The reversed fortunes of sago and rice, *Oryza sativa*, in the rainforests of Sarawak, Borneo

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1. Introduction

Domesticated rice, *Oryza sativa*, is the main carbohydrate staple for most peoples in Sarawak. Its dispersal is linked to the origins of agriculture and spread of the Neolithic in the region (Bellwood, 2005: 134–141). Currently it is argued that domesticated rice is an introduction from mainland Southeast Asia, following either a sea-borne route into Borneo from the north via Taiwan or west via the mainland sometime during the mid Holocene. The purpose of this paper is to reappraise the model and suggest that while rice might have been introduced during the mid Holocene, it was not successful, and in fact might not have been widely adopted until the historic period. Rice appears to be an illogical crop choice in the rainforests of Borneo; it is difficult to grow, prone to failure and often low-yielding. By contrast, people had access to many other high yielding plants, particularly the sago palms which appear to have been widely cultivated in the recent historic past. As a crop, rice, in a vegetation world of sago and taro, may not have been adopted to reduce the ‘risk’ of going hungry, but because its successful cultivation is inherently ‘risky’ and prone to failure, and thus uniquely, was attractive as a playing piece in games of social competition between individuals.

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the region. The paper also considers the possibility that rice and its associated agricultural practices, while introduced during the mid Holocene, may have been largely ignored as a food crop here for millennia.

2. Archaeological context of rice in Borneo

Based on limited archaeological evidence, rice remains, including rice phytoliths, have been recovered from cave sediments at Gua Sireh (Fig. 1) located on the southwest coastline of Sarawak at 4840–4100 cal BP [ANU 7049] (Datun, 1993). More recently, pollen grains at a site near Niah Cave have been identified as domesticated rice pollen, dated to c. 6000 BP (Hunt and Rushworth, 2005: 467). However, given that four species of wild rice (O. meyeriana, O. officinalis, O. ridleyi, O. rufipogon) grow on Borneo (Vaughan, 1991; Vaughan et al., 2005), this claim for early domesticated rice should be treated cautiously. Following these early dates, the record of rice in the region falls silent in Borneo, and indeed in other island sites, where most of the archaeobotanical evidence of rice actually consists of rice impressions or temper within pottery, rather than as food refuse (Paz, 2002). For example, a grain of rice (of unknown species) was identified in pottery fabric at Niah Cave dated to 2925–2469 cal BP (Doherty et al., 2000).

The nature of rice inclusions in pottery deserves further scrutiny. There is a tendency to refer to rice inclusions as ‘temper’ when in fact all that is reported is the presence of a single or few grains or fragments of rice husk (e.g. Bellwood et al., 1992; Doherty et al., 2000; Snow and Shulter, 1986). Additionally when rice is identified, the species of rice is not, and often it is not even clear if the fragments are derived from wild or domesticated varieties (e.g. Snow and Shulter, 1986; Yen, 1982).

Peter Bellwood has strongly argued that domesticated rice was brought into Borneo during the dispersal of Austronesian-speaking rice farmers and also claims that there is no evidence for any form of food production in island Southeast Asia prior to 3000 BC [ca.5000 BP] (Bellwood, 2005). Recent work at the Niah Caves on the northwest coast of Sarawak, Borneo, has reaffirmed the antiquity of human occupation here (dating to at least 45,000 BP) with continuous though intermittent use of this site until the late Holocene (Barker et al., 2002; Barton et al. forthcoming). Analysis of plant and animal remains at Niah Cave shows a terrestrial-based, rather than marine or coastal-based economy throughout the Pleistocene, with evidence of hunting arboreal prey, use of composite organic weaponry and ballistic technology (Barton, 2009) and people with the ability to detoxify several poisonous but high yielding plants (Barton and Paz, 2007).

Recent archaeological work in the interior Kelabit Highlands has now provided the first well-dated evidence of human occupation here, which dates from at least 3000 BP, with suggestions of earlier forest disturbance dating to c. 5000 BP (Barker et al., 2008; Lloyd-Smith et al., 2010). Further work is needed, but currently there is good archaeological evidence of sedentary communities, constructing megaliths and possibly longhouses from at least 2000 BP (Lloyd-Smith et al., 2010). Analysis of pollen cores and phytoliths is ongoing. Today, some Kelabit state firmly that they have only ever grown rice, whilst others admit to their grandparents eating sago on occasion, and Harrisson (1959) recorded the use of sago by Kelabit hunting parties when several days away from home. Large stands of sago palm that surround current Kelabit settlements, both occupied and abandoned, suggest that this palm was of central importance to these and other inland groups in the not so distant past. The recovery of large numbers of cylindrical stone pounders from many locations in the highlands (Harrison, 1951) used as sago processing tools (Barton, forthcoming) further indicate the importance of this palm in prehistory. Recent excavation has recovered a broken section of one of these pounders from a stone wall feature near the village of Pa Dalih, in the southern Kelabit Highlands (Fig. 1). Radiocarbon dating of charcoal recovered from the packing of this wall produced an age of 1700–1500 cal BP (Beta-280499), providing a plausible date for the antiquity of sago use and perhaps also of sago cultivation in the interior highlands of Borneo.

3. Ethnographic context

The ethnographic and historic record suggests that the story of domesticated rice is highly contextualised throughout Southeast Asia. The introduction of rice into Southeast Asia, particularly Island Southeast Asia, may not have been a sudden change associated with
intermittent but sustained population dispersals from Taiwan (e.g. Bellwood, 2005; Diamond and Bellwood, 2003), nor necessarily a slow gradual transition following its earliest regional introductions in the mid Holocene. Rice may have waxed and waned in importance across space and through time; in some places it may have been more important in ceremonial contexts (especially in the production of alcohol) than as a food (Hayden, 2003; Janowski, 2004) and may also have become important as medium of exchange between some indigenous groups and the expanding inter-island trading networks associated with European spice merchants and Chinese traders (e.g. Bulbeck and Caldwell, 2008; Swadling, 1996). In the recent past and today, rice is used to establish and reinforce individual and inter-group social hierarchy (Janowski, 2007).

Amongst many groups in interior Borneo, rice remained a minor crop until relatively recently, supplementing other starchy staples, frequently root crops (Harrisson, 1949: 142). Amongst the Dusun of North Borneo, though rice was planted by all ethnic groups, it was considered supplementary to a diet of taro and imported South American cultivars such as cassava, sugar cane and maize (Rutter, 1929: 75). Wild fruits and sago were also considered important, though the latter more so in the swampy lowlands (Rutter, 1929: 96) which suggests the sago in question may be the introduced swamp-sago, Metroxylon sagu Rott. In his assessment of the pre-1960s irrigated rice fields of the Kelabit Highlands, Tom Harrisson considered them uncharacteristic of wet rice farming elsewhere and thought them overly elaborate: possibly a relic of an earlier agricultural system, one that may have been based on root crops and sago (Harrisson, 1964: 333). Likewise, Egghenter and Sellato (2003: 23) are willing to consider that the earliest groups occupying the Kerayan region of interior Indonesia may have been horticulturalists with a subsistence system based on tubers.

Taro is almost certainly indigenous to Borneo, present as charred tissue in the Niah Caves at least 20,000 years ago (Barton and Paz, 2007) and may well have been independently domesticated in Island Southeast Asia (Lebot, 1999). The poisonous yam, Dioscorea hispida, is also present in Pleistocene sediments at Niah Cave, and was an important food for several groups of hunter-gatherers in Malaysia (Kuchikura, 1987) and the Philippines (Eder, 1978). Henry Burkill (1935: 831) considered this yam to be the most important famine food of the East. The giant taro, Alocasia marcorrhizos, produces a massive starchy rhizome, is also common throughout the region, and while largely ignored today was almost certainly a target of foragers and cultivators in many places (Brown, 2000: 262). It is frequently found in disturbed locations and areas of abandoned cultivation in coastal and interior regions of Sarawak.

Starch-rich palm pith, known collectively as sago (see Ruddle et al., 1978) was widely exploited by many groups across Borneo (Morris, 1953, 1991; Rousseau, 1990: 247), Indonesia (Ellen, 2006), Sumatra (Henley, 2005; Wallace, 1869), New Guinea and near Oceania (McClatchey et al., 2006; Townsend, 2003) and even in India and Nepal (Ganwar and Ramakrishnan, 1990; Smythies, 1952). Amongst different groups, sago plays the role as either the chief cultivar or as the most significant fall-back food, should the rice crop fail (Burkill, 1935: 1485). Sago also appears to have been exploited since the Pleistocene in Borneo as evidenced from recovered starch granules of sago palm at Niah Cave dated to 40,000 years ago (Barton, 2005). In Borneo there are several families of palm that produce sago. Of these, two genera are the most important in Borneo, Metroxylon sagu Rott. (New Guinea swamp sago – used by the sedentary Melanau (Morris, 1953)) and Eugeissonia utilis (hill sago), used by the eastern Penan. Indigenous Cynotrya spp. and Arenga spp. were also important sources of sago (Langub, 1989; Puri, 1997) and there are several other smaller palms that may be used in emergencies.

Observations of the cultivation of rice in the wet tropics have raised conflicting questions about its suitability as a crop where it is sometimes cited as ‘illogical’, ‘low-yielding’, and ‘hard work’ (e.g. Ho, 1967: 98; Persoon, 1992; Strickland, 1985) and occasionally as ‘surprisingly productive’ (e.g. Lambert, 1985; Padoch, 1983). Palm sago is frequently mentioned, sometimes shamefully, as a resource to make up shortfalls in the rice harvest or as an important famine food. A Malay farmer remarked to Tom Harrisson that sago is only good for one thing, ‘keeping from total empty’ (Harrisson, 1970: 300). The Dusun of North Borneo (Rutter, 1929: 95–96), the Maloh of west Kalimantan (King, 1985: 154), the Kayan (Rousseau, 1990: 146), the Kajang (Nicholaesen, 1986), the Kejaman (Strickland, 1985), the Iban (Freeman, 1955: 105), Malays of southwest Sarawak (Harrisson, 1970), and the Kelabit (Harrisson, 1959: 66) are all recorded as using sago in the recent past and of sometimes cultivating small stands of sago palms. Studies by Persoon (1992) and Strickland (1985) showed clearly that the relative productivity of sago is much greater than that achievable with rice amongst swidden farmers, yet individuals appeared continually drawn towards rice and rice farming, even if that meant they had less free time and put themselves under greater pressure to feed their families.

4. Benefits and costs of rice farming

Most forms of rice cultivation have high labour costs; irrigated wet fields for example, demand constant attention and regular supplies of water (Fuller and Qin, 2009). Dry fields, or swidden rice, also require significant labour inputs. Padoch (1983: 38) estimated that keeping irrigated wet fields required inputs from 178 to 193 person days per hectare, and Padoch (1985: 281) that hillside swidden varies between 122 and 135 person days (6.5–7 h), while Conelly (1992:208) records that managing forest fallow varied between 118 and 142 (up to a staggering 357 person days per hectare. After all this effort, harvests are still prone to failure or major reductions in yield due to many extraneous factors, mostly rainfall, weeds and pests (De Datta, 1981). Figures supplied by De Datta (1981: 472) show that left unchecked, weeds may reduce grain production by as much as 83%. Modern methods of rice farming can produce high crop yields in both wet and dry methods of cultivation (De Datta, 1981). Yields for wet fields in Southeast Asia typically average around 3.6 t/ha though yields of greater than 5 t/ha are possible (De Datta, 1981: 561). Yields from dry fields or swidden hill rice are often much lower at around 1 t/ha on average (De Datta, 1981: 253). However, these figures may be quite misleading when considering the historic context of rice and the likely yields available to farmers using hand tools to clear forest and make wet and dry fields. Typical yields from farms using hand tools for hill swidden range between 200 and 800 kg/ha and for swamp rice from about <200 to 1000 kg/ha (Fig. 2).

Major constraints on upland rice yield include variation in rainfall, soil nutrients, weed competition, and diseases such as rice blast (De Datta, 1981: 253). Within the tropics the timing of the harvest is also crucial to minimise losses due to pests such as rats, birds, insects and from shattering of the seed head during harvesting (De Datta, 1981: 514). Derek Freeman recorded rice yields for 25 Iban families from 1949–1950 noting that 32% would produce an annual surplus, 48% would achieve results somewhere between 51% and 100% of their annual requirements of rice, and 20% would fail to produce less than half their annual requirement. Thus a shortage of their staple carbohydrate was not infrequent. Freeman (1955: 103) estimated that an average Iban family of five would need approximately 500 gantangs of unhusked rice) annually including a small surplus for replanting, rituals and other activities. The volume of 1 gantang is approximately 2.5 kg of unhusked rice. Some in the region would need approximately 500 gantangs of unhusked rice (Fig. 2).
offerings and fermenting into rice wine, known locally as *tuak*. For subsistence alone the requirement was around 440 gantangs or ~1056 kg for family of five (Freeman, 1955: 103).

Not all farming communities are as successful as the Iban however. Amongst the Sekapan over a two year period from 1983–1984 out of 63 households, only 36% attained their annual needs for rice, where 39 households produced only 50% of their annual needs (Nicholaisen, 1986). At a settlement of 49 Punan Bah households that farmed rice in 1982/83, only 27% of the annual village needs of rice were met and in 1983/84, the figure was only 23%, though two households did produce enough to cover their own needs completely (Nicholaisen, 1986: 96).

In the recent past only one group of settled shifting cultivators still relied on and cultivated sago as the main staple; the coastal Melanau. Historically the Melanau occupied the low coastal plains of Sarawak from Bintulu to the mouth of the Big Igan River where they cultivated large stands of up to 748 palms/ha (Morris, 1953: 22) of swamp sago, *Metroxylon sagu* Rott (Morris, 1991). This particular sago palm originally grew no further west than the Moluccas and Papua New Guinea (Flach, 1997) and has been introduced into Borneo and further westwards sometime in prehistory. The coastal environment inhabited by the Melanau was not suited to intensive rice cultivation, though some groups did produce a little swamp rice, *padi paya*, grown along the river banks, though yields were low and it could never be relied on (Morris, 1991). The inland Kajang groups (which include the Sekepan, Kejaman, Lahanan, Punan Bah, Sipeng and Bemali) (Nicholaisen, 1986) until recently also cultivated a mixture of the indigenous hill sago and imported swamp sago, c. 1 palm/ha (Nicholaisen, 1986; Strickland, 1985: 126). In one village under study, individual households were said to own on average between seven and 41 swamp and hill sago palms (Strickland, 1985: 126). While they grew other crops including cassava, maize, sweet potato, taro, and yam, major carbohydrate deficits were normally made up by the consumption of sago flour (Nicholaisen, 1986: 96). The botanist-explorer Hugh Low recorded in 1882 that the Kejaman (Kajaman) ‘prefer sago to rice, farm meagrely, but then they grow the palm’ (ibid: 65). Monica Freeman (2009) recorded several instances of sago processing amongst the Iban when rice was short, for example, for 21st July 1949 ‘several people arrived seeking rice having only four guntans (about 8 kilos) left, despite the fact that the *padi* has not been long reaped’ and for the 24th November 1949, that ‘a number of men have left to get sago as a result of the gawai. Every *bilek* but one is out of rice’. As a result of frequent rice shortfalls, most families, *bilek*, maintained small plantations of sago palms (D. Freeman, 1955: 105).

Harrisson also noted groups of Malay rice and rubber farmers either collecting sago or keeping an eye on it as ‘The knowledge, the feeling, that there *is* sago about matters a bit to a Malay, in trouble. The sago has to be at least nurtured and should be cultivated in the delta. But such interest will seldom be admitted, in this area, at this time’ (Harrisson, 1970: 298). Practicing a mixed farming economy is typical throughout the region, both on the Mainland (Gianne and Bayr, 2009) and the islands. Amongst the Pahang Malay on the Peninsular ‘Root crops are planted as insurance, in case the rice crop fails. Wild food plants are protected from destruction when clearing and burning garden plots, in case of subsequent cultivated food scarcity’ (Lambert, 1985: 28). Rice is ‘risk’ in these landscapes and yet it is grown and communities continue to persevere with rice in the face of other less risky and less labour intensive alternatives. Rice is not a logical crop option in rainforest, and while it does have the potential to produce very high harvest yields, for many, harvests are either less than required for self-sufficiency, sometimes break-even, and rarely in excess. When growing rice, people remain heavily dependent on indigenous plants (sago, taro, yams) and imported (manioc, sweet potato, maize) alternatives and fallbacks. In other words, there appear to be strong cultural pressures, rather than rational economic reasons for persisting with rice cultivation in the wet rainforests of Borneo.

5. Harvest yields of swidden and swamp rice

Calculations of harvest yield provide a useful framework for understanding the nature of this crop and an expression of its inherent variance between harvests. Fig. 2 provides an overview of rice production from swidden and swamp rice, *padi paya*, fields using hand tools. All data presented in Fig. 2 (yield/kg/ha) are derived from published data though conversion from local units, such as gantangs and usually conversion from imperial units to metric were necessary in most cases. The data for swidden yields derives from several independent sources (Strickland, 1985; Nicholaisen, 1986; Conelly, 1992; Colfer, 1997) and those for swamp rice come from a single source (Lambert, 1985). There are other published figures and these are by no means exhaustive, but for swidden yields these were preferred as they included field size and in most cases total person hours. The latter data is necessary for calculations of energetic return rates that are provided below. Sometimes hours worked was recorded, but these data were averaged across all farms surveyed, which made it unsuitable for this analysis as it removed inherent variance between fields.

In this sample field size ranges from c. 0.3 ha up to 3.7 ha and yields from 229 kg/ha up to 1170 kg/ha. The lower value seems to repeat in studies of swidden and swamp rice, suggesting that this is a common minimum field unit. Harrisson (1970) also recorded this value for pioneer rice farms made by coastal Malay populations, normally expressed in local units as consisting of 9—10 *pajak* (where one *pajak* = 10 fathoms²/60 ft²/18.3 m²). A *pajak* is also referred to as a unit of work; representing the expected unit of daily effort (Harrisson, 1970: 575). Average field size for the swidden data is 1.8 ha (SD 0.9) and for swamp rice the figure is slightly lower at 1.3 ha (SD 0.8). As noted above, Harrisson recorded that pioneer rice farmers cleared initial fields of around 0.3 ha, and these were gradually expanded if the farmers stayed with rice. The distribution patterns of yield by field size between swamp and swidden rice are slightly different where swamp rice shows a clear trough once field sizes increase beyond 1.5 ha in size, though both show decreased returns in field sizes above 2 ha. The marked drop in returns for swamp rice at this point probably reflects differences in the organisation of labour groups amongst the Pahang Malay, from which these data are drawn. They preferred to work as independent households with very little cooperative labour between households (Lambert, 1985: 91),

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**Fig. 2.** Harvest yield data (kg/ha) of swidden and swamp rice from Malaysia and the Philippines.
whereas cooperative labour is an important feature of the hillside swidden farmers such as the Iban (Freeman, 1955).

Derek Freeman (1955) estimated that an average family of five would require \( c. \geq 1200 \text{ kg/year} \) (including excess for replanting fields) to remain self-sufficient on rice alone, which provides a useful upper figure for rice production. Within the figures shown here total farm yields/ha were on average 578.1 kg ranging from 229 kg/ha up to 1170 kg/ha where field sizes range from 0.3 ha up to 2.4 ha. While field sizes do vary considerably, where these data can be calculated \((n = 16)\) 75% of farms produced yields of between 200 kg/ha to \(< 600 \text{ kg/ha} \) – which is enough to feed 1-3 persons for a full year only. The data used here expresses harvest yield in terms of unhusked rice. On average then, rice could rarely fulfil the energy requirement of a household in most years and often was not enough for less than half of the household. As such, there were times when rice might be considered a staple and others when rice was only a minor part of the annual diet. Such high variance in return rates has an enormous impact upon the strategies necessary to feed yourself and especially, dependents within the family group, where some harvests might produce very little while a very few could produce a surplus.

The results reaffirm the relative risks involved in farming rice in this landscape, but also the occasional payoffs. Rice provides a moderate return for the labour invested, and is not dramatically different from a range of other options available to rainforest communities in Borneo, such as foraging for tubers (Table 1). But, when the energetic costs of upland rice are compared with the harvesting of wild sago (below), rice is completely dwarfed by the returns from sago in particular and possibly also from taros (including Colocasia esculenta and Alocasia macrorrhizos) and yams, was rice cultivation even possible in the rainforests of Borneo?

### 6. Comparison of rice and sago productivity

The calculation of caloric return rates (energy input/output) of rice farming allows comparison of the relative productivity of rice as a food source against other subsistence options within the rainforest. The data presented in Table 2 are based on foraging calculations that present energy returns in kcal/person/hr based on total harvest yield minus the energy spent collecting and processing that resource. Data of this sort are normally collected to analyse decision-making in hunter-gatherer economies based on an optimisation premise that individuals will tend towards cost efficient behaviours in the pursuit of food, freeing up time and resources to engage in other activities (Winterhalder and Kennett, 2006). These models assume some kind of ‘rate-maximising’ behaviour on the part of individuals, often measured using an energy budget (e.g. kcal/h). A calculation of calories is used in part because subsistence behaviour on the part of individuals is regarded to be of primary concern for hunter-gatherers, but also because it represents a value that can be measured repeatedly and has application for use in archaeological models.

#### Table 1

<table>
<thead>
<tr>
<th>Type</th>
<th>Plant</th>
<th>Scientific name</th>
<th>Kcal/hr/person</th>
<th>Environment</th>
</tr>
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<tr>
<td>Nuts</td>
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<td>Quercus gambeli</td>
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<td>Great Basin*</td>
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<td></td>
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<td>Fruits</td>
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<td>Carapee gigantea</td>
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<td>Arizonaa</td>
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<td></td>
<td>Bush tomato</td>
<td>Solanum centrale</td>
<td>5984</td>
<td>Central Austriac</td>
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<td>Figs</td>
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<td>Casimiroa sp.</td>
<td>4181</td>
<td>Paraguayd</td>
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<td></td>
<td>Readio sp.</td>
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<td>Tubers</td>
<td>Yams</td>
<td>Dioscorea luzonensis</td>
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<td>D. hispida</td>
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<td></td>
<td>Metroxylon sago</td>
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<tr>
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<td>Maize</td>
<td>Zea mays</td>
<td>2341I</td>
<td>Arizona1</td>
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*Based on an estimate of Early Agricultural period grinding rates.
*a Data from Palawan Island, Philippines. All other data from tribal groups in Borneo.

#### Table 2

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Field Size</th>
<th>Yield/ha</th>
<th>Person hours</th>
<th>Kcal/hr</th>
<th>Source</th>
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<td>Kejaman</td>
<td>0.3</td>
<td>283</td>
<td>3248.3</td>
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<td>Kejeman</td>
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<td>1716.2</td>
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<td>Belanga District</td>
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<td>Lun Dayeh N</td>
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<td>–</td>
<td>215.3</td>
<td>Padoch, 1985</td>
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<td>Kajang</td>
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<td>795.3</td>
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<td>1380</td>
<td>215.3</td>
<td>Freeman, 1955</td>
<td></td>
</tr>
<tr>
<td>Iban</td>
<td>2.6</td>
<td>1580</td>
<td>118.8</td>
<td>Freeman, 1955</td>
<td></td>
</tr>
<tr>
<td>Kenyah</td>
<td>1.02</td>
<td>800</td>
<td>2099.0</td>
<td>Colfer, 1997</td>
<td></td>
</tr>
<tr>
<td>Kenyah</td>
<td>2.35</td>
<td>1400</td>
<td>1730.1</td>
<td>Colfer, 1997</td>
<td></td>
</tr>
</tbody>
</table>

Figures in italics are estimates based on existing data, see text on page 6.

References:

- O’Connell and Hawkes, 1981.
- Hill et al., 1987.
- Kennett et al., 2006.
These calculations are frequently used to calculate resource ranking (from high yielding to low) describing a group’s diet breadth, comparing items that are added or subtracted from the diet due to factors such as resource availability, density, or changes in mobility (Winterhalder and Kennett, 2006: 14). Where caloric return rates have been applied to address other questions, such as the transition from hunting and gathering to agriculture (e.g. Kennett et al., 2006), issues have normally focussed on how farming - which is often expensive in labour terms but produces modest energetic returns - could have replaced hunting and gathering in the first place (e.g. Barlow, 2002, 2006; Kennett et al., 2006; Tucker, 2006).

Determination of the primary return rate (kcal/h) follows established procedure, calculating energy input (e1), representing the total energy budget of the harvested resource minus the effort required to acquire it (e2), divided by the total time in person hours for all related activities (t):

\[
\text{Rice farming return rate} = \frac{e1 - e2}{\sum \text{time}(t)}
\]

An estimation of returns for effort measured for swidden rice is provided in Table 2. Returns for swamp rice could not be included as it was not possible to collate reliable person hour inputs on a field by field basis from those records.

In order to arrive at the final figures a few additional calculations were necessary. A key variable of this calculation is knowledge of the total handling time (harvest time and all subsequent processing). The hours spent harvesting were not given in all the papers used here, which is a crucial variable, so using the existing data where known, harvest hours were plotted against field size and a linear regression line was plotted through the result. From this, harvest hours were determined for fields where these data were absent (indicated in Table 2 by figures in italics). None of the data recorded historically were ever intended for use in this manner, though it was sometimes the intent to produce general input/output calculations of relative productivity (kg/ha). A second quite important variable is the assessment of losses of the crop due to processing the grain such as drying and threshing necessary to remove unwanted chaff and other waste. There are widely varying estimates on the loss due to winnowing rice ranging from 10 to 37% of the total (De Lucia and Assennato, 1994). Lambert (1985) calculated one gantang of swamp rice by dry volume to be ~2.4 kg, reduced by winnowing to ~1.7 kg of processed rice. Harrisson (1970: 569–70) expressed this figure in gantangs where two to three gantangs of unhusked padi were required to produce one gantang of husked padi, and Lambert (1985) arrived at similar figures. Thus an upper figure of ~30% loss of dry weight during processing seems a reasonable estimate using the hand technologies of the time, and has been factored into the final calculations.

The 16 farms in this sample show a range of value in return rates from as low as 31 kcal/h up to the highest values of just over 3248 kcal/h, with a mean of 955 kcal/h. The enormous variance in returns continues to stand out, where farms below 1000 kcal/h (n = 11, 69%) returned a relatively modest average of c. 485 kcal/h. Taken as a group, four farms (25%) of the sample achieve >1200 kcal/h, which is a reasonable return-rate against other foraging options. In direct comparison with the returns possible from foraging strategies (Table 1), average returns from rice farming seem a poor return for their relatively high investment of labour and effort.

7. Return rates from sago

The extraction of starch from the pith of all palm sago is labour intensive (Anderson, 1979; Brosius, 1986; Harrisson, 1949) but the energetic yields are high. Ellen (2006: 288) calculated for the Nuaulu of Seram that up to 902 kcal/head/day came from the production of Metroxylon sagu, and Ulijaszek and Poraituk (1993) calculated returns in excess of 6000 kcal/person/h from the processing of M. sagu in New Guinea. Return rates for the indigenous Bornean sago palm, Eugeissona utilis, are slightly lower, but still impressive. Strickland (1985) for the Kejaman calculated returns from sago that range between 3120 and 4690 kcal/h, and the author’s calculations of sago processing with the Penan, using a metal axe and wooden tools, was 3067 kcal/person/h. Summary statistics then for Eugeissona utilis, hill sago, provide mean returns of 3803 kcal/h (SD 815.1 kcal/h). A comparison of foraging rates for sago, swidden rice and the collection of wild grasses is shown in Fig. 3. Here rice is shown to be a much poorer strategy than collecting sago and in the lower quartile, overlaps with returns possible from collecting wild grasses. Overall returns from hill sago are three times that possible with rice (though the figures for PNG swamp sago are even greater) and the activity is far less risk-prone, with a relatively stable return possible from each harvest. A comparison of the Coefficient of Variation (CV) between rice and sago shows the differences clearly, where sago produces a CV of 0.214 (low variance around the mean) and by comparison for swidden rice this figure is 0.904, which approaches CV calculations of hunting small game (e.g. Bleige Bird and Bird, 2009).

As these figures clearly show, people choosing rice are selecting a subsistence option that is lower yielding than alternatives and more importantly has a much higher risk of failure. However, harvest yield variance is high and potential payoffs for an exceptionally good harvest could mean enough for annual requirements, plus a surplus, but high variance also means that rice alone cannot be relied upon as a subsistence staple. Rice has some positive benefits over sago flour in this environment; it can be stored for prolonged periods — sago flour may also be stored, but only for one month or so. A Penan informant, T’bari Bala from Long Beruwang, explained that processed sago flour was sometimes stored in wooden bins lined with beeswax. In Northeastern India, Ganwar and Ramakrishnan (1990) record the underground storage of starch flour from a tree-fern, Cyaetha gigantea, which may keep for up to one month.

Arguments in favour of rice farming have normally been framed in terms of its superiority as a mode of subsistence (e.g. Diamond and Bellwood, 2003). However, the data presented here radically redefine that position, showing that rice is in fact economically inferior to pre-existing alternatives. How has such an illogical choice become the primary mode of subsistence within these rainforests?

Fig. 3. Comparison of caloric return rates (kcal/hr) for sago and swidden rice harvested and processed with hand tools and foraging wild grasses.
8. Rice, prestige and status

While apparently an illogical choice for a staple carbohydrate in wet rainforest, rice maintains a unique position as a plant of prestige and status in Sarawak, and maintains an equally unique relationship with its human hosts. Rice is often regarded as ‘proper’ food or a ‘real food’ (see Janowski, 1997) whilst other equally useful carbohydrate-rich plants, such as sago, taro and manioc, are not — in fact they may be viewed as a shameful alternative if people are forced to eat them, though they may often be used as snack food or supplement to rice (Harrison, 1970: 300; Janowski, 1996: 56). Indigenous taro, Colocasia esculenta, is considered by many in Sarawak as food suitable only for pigs and human consumption may even be forbidden (Harrison, 1970: 521). Taro though is always present about human settlements, and many groups often use the leaf as a vegetable and may include the rhizome in their list of snack foods. Manioc or cassava, a possible 16th century introduction, grows well and produces an abundance of large tubers, is also often considered to be food suitable only for pigs, but may appear as a snack food (Janowski, 2004). Harrisson (1970: 519) noted that the Kelabit would refuse to serve manioc to visitors, considering this a slight on their standards of hospitality. Other inland groups such as the Kajang, who still relied on a mixed economy that included rice, sago, and manioc, were seen bowing to increasing external social pressures to produce more rice during the 1970s. Nicholaisen (1986: 84) noted that the Kajang as a group seemed upset and embarrassed by their overdependence on other carbohydrate staples and acknowledged that they did not grow enough rice. Some young families then refused to eat sago, regarding it as a second-rate food. Similar comments were also made of the Kejaman, a group who still cultivated and ate sago on a regular basis, but were moving towards rice because of external perceptions of their low status and poverty in having to rely on sago and manioc (Strickland, 1985: 148).

The Kelabit make a very interesting distinction between easy foods, such as taro, sago and manioc, and the unique aspects of rice. They conceive of most living things as being able to ‘grow on its own’, mulun sebulang, while rice can only grow if humans care for it. They see the cultivation of rice as initiating a particular way of living in the landscape and in the cosmos (Janowski and Barton, in press). For the Kelabit, the distinction between a rice-growing way of life and a way of life which does not involve rice-growing is very meaningful. The choice of rice-growing in the tropical forest is not an economically sensible one, and they are quite clear about this; the point of growing rice is rather to show exceptional ability. If they only wanted to survive, they could make sago or grow root crops (Janowski and Barton, in press).

What then is it about this weedy grass that places it in such a premium in people’s lives that they would forego a rational and reliable subsistence base to pursue a high risk venture of hard labour interspersed, potentially, with spectacular failure? Part of the answer may lie in the inherent instability of the crop. In a world of plants that otherwise take care of themselves, rice is attractive culturally because it is unpredictable; a successful rice crop is a marker of cultural success. Rice may also facilitate access into pre-existing structures of status and rank, and provide access into worlds outside one’s own in ways that were simply unavailable to people with sago and taro.

For example, the Kelabit and other rice farmers such as the Iban, actively convert excess rice into social ‘capital’, or perhaps social ‘potential’ might be a better phrase, through the purchase or trade of prestige items such as brass gongs or Chinese jars. These are products external to Sarawak. ‘Each season, some families succeed in producing a surplus; while others find themselves with a deficit; and so, year by year... scores of different families exchange gongs for padi, or padi for gongs’ (Freeman, 1955: 105). Rice amongst the Kelabit may also be transformed into the organisation of communal labour for the construction of ceremonial ditches nabang, or irrigation ditches abang and the erection of celebratory stone monuments through the ability for families to ‘feed’ people at an irau or feast (Janowski, 1996). In the process, such events create and enhance social bonds and create situations of reciprocal obligation (Hayden, 2003: 35). Such a system then allows the conversion of a perishable food crop into something that is more than just food; a socially acceptable recognised ‘valuable’ that can be manipulated in games of social ranking.

Rice may have been attractive within such a system precisely for the reasons that make it seem such an illogical food crop within the rainforest. Variation in rice production thus creates and enhances a system of inequality (Hayden, 2003: 35), as yield varies dramatically due to outside forces such as climate, pests, and other natural causes as well as being partly reliant on the available labour input that is necessary to increase ones chances of success come harvest. Once such a system is established and accepted, rice yields act as a ‘pump’ pulling valuables into society and influencing their redistribution, creating obligations through its inherent instability. In a world of vegeculture focussed on sago and yams, rice may not have been adopted to reduce the ‘risk’ of going hungry. Rice may have been attractive for its unreliability; because successful cultivation is inherently ‘risky’, prone to failure, the cultivation of rice uniquely became highly attractive as a valuable piece in games of social competition between individuals. Only those individuals who could devote their time and mobilise the necessary resources, which may have included human labour, were ever likely to be successful in growing rice.

9. Conclusion

On the evidence of return rates, rice is a poor option as the staple carbohydrate of choice in the rainforests of Sarawak. In fact, at the time that these figures were recorded, many farming communities were ‘insuring’ their rice harvest with indigenous alternatives such as sago. If judged on the basis of their comparative return rates alone, the reverse might reasonably have been expected: grow sago and some rice — possibly using rice as a crop for ritual activity or occasional trade should the opportunity present itself. The ethnographic record indicates that several groups of swidden farmers in Sarawak were still utilising sago as their main crop, some used it on a regular basis, while others had shifted more fully towards rice, but were still dependent upon sago, and kept it nearby as insurance against a poor harvest or failure of the rice crop. Viewing the ethnography as a snapshot of cultivation practices across Borneo at the time, there appears to be a gradient of slash and burn cultivators with some reliant on sago, some partially between sago and rice, and those fully embedded within rice cultivation. There appear to be significant parallels in neighbouring areas. In upland regions of the Philippines, including the area of dramatic rice terracing in Ifugao, the adoption of rice and wet rice in particular was still ongoing in the 19th Century (Scott, 1958). Many groups of swidden farmers were still reliant on root crops, including taro, where rice and access to rice was highly restricted; it was a crop only for the rich where the wealthy were distinguished by their ability to subsist on rice and not other types of swidden crop (Scott, 1958: 92).

Barton (2009) and Barton and Denham (2011) have argued that rice farming represents a method of cultivation that is inherently unlike vegecultural systems of propagation (which includes cultivation of sago palms, yams and taros) in that these cultivars are reproduced asexually from suckers and parts of the rhizome and tuber. These plants can be seen as long-lived, trans-generational cultivars. In dramatic contrast, rice is an annual, reproduced from seed, and cannot compete within the jungle on its own; it needs human attention and human effort to survive.
Plants like hill and swamp sago can be coppiced and managed; a single clump can continue to produce sago for many years (Langub, 1989). Like fruit trees, individual plants may become an important aspect of heritable property, providing a sense of security for the living that their descendants will be provided for once they are gone. The long-lived nature of vegicultural cultivars is expressed in social and cosmological world views in Island Southeast Asia and Melanesia (Barton and Denham, 2011). This creates tension between rice as a greedy annual and the embedded nature of vegicultural cultivation and other patterns of human forest management that form a cline of disturbance practices from the garden to the forest proper.

Spencer (1966) recognised early, as did Sauer (1969), the complexity of human–plant relationships in the region, and considered that most of the mature forests were not ‘virgin’ forests at all in the sense known to Europeans, and that many were not even secondary forests or even tertiary forests, but rank some number above three (1966: 39). Clifford Geertz (1963: 16) also recognised that the activities of shifting cultivators maintain or reduce the pre-existing forest structure in their own gardens, creating humanly managed ecosystems that project into the surrounding forest rather than creating an agricultural plot organised along novel lines with novel internal dynamics.

An old Malay farmer expressed his frustration with the new government policy of the 1950s centred primarily on rice and other short-lived annuals: ‘My father and my grandfather before him planted rice, coconuts and all sorts here... Before, the days of my father and grandfather all this was coconuts but they have gone now. That is why I want to plant them again. But I am only allowed to plant anything that dies at the end of the year’ (quoted by Harrison, 1970: 577, italics mine). Harrison (1970: 567) too was acute to this sense that rice was out of place here: ‘It is difficult to account the local factor which can hardly have failed to get into Batu: the Malay feeling about keeping on planting the same crop in the same place. There is something, to them, faintly unnatural about this. A plantation of anything annual should presently transfer into something semi-centennial — from tapioca to durian, from rice to rubber’.

For people who have been engaged in vegicultural systems of propagation for a long period of time, as is the case for Borneo and much of Island Southeast Asia, moving into rice would have been difficult, and was probably too much for some, such as the Penan and Melanau and groups of Kejaman who maintained sago management and cultivation into the present. Rice does appear early in the archaeological record in Borneo, but what is less clear is the context of this plant: just how important was rice as a staple food and when did it become a staple? Was it more important in a sacred context, grown in small quantities, only very gradually making the transition into a major cultivar in these wet rainforests? Much more archaeological work is required in the region to fully answer these questions and they are questions worth pursuing as they speak right to the heart of assumptions about the nature of agriculture, why some crops spread and how. This also highlights the importance of not assuming too quickly the role of an introduced plant in indigenous systems of cultivation when all this is evidence of its presence, but little or nothing is known about the context of its use. The introduction of rice into Borneo is just one part of the story: the real complexity lies in understanding the context of that introduction and of what followed.

References


