuka (1977: 478)	2.00	Oriomo	Western
3. Schinldbeck (1980: 88)	3.66	Sawos	East Sepik
4. Ulijaszek & Poraituk (1981: 29)	3.50	Koravake	Gulf
5. Suda (1995: 5)	2.95	Siuhamason	Western
6. Laufa (2004b: 52).	2.00	Malalaua	Gulf

Notes: compiled and adapted from the literature review on Sago Research in Papua New Guinea by TOWNSEND (1982: 15) for author references 1-4, while author reference 5, was adapted from SUDA (1995: 5). Reference 6 was adapted after the author's original doctoral research results.

Source: Adapted and modified after LAUFA (2004a).

Moreover TOYODA (1995, 2001) studied the eating behaviour [consumption patterns], surrounding sago rituals and myths of the Abelam people of East Sepik province and reiterated again from previous anthropological studies (*cf*. LEA 1964) that one's own sago was to be given as a gift to someone, meaning one's own sago was not for self-consumption. MORAUTA (1982), on the Kukipi people of Gulf Province assessed the household behaviour and consumption patterns of the people and concluded that Kukipi people had a high rate of 'rural-urban' migration to Port Moresby and that most households surveyed relied heavily on trade store consumable goods such as rice and canned meat and fish, not to mention, they were buying most of the sago from other inland sago growing areas within Malalaua District. BUSSE *et al*. (1993: 46-7 cited in NISHIMURA and LAUFA 2002) describe in vivid details the cultural attributes of sago making, let alone the daily patterns of life in Fasu and Foi villages of Southern Highlands and Kikori people of Gulf Province (all ethnic groups are located within close proximity of the Oil Search company's oil project in the Kutubu area of Southern Highlands Province.

Teleological Studies

Teleological studies on the sago palm attempt to explain some of the philosophical interpretations of the specific uses of the sago palm's mode of production and utilization systems, be it traditional or modern *modus operandi*. Describing some cultural aspects of sago palm phenomena by capturing the purpose these serve; in a way, helps to illuminate the probable underlying salient features of SUAS, which could be quite useful in clarifying

the purpose and motivational factors behind starch utilization in different cultural settings. Not only is it crucial to discuss the important role a staple food such as sago starch has on SUAS, it is equally important to assess how different applications of technology to suit local food requirements may have an enormous input for supporting local food industries. Studies on technological adaptation of different SUAS with respect to sago palm pith extraction and pulverizing the sago palm piths so as to draw the starch, which is then used for food, have been explored. NISHIMURA and LAUFA (2001), in a study done on comparing sago pith extraction technologies and washing of sago piths technologies of SUAS in Southeast Asian countries and PNG, identified some similarities and differences, in which they attempted to classify according to three sago cultural zones. The classifications made were based on two factors: (1) on the purpose of sago starch use and (2) on the technologies used for pith extraction and washing of piths. Table 3 below provides the summary of the classified types done (NISHIMURA and LAUFA 2002).

Table 3 Summary of Classifications of Sago Cultural Zones

Classified Types	Area (Country)	Purpose of starch use	Technology used for sago pith extraction	Technology used for sago piths washing
1. Malay-type	Sarawak (Malaysia)	Commercially-oriented for domestic and international market	Grating[a]	use of feet (trampling)
2. Intermediate-type (Sulawesi)	Sulawesi (Indonesia)	Commercial & self-consumption	Grating & hatchets	use of feet (trampling) & hands (kneading)
3. New Guinea-type	Malalaua (PNG)	Mainly for self-consumption with exceptions for sale at local markets	hatchets	use of hands[b] (kneading)

Notes: (a) The Malaysian case is now heading towards automated machinery.
(b) The use of hands here is only representative of the Malalaua case and is not inclusive of other places within Gulf Province or other provinces in PNG (*op.cit.* BUSSE *et al.* 1993: 46-7).

Source: Modified and adapted after NISHIMURA and LAUFA (2002), p.14.

Though the use of hands in washing sago piths (kneading) is quite common also in PNG, there are some exceptions to this method, as is indicated in a study by BUSSE *et al*. (1993) conducted in the Kikori area of the Gulf Province and in the Lake Kutubu area of Southern Highlands Province. BUSSE *et al*., (1993: 46 cited in NISHIMURA and LAUFA 2002) observed that Kutubu project area, owing to its close proximity to the Central Highlands or the Papuan lowlands, rather than other cultural aspects witnessed two distinct methods of washing sago by feet and hands (kneading and trampling). Fasu and Foi people of the Southern Highlands Province living closest to the Central Highlands use hands to wash sago piths to collect starch, which is quite similar to Goaribari Islanders in Papuan Lowlands. In a stark contrast, women in Manu and Tamadigi, the Fasu villages closest to the Papuan Lowlands and women in lower Foi, squeeze the sago piths with their feet. In the Highlands, it is widely believed that when women squeeze the sago piths with their feet, they are

contaminating the food, which would make men sick, if they were to consume this sago (*ibid*: 47 cited in NISHIMURA and LAUFA 2002).

Food Technology, Biotechnology and Food Security

Food technology bordering on biotechnological innovations has been explored, so as to produce a desirable outcome such as achieving food security, especially for developing countries facing critical food shortage, which is attributable to chronic balance of payment problems caused by heavy dependence on food imports, are not new themes. Studies have proposed that the genetic manipulation of sago palm could reduce the maturity period from ten or more years to lesser number of years. In comparing starch utilization in Asia, CHULAVATNATOL (2001), from his vast experience in cassava starch research, argues that, for sago starch to be developed as a prominent material, much has to be done on speeding up the maturity of the plant and reducing the pollution during starch processing (*cf.* CECIL 2001). Cassava as a source of starch only takes a year to harvest (CHULAVATNATOL 2001), while sago palm reaches maturity eight to fifteen years (*cf.* HASSAN 2001). Genetic manipulation to reduce the maturity of sago palm is possible; however, such a strategy adopted for sago starch will not guarantee automatic entry into the starch market, as cassava, rice and wheat presently enjoy a large share of the global starch market. From a more realistic viewpoint, it is argued, "before esoteric methods of producing new palms are adopted for the production of genetically modified 'early maturing' palms, a thorough search amongst existing genotypes should be conducted" (STANTON 1993: 4).

Theories of Sago Palm Research

The two main theoretical assumptions pertinent with sago palm research, especially related to cultural ecological accounts of this palm, which have generated much intellectual debate amongst sago palm researchers are: the centre of diversity hypothesis and the Headland/Bailey food scarcity thesis. The divergent and convergent views surrounding one of humankind's staple foods, the sago palm starch in marginal lands of some tropical countries, makes the sago palm research in this area an unsettled polemic and perhaps a new paradigm or model to incorporate these hypotheses is quite necessary, albeit reservations and paucity of data to reconfirm, refute on the basis of positivism or empiricism [laboratory experiments] as it were. As can be judged in the present time, there is no emergent school of thought, let alone a train of thought that will advance the theory building aspect further. Significant interest in sago research is still abound in the literature and remains so, thus exploring them may serve to reinforce our thinking and appreciate other scholars' research data and information, whilst at the same time acknowledging that synthetic efforts may override other important measurements and conceptual issues, of which in some respects, negations of assumptions may result.

The "Centre of diversity" of Sago Palm (*Metroxylon sagu* Rottb.) Hypothesis Debate Revisited

The underlying assumptions of the centre of diversity hypothesis of the sago palm has

drawn much of its strength and character from its nature as being part and parcel of the rainforest; the connotations associated with sago palm's "wildness" (STANTON 1993 cited in NISHIMURA and LAUFA 2002), who aptly referred to the centres of diversity of sago palm as the "saga" for sago, in which the palm's "wildness" has not been lost, in a challenge he offered to stimulate researchers to venture in, as this served as advantage in the first publication of the *Sago Palm Journal*. Taken from a regional perspective, FLACH (1997) refutes an earlier claim by BECCARI (1918) that the centre of diversity of the sago palm is the Moluccas Islands in Indonesia by counter arguing that given the considerable amount of wild stands of sago palms; in FLACH (1983) estimate of 2.2 million hectares found on the Island of New Guinea alone, it was therefore logical to consider New Guinea as the centre of diversity. BECCARI (1918) centre of diversity hypothesis appears to be an unsettled matter of academic interest in sago research, which oscillates between Moluccas Island and New Guinea Island, according to different researchers. Devotees of this Beccarian hypothesis (e.g., CELIZ *et al*. 2000: 44; 2001: 2; 2002: 17 cited in NISHIMURA and LAUFA 2002) also claim that the sago palm originated from Moluccas Island in Indonesia because "it was reported as a major agricultural crop in the 14th century in South Mindanao, Northern Borneo, Sulawesi and Maluku Islands".

The PNG Ministry of Agriculture and Livestock via its blueprint observes adamantly, too, that because one million hectares of sago stands, comprising of 20 to 30 folk varieties; then such a high degree of genetic diversity makes PNG the potential candidate for the centre of origin for sago. NISHIMURA and LAUFA (2002) also support this view on the basis that sago palm is a native crop of New Guinea Island because it is still very much a staple food crop, especially for the Gulf people, though much of it is gathered from wild stands in the swamps (*cf*. VASEY 1985: 50). Thenceforth, any thesis related to the centre of diversity hypothesis of the sago palm should not loose sight of the key issues of sago palm's role as a staple food source as well as its sheer magnitude from spatial contexts, as being an essential component of the natural rainforest. It could well be argued that the origin of sago palm's loci could be traced back to the New Guinea Island; however, the plant was then transmitted to the western part of the island, which later reached Sulawesi and then to Malaysia. Therefore, there is a strong possibility, postulates NISHIMURA and LAUFA (2002) that the borderline of sago palm plant and idea transmission is Sulawesi Island, as is also highlighted in a study (WHITTEN *et al*. 1987: 60 cited in *ibid*.) in reference to the Wallace line and Weber line as a borderline area for ecological studies. Perhaps these two different biogeographical lines allude to the possibility that sago could have originated from the Pacific, especially from PNG and moved eastward towards Solomon Islands and Vanuatu and then moved westward towards Irian Jaya, eastern Indonesia to Borneo and moved further as far as Northern Mindanao, Philippines. The characteristics and the purposes of starch use in Sulawesi mediate between the New Guinea Island and Malaysia. Suffice it to say, with the transmission of sago palm came the use of different technologies, which were adopted and adapted for the local conditions and reality (NISHIMURA and LAUFA 2002).

Headland/Bailey Food Scarcity thesis

HEADLAND (1999 citing HEADLAND 1987; BAILEY *et al*. 1989), argue that they popularised the Headland/Bailey food-scarcity thesis; developed independently of each other in their initial writings, which later drew much criticism from other scholars with references to the underlying assumptions of their hypothesis. Because of the enormous interest in empirically verifying and refuting the initial arguments of the Headland/Bailey food-scarcity thesis, the academic journal, *Human Ecology* volume 19; a special issue, was expressly dedicated to discussing the merits and demerits of this hypothesis. Interestingly enough, THOMAS HEADLAND and ROBERT BAILEY were the guest editors of this special issue then, which was entitled, *Human Foragers in Tropical Rain Forests* (HEADLAND 1999). The main underlying assumption of their [Headland and Bailey] hypothesis was that hunter-gatherers would never have lived in tropical rainforests without direct or indirect access to cultivated foods. This alluded to the possibility that some form of trade relationship existed between horticulturists and rainforests foraging communities. HEADLAND and BAILEY (1991) challenged the assumption that peoples living today as foragers in tropical countries, to whom, it is argued, have been subsisting in their forests habitats for millennia were only recently introduced to sources of domesticated plants and animals.

BROSIUS (1991), on a study on the Penan hunter-gatherers of Sarawak in East Malaysia, refuted earlier studies by BAILEY *et al*. (1989); HEADLAND (1987) on their food-scarcity hypothesis on the basis that the Penan foragers had always and will continue to subsist on the sago palm *Eugenissona utilis* Becc.; thus, the [Penan's] mere subsistence on sago palm does contradict the validity of the assumptions put forward by HEADLAND and BAILEY (1991). By the same token, BARKIN (1998) challenged the assumptions of the food-scarcity hypothesis of HEADLAND (1987) and BAILEY *et al*. (1989), citing the same case of the Penan foragers of Sarawak to refute the claims championed by HEADLAND and BAILEY (1991). BARKIN (1998) referred to the Headland/Bailey food scarcity thesis as the 'Green Desert Hypothesis', in a sense that rainforests are generally argued to be nutrient deficient in complementing dietary requirements for human consumption. Because the initial writings of HEADLAND (1987 cited in BARKIN 1998) addressed the 'Wild Yam Question', a vital source of carbohydrate for a Filipino foraging community in Sierra Madre, the largest tropical rain forest in the Philippines, may have justified the underlying assumptions of the food-scarcity thesis; however, its general and wider application to other foraging communities, is open to question. It is argued that all human activities, be it hunting, gathering, horticultural, and perhaps trading (e.g. ENDICOTT and BELLWOOD 1991, BAHUCHET *et al*. 1991) from spatiotemporal perspective, is rather anthropogenic, therefore, acknowledging that natural habitats are modified by humans; hence, the ensuing debate on the food scarcity debate (HEADLAND 1999). DWYER and MINNEGAL (1991), in a study observed that the socio-ecological bases of the hunting system of the Kubo Lowland people of PNG aptly shows the apparent lack of necessary dependence on agricultural system and proposed a model of non-agricultural subsistence in lowland tropical rain forest. ALLYN STEARMAN (1991: 245-260) proposed that human disturbance was a causal factor of dependence on agriculture by modern human foragers rather than as a necessary

precondition for successful exploitation of tropical forest. HEADLAND (1999), in the final analysis recognizes and concurs that the original hypothesis he put forward is no longer as simple as it once seemed, he cites the example here that "most of the sago forests in Borneo and Maluku are anthropogenic, with many of the "wild" sago palms actually planted by man.

Sago Research - Where do we go from here?

In eclectically reviewing the literature on sago research, there is a distinct gap in knowledge, especially on conceptualising what the underutilization phenomena of the sago palm entails, of which only two studies (*cf.* FLACH 1997, RUDDLE and RONDINELLI 1983) broadly and partially highlight that sago palm is very much a 'neglected' and 'underutilized' plant. While this bears an eloquent testimony in the literature, there has been no unified position taken to clearly demarcate the discernible association of what entails the 'neglected' and that of the 'underutilized' of sago palm studies, as it were. A study done four years ago by LAUFA (2004a) attempts to fill part of this knowledge gap in not only explaining, in terms of abstracting and describing causes of the underutilization phenomena, but extends beyond that by also attempting to provide an understanding [making sense] of the phenomena in principle. To do this, LAUFA (2004 a, b) works are devoted to explaining the underutilization phenomena of the sago palm, of which evidence is drawn from SUAS in Malalaua area of PNG to verify some of its underlying causes. Following on from that a recent study observes that strategic management of sago palm resources would be better understood through applying and promoting biodiplomacy at both international and local levels wherein knowledge management is a critical requirement that promotes mobilisation of scientific and traditional knowledge so as to bring sago palm to the next level of commercial production anchored in scientific principles of constant experimentation for higher yields, especially for rural based SUAS as reported in (LAUFA and KAVANAMUR 2008: 57).

Conclusions

This study is not exhaustive and only attempts to illuminate some of the sago research carried out in Pacific Island Countries with some reference being made to Southeast Asian region. From agronomics point of view, it has been noted that the 8th ISS (Jayapura, Indonesia 2005) concluded that various types of sago palm (*M. sagu* Rottb.): this species includes not only spineless sago palms but also spiny sago palms and that they should be identified as "folk variety" because genetic diversity of sago palm is not clear at this moment. Furthermore some scientists suppose from their molecular works that four genetic groups exist in (*M. sagu* Rottb.). Until the genetic diversity is made clear, sago researchers will use the term "folk variety" to explain variation of sago palm. Future reviews studies need to update knowledge, information and data researched and reported on the following: (1) on agronomics of sago palm, (2) ethnological studies which covers socio-economic

studies, (3) teleological studies that examine closely the linkage between the adoption of biotechnology and food technologies and how this might affect food security in SUAS and (4) on the various scientific and social theories on sago palm put forward and these could come from the three identified areas of key research considerations.

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