A 10,600 YEAR POLLEN RECORD FROM NONG THALE SONG HONG, TRANG PROVINCE, SOUTH THAILAND

Bernard K. Maloney

School of Archaeology and Palaeoecology, The Queen's University, Belfast BT7 1NN, N. Ireland

ABSTRACT

Nong Thale Song Hong provides the first Late Quaternary – Holocene pollen and microfossil charcoal record from south Thailand but there are problems with the radiocarbon dates and an attempt to resolve these is being made using stable isotope analysis.

The core is from the deepest part of a shallow bean-shaped lake, which has no inflowing or outflowing streams, located at 7°52' N, 99°28'50" E to the north of Trang, an ethnic Malay area of Southern Peninsular Thailand. It is at *c.*100 m altitude and the highest point in its vicinity is at *c.*400 m altitude, around 14 km southwest of the lake. The local geology (Figure 1) consists of acid and moderately acid shales, sandstones and sandy shales of the Kanchanaburi Series which have often been metamorphosed to phyllites, argillites, quartzites and slates (Royal Survey Department 1969). The Kanchanaburi Series ranges from the Early Carboniferous, to Devonian and Silurian in age.

The soils near the site are red-yellow podzolics (Figure 2). Red yellow podzolics correlate with the ferrugineous soils of French and Belgian soil classifications (Young 1976) and have some weatherable minerals remaining, so they are more chemically fertile than ferrallitic soils, which have a negligible amount of weatherable minerals left. They form under seasonally dry climatic conditions, while ferrallitic soils develop under everwet conditions. Red-yellow podzolic soils commonly occur under various types of wooded savanna vegetation but ferrallitic soils are characteristic of humid tropical rainforest areas. The 1:50,000 soil map for the area shows the site to be surrounded by the Fang Daeng series, while to the east, in the hills, the soils series 104, "slope complex" (colluvial soils) occurs; the other soil series in the vicinity is the Kho Hong "mottled association". The fact that the Kho Hong association is mottled suggests that there has been seasonal drying out, with oxidising conditions replacing reducing conditions.

The climate is characterised by mean annual temperatures of 26-28°C, a mean annual relative humidity above 80%, due to the surrounding seas, and a mean annual evaporation of 800-1000 mm (Donner 1978). The mean annual rainfall is variable but falls throughout the year, and that of the east of the peninsula differs from the west. The Trang area has a Koppen type Am climate with heavy annual rainfall and a short drier season from January to March, so most rain falls in summer and from the southwest monsoon. Trang had a mean annual rainfall total of 2177.7 mm between 1931-60. The southwest monsoon starts in April and reaches a maximum in October. Thereafter the northeast monsoon begins to dominate.

The east coast has moderate rainfall from January to September and most precipitation occurs during the northeast monsoon period in early winter (from October to December). Rainfall amounts also tend to be lower on the east than the west coast. Higher west coast rainfall means lower losses through evaporation, so the natural vegetation should be more mesic.

The natural vegetation of the area is said to be lowland tropical rainforest with tall trees in the Dipterocarpaceae family prominent. Dominant species include *Dipterocarpus* spp., together with *Hopea odorata*, various *Shorea* species, *Lagerstroemia speciosa* and *Schima wallichii..* (Royal Survey Department 1969; Donner 1978) Lauraceae, Myrtaceae and Annonaceae are generally predominant in lower canopy levels with Acanthaceae and Rubiaceae well represented as undergrowth shrubs. Bamboos are rare, except for climbing forms, but palms, canes and other monocotyledons are abundant. The only ecological study from the region is for Khao Chong, 22 km east of Trang (Ogawa *et al.* 1965), on the western slopes of the central mountain range. This shows that when the dipterocarps are removed taxa such as *Eugenia clarkeana, Alstonia spathulata, Padbruggea pubescens* and *Sterculia* spp. become the dominants.

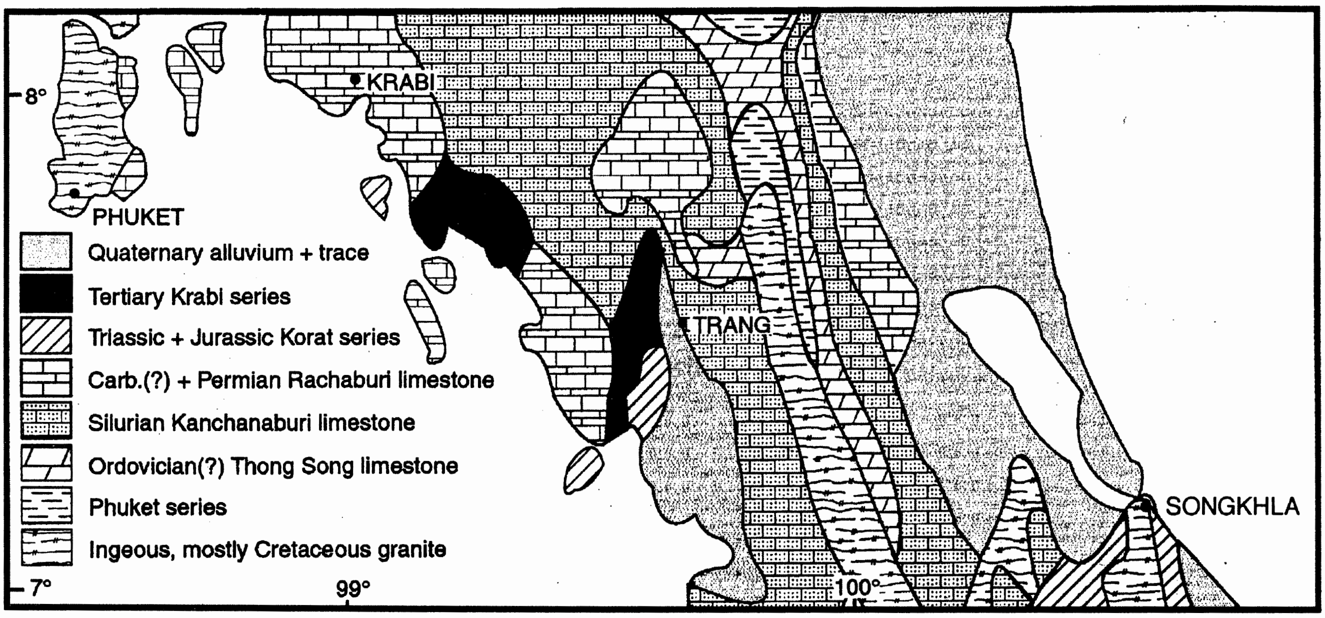

Figure 1: Geology of the Trang region.

Where swamp forest occurs (Donner 1978) it consists of *Lagerstroemia speciosa*, *Elaeocarpus* spp., *Fagraea fragrans*, *Alstonia spathulata*, *Eugenia* spp., *Saraca* spp., and many types of canes.

South Thailand is now mainly an area of tree crops, particularly rubber, which was introduced to Trang from Malaya in 1901. Rice has second largest cover, followed by coconuts, maize, cassava and peanuts. Perennial fruit trees are grown on upland soils more as forest than orchard, or are planted in gardens or farmyards. The largest numbers of trees are various types of orange, followed by rambutan, limes and mango. The area has about nine million *Areca* palms and around one million kapok trees.

PREHISTORY

The oldest archaeological site in the region is Lang Rongrien Rockshelter, at 8°13' N, 98°53' E (Anderson 1988), which ranges in age from 3500 BP to greater than 43,000 BP. The earliest occupations (Anderson 1997), seem to represent hunter camp sites pre-dating the last glacial maximum. Apart from faunal remains, chipped stone tools (mainly flakes), stone debitage, and traces of camp fires were found. The cultural remains above these levels comprised 1 m of occupation midden containing implement assemblages resembling those labelled elsewhere as Hoabinhian and which date to the early Holocene. During late prehistoric times the site was used as a short term shelter, and, between 4000-2500 years ago, as a burial site.

Traces of food plants were absent but (Bellwood 1993) and Bulbeck (1985) suggested that the teeth excavated from the Gua Cha Hoabinhian rockshelter layers in Peninsular Malaysia indicated that people ate well-balanced meals with considerable fibrous starchy vegetables, especially yams, and a relatively large proportion of sweet foods, e.g. fruits and honey.

Other sites in the Trang-Krabi area, which may date from 6000-5000 BP, include Khao Kanab Nam, Na Ching and Than Phi Huato. The occupation of Khao Kanab Nam corresponds to a period of high sea level from around 6000-5000 BP. The middle Holocene sites contain pottery and ground stone tools, especially adze/axe blades. These suggest that forest trees could be cut down but whether or not large dipterocarps could be felled needs to be demonstrated experimentally. No edge wear analyses have been carried on these tools. Evans (1931) also reported adze heads from Chong in the Trang-Phattalung hills.

Old, but undated, tin workings, largely in alluvial deposits (Bourke 1905), occur in the Trang-Phuket region. In historic times Indian merchants (Donner 1978) called at Phuket to trade in tin (there are several deposits in the Mae Nam Trang valley), gold and spices.

EVIDENCE FOR PAST ENVIRONMENTAL CHANGES IN SOUTH THAILAND

Much of the Sunda Shelf was dry land during the last glacial period but sea level rose rapidly during the early Holocene. It was 4 m higher than present between 6000-

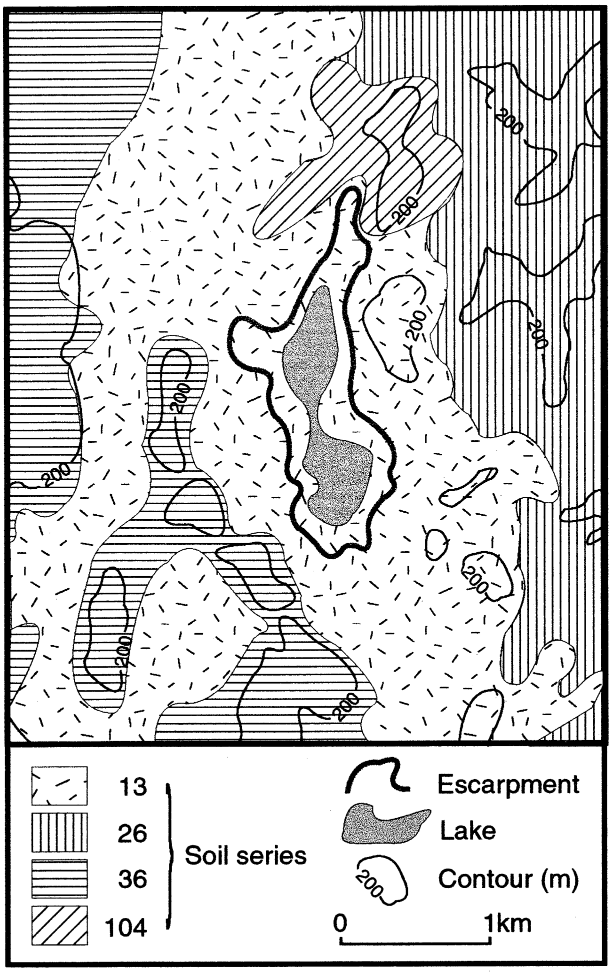

Figure 2: Topography and soils of the Nong Thale Song Hong area.

4800 BP, and about 2 m higher around 4000 BP, 2 m about 2500 BP and 1.5 m about 2000 BP, with regressions between these dates (Figure 3) due to isostatic rebound (Tjia 1996).

Two pollen diagrams from the area have been published (Thanikaimoni 1983; Hastings 1983), both from the east of the peninsula but extending back no more than 4000 years. The Satingpra core has not been dated directly, and Allen (1988-9:169) has shown that the inferred age of the basal sample is incorrectly calculated, and there is no reason to accept that forest clearance began 4000 years ago, while only one radiocarbon date (laboratory number not given) is available from Narathiwat.

Where *Borassus* pollen is present in the upper part of the Satingpra diagram it is safe to assume that wet rice cultivation was taking place as this sugar palm is typically planted on rice field bunds, but it is known to be a recent introduction. However, we know from the Lang Rongrien charcoal dates that fire has been used in the region for at least 37,000 years.

Ten samples from the Narathiwat core were analysed and no indication is given of the size of the pollen sum. The basal sample was dominated by palm pollen, especially that of *Areca*, and it is tempting to think that this may have been cultivated, particularly in view of the late age of the deposit (*Areca* pollen also occurred at Satingpra [Thanikaimoni 1983]). Grass pollen was fairly abundant too in addition to *Macaranga*, a possible forest clearance indicator.

More mangrove and mangrove transition taxa (including *Pandanus* and *Nipa*) were present further up the diagram and Hastings suggested that conditions became more brackish, that a minor marine transgression took place, that tidal inlet patterns altered due to siltation or marine transgression, or that mangrove vegetation moved landwards.

Continuing upwards, the changes are suggestive of vegetation succession within a freshwater swamp forest: *Melaleuca* in particular became better represented. *Elaeocarpus* had high percentages throughout, and therefore probably grew near the pollen accumulation site. The percentages of some low pollen producers, e.g. *Dysoxylum* and *Aglaia*, were large enough to suggest that they too were to be found locally. *Trema*, a weed tree, appeared and may indicate disturbance of the vegetation. A rise in

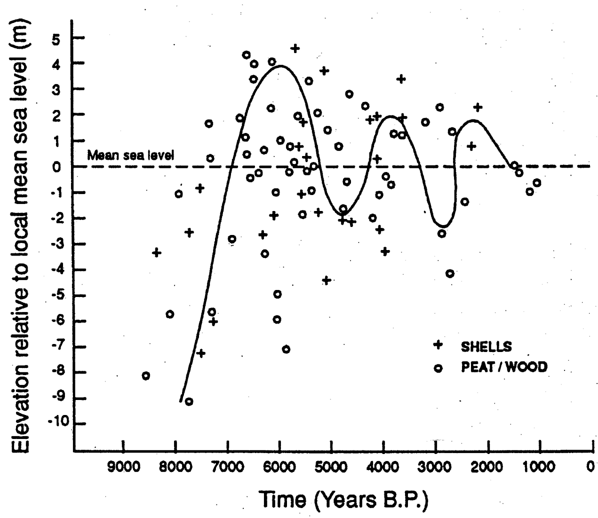

Figure 3: Holocene sea level curve for Thailand using mean local sea level (adapted from Tjia 1996).

Core number	Depth (cm)	Radiocarbon age (uncalibrated)	Laboratory number	d13C	Sedimentation rate (cm/yr)
2TS1	84-90	6330±50	Beta-106539	-26.0	0.014
2TS2	50-60	10820±50	Beta-106537	-25.4	0.015
2TS3	36-40	21170±90	Beta-106538	-22.3	0.007
2TS4	25-31	9420±50	Beta-106540	-27.4	0.004
2TS4		16490±120	Beta-101966	-27.9	

All samples were converted to CO_2 by Beta Analytic and AMS dated at Oxford

Table 1: AMS dates from Nong Thale Song Hong, Trang.

palm pollen also took place, but closer pollen identification is needed to deduce what this means. Hastings interpreted this part of the diagram in terms of the first impact of humans, using *Trema* and *Lycopodium* to do so, but the disappearance of Dipterocarpaceae is more significant as this family includes important timber trees and the pollen is usually under-represented in the fossil record.

NONG THALE SONG HONG: THE RADIOCARBON DATES

AMS radiocarbon dates from core sections 2TS1, 2TS2 and 2TS3 (Table 1) are consistent, but the dates from section 2TS4, while consistent for that section of the core, contradict the overlying sequence.

It is assumed here that the dates from 2TS1-3 are reliable, leaving the base of the core at about 22,000 years old. This is being tested by measuring the $d^{13}C$ values for several other samples from the cores and through phytolith analysis. It is difficult to see how tectonic activity could explain the apparent inversions.

THE POLLEN AND PTERIDOPHYTE SPORE RECORD

Only core sections 2TS1-3 will be considered here. The general changes in the pollen and pteridophyte concentration figures (Figure 4) suggest that there was greater deposition in the early Holocene but these have been derived using just two radiocarbon dates and sedimentation rates may have varied quite considerably at different times during the Holocene. Using the same dates to calculate pollen deposition/cc/yr indicates that the high pollen and pteridophyte concentrations are more apparent than real (Figure 5) but the concentrations/cc and concentrations/cc/yr run largely parallel for the middle to later Holocene. The same is true for microfossil charcoal particle concentrations, but the high value for the *c.*10,300 BP level may not be real, although all the later ones are. Greater pollen and pteridophyte spore deposition in the early Holocene implies wetter conditions than present, probably because the southwest monsoon was passing over an increasingly large expanse of sea as sea level continued to rise.

Van der Kaars (1990) attributed increasing pteridophyte spore frequencies in deep sea cores from eastern Indonesia to wetter conditions, and therefore increased fluvial transport. Fern spore concentrations at Nong Thale Song Hong are above 10,000/cc around 10,300 BP, from *c.*7600-3300 BP, and between *c.*1900-760 BP. Most that could be identified are taxa of dry slopes (Tagawa and Iwatsuki 1979a-e, 1985, 1989) and the spores are likely to be of local origin. So, conditions in the lake basin could have been drier at these time periods. The highest pteridophyte spore concentrations occurred around 5100-4800 BP and in the recent period. The peaks do not show a consistent relationship with those for microfossil charcoal concentrations, and the increases before *c.*2900 BP especially appear to relate to edaphic conditions, not to regional climatic variations. With edaphic dryness on the slopes, a rise in the concentrations of tree taxa characteristic of mixed dipterocarp forest might be expected. This does indeed occur, particularly between 7600-3300 BP, but again the concentrations are not completely consistent with those for the pteridophytes. That the figures are much lower is not a surprise as the taxa concerned, *Acacia/Albizzia*, Combretaceae/Melastomataceae and *Lager stroemia,* are poor pollen producers and the pollen is unlikely to be well dispersed. The Dipterocarpaceae pollen concentrations (*Dipterocarpus*, *Shorea* and *Hopea* types) follow the general trend of the dry forest elements suggesting that mixed Dipterocarpaceae forest was represented on the slopes (Figure 6).

Interpretation is further complicated by two factors: the strong fire record, of probable natural **and** human origin, and the possibility that the lake was surrounded by fring ing swamp forest. Trees which could occur in fringing forest include the Fagaceae (*Castanopsis/Lithocarpus* and

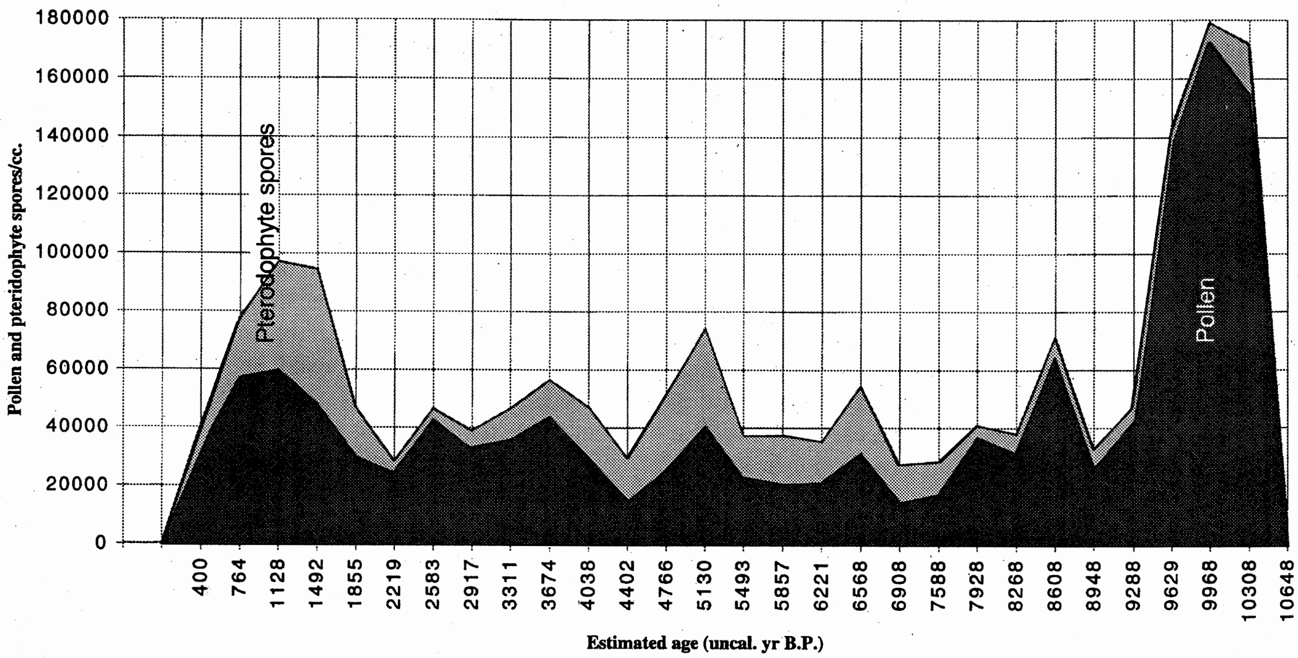

Figure 4: Nong Thale Song Hong pollen and pteridophyte concentration figures/cc.

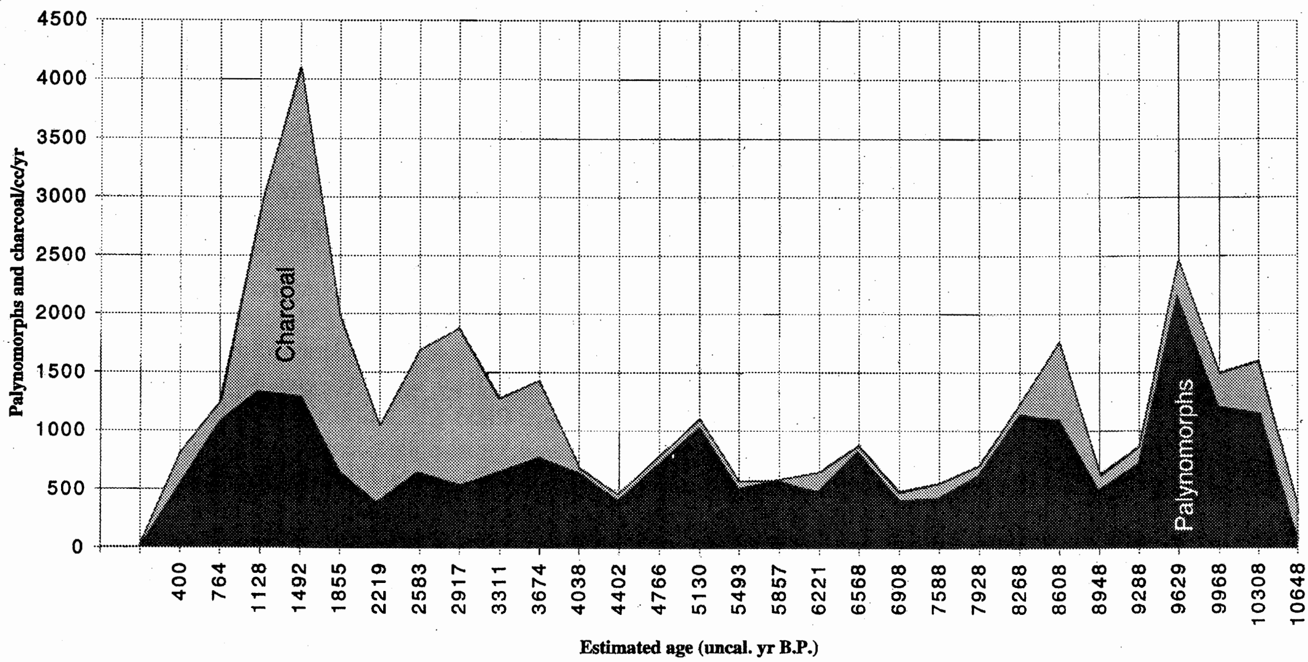

Figure 5: Nong Thale Song Hong pollen and pteridophyte concentration figures/cc/yr.

Quercus), *Elaeocarpus, Calophyllum, Carallia brachiata, Eugenia* and *Ilex. Carallia brachiata* has pollen which can be identified to the species, but Ding Hou (1970:13) indicates that it is a tree of evergreen or mixed forests which is sometimes found at the edges of freshwater swamp forests.

Swamp forest may have existed throughout the 10,650 year continuous record, while grasses dominated the water front vegetation. The grasses could have included wild rice as pollen within the size range of rice occurs consistently throughout the sequence.

The disturbance indicators (Figure 7) include *Macaranga/Mallotus*, *Celtis timorensis* type, *Myrica*, *Ardisia*, *Maesa*, *Trema*, Urticaceae/Moraceae and, possibly, *Schima wallichii*. Grasses cannot be considered as reliable disturbance indicators since they can grow in such a wide range of ecological situations. The strongest records are those of *Macaranga/Mallotus*, Urticaceae/Moraceae and *Schima wallichii*. The latter is the only taxon with pollen identifiable to the species but it can grow in various plant communities over a wide altitudinal range. Its highest pollen concentrations occurred after the palm *Borassodendron machadonis* faded from the record around 4000 BP and it persisted until *c.*2900 BP, suggesting that it might have been a regrowth tree. It was also important in a sample dating to *c.*1100 BP.

Borassodendron machadonis is very rare in Thailand and Peninsular Malaysia today. It has a large, very distinctive pollen (cf. Ferguson *et al.* 1987), and would be a useful indicator pollen if more was known of its present day ecology.

Macaranga and *Mallotus* too can grow in a wide variety of ecological locations, including fringing forest and evergreen forest, but are characteristically small trees of regrowth following vegetation disturbance. Their record is almost continuous over time, with absences only from samples which may date to *c.*10,650 and 8600 BP respectively. There was a peak at *c.*10,000 BP corresponding with one in the microfossil charcoal record and the dry forest pollen concentrations, suggesting that the vegetation on the slopes around the site was disturbed, presumably by natural vegetation burning. Large trees in the Dipterocarpaceae family survived. However, Urticaceae/Moraceae pollen concentrations were also high at this time period, particularly around 10,300 BP. It is tempting to think a Younger Dryas climatic reversal to cooler, drier conditions might be represented but the pollen record becomes even more perplexing because grass pollen has some of its highest concentrations between 10,000-9600 BP while weed *Alternanthera* and Chenopodiaceae/Amaranthaceae entered the record at *c.*9600 BP. *Alternanthera* occurred continuously until around 8300 BP then disappeared entirely. These occurrences could lead to speculation that some form of cultivation was practised as the taxa can be weeds of rice and root crop cultivation, but the evidence is very tenuous in the absence of detailed local archaeological information. Charcoal concentrations had another peak around 8600 BP.

Macaranga/Mallotus concentrations above 4000/cc occurred again between *c.*5500-4800 BP and Chenopodiaceae/Amaranthaceae pollen was present but insignificant. Gramineae pollen had quite high concentrations, but only concentrations in a sample about 6200 years old matched those for the opening of the Holocene. The forest edge seemed to be nearby between 6900-6200 BP as *Calamus*, a climbing rattan palm, entered the record for the first time. Urticaceae/Moraceae concentrations were moderate, but weed *Smithia* pollen appeared for the first time around 6200 BP. There was also a peak in charcoal concentration, but it was not as high as earlier ones.

Artocarpus type pollen occurred for the first time at *c.*4000 BP and remained present until *c.*3000 BP. There was another rise in *Macaranga/Mallotus* pollen concentrations at *c.*3700 BP, matched by one of Urticaceae/Moraceae, but grass pollen concentrations were moderate. However, Dipterocarpaceae had their highest concentrations so far (1100/cc) in the diagram. Piperaceae pollen similar to that of the *Peperomia* spp. illustrated by Huang (1972:Plates 115:3, 4) also entered. *Peperomia* is an ornamental plant of tropical South American origin (Purseglove 1974) so it is likely that the pollen actually comes from a *Piper* species. This is in keeping with historical information that pepper was grown in the area in the past. It would seem that people were responsible for these vegetation changes but could not, or did not want to, remove the large trees.

Macaranga/Mallotus, *Maesa* and *Saurauia* (sometimes a forest edge tree) were significant around 3300 BP and there was some weed Compositae pollen in the sample. The *c.*2900 BP level saw another peak in *Macaranga/ Mallotus* pollen concentration but Urticaceae/Moraceae pollen concentrations were considerably lower than at *c.*3700 BP, although they increased greatly in the sample dating to around 2600 BP, where the *Peperomia* type pollen reappeared. Grass pollen concentrations remained moderate, but regrowth *Trema* had its highest concentration for the diagram. Microfossil charcoal concentrations were high from *c.*3700 BP until the top of the diagram. The decline in the pteridophyte spore concentrations about 2900-2200 BP suggests that the slopes around the lake were burnt. There is no indication of what, if anything, was cultivated, but parallels with present day northern Thailand suggest that it was probably dry rice. *Macaranga* regrew between 1900-1500 BP.

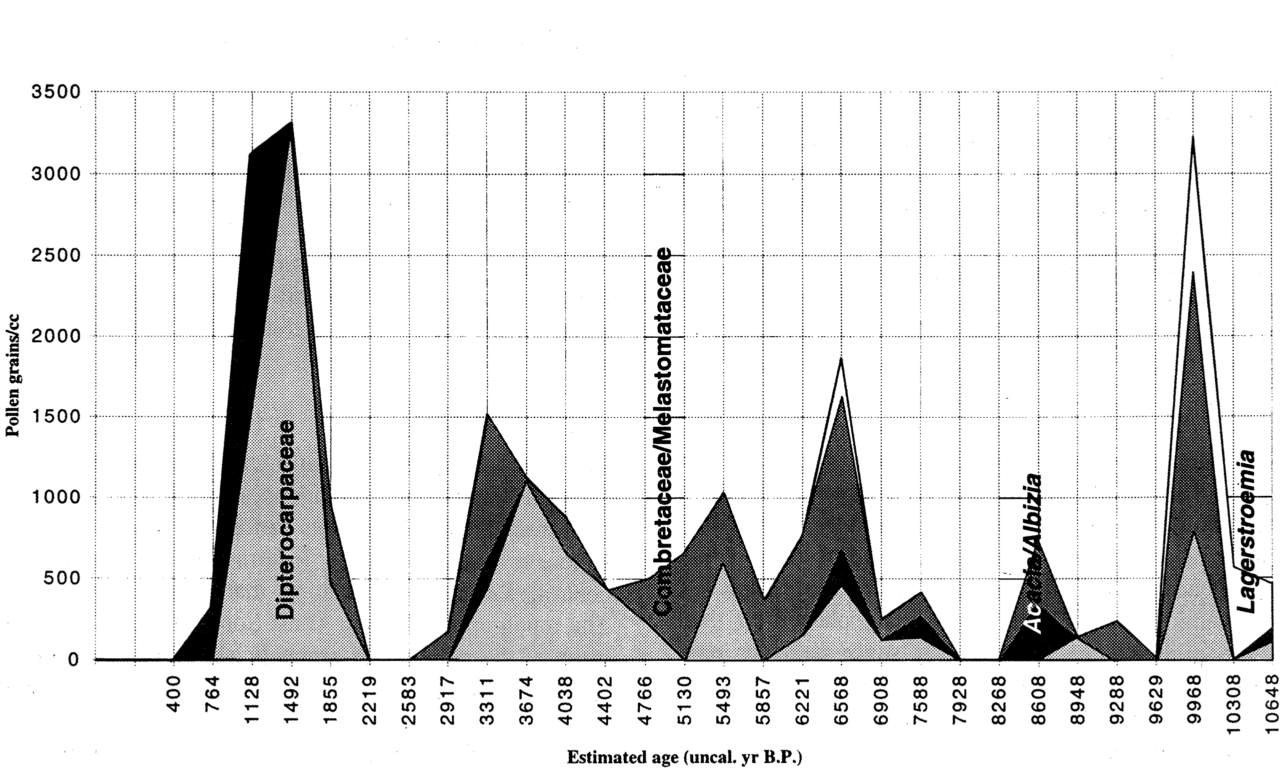

Figure 6: Nong Thale Song Hong Dipterocarpaceae and dry forest pollen taxa.

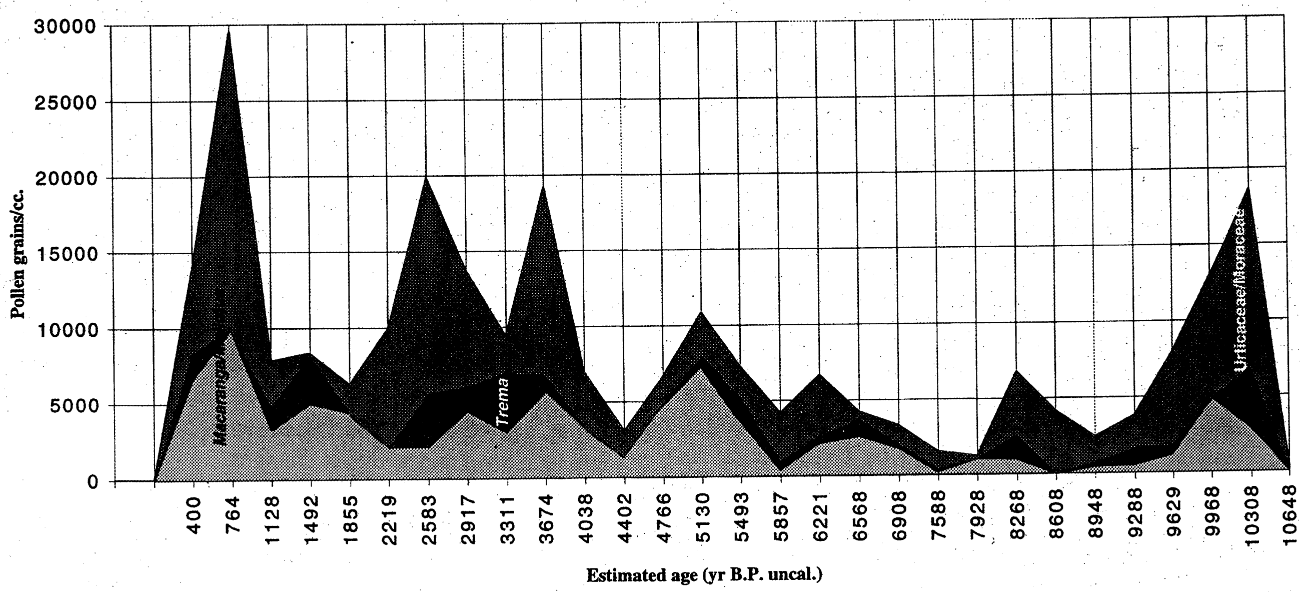

Figure 7: Nong Thale Song Hong selected disturbance.

The upper part of the diagram is also difficult to interpret but the frequency of charcoal suggests that some form of shifting cultivation was practised, although useful trees were probably conserved, e.g. *Palaquium* from *c.*1100 BP, when the charcoal concentrations decreased markedly from the very high values of 98-200,000/cc which occurred between *c.*1900-1100 BP. Indeed, Dipterocarpaceae concentrations reached their peak (3300/cc) in the diagram at *c.*1500 BP. It seems possible that the frequency of shifting cultivation became less in the last few hundred years. *Artocarpus* type pollen reappeared around 760 BP, *Peperomia* type pollen was present in the *c.*1100 and 760 BP samples, *Macaranga/Mallotus* was also common and Urticaceae/Moraceae had their highest concentration in the diagram at 760 BP. There was an isolated peak of *Piper* at 1500 BP and *Areca*, which was present in the *c.*10,300 BP sample, occurred more continuously from *c.*6600-4000 BP, but had its peak in the uppermost two samples. It seems safe to assume that it was being planted by then. So too probably were *Caryota*, a sugar palm or ornamental, depending upon the species, and *Corypha mangifera* was present in the most recent sample.

Other than indicating when the slopes were dry, the pteridophyte spore record adds little to the story. Cyatheaceae (tree ferns) and *Dicranopteris* can be regrowth taxa and they occur sporadically between 5500-2600 BP. *Dicranopteris* is often among the first weeds to enter following dry rice cultivation, regenerating from underground rootstocks, but the spore concentration figures and the frequency of occurrence are too low to use its presence to argue for shifting cultivation of dry rice.

The forest epiphyte, *Asplenium nidus*, the bird's nest fern, was only present once, around 7900 BP. *Selaginella*, another everwet forest indicator, occurred at *c.*8900 BP but there were no spores of filmy ferns (Hymenophyllaceae) which are found exclusively under very wet forested conditions. Unfortunately, a significant number of the pteridophytes could not be determined closely as they had lost their outer coating, the perine, which is sometimes distinctive at the species level.

Lycopodiales are often indicative of wet conditions and *Lycopodium cernuum*, which has a very distinctive spore type (cf. Knox 1950), can grow on very wet bogs. Were it not growing on dry slopes, it could be considered as indicative of locally wetter conditions between *c.*6600-5500 BP, around 3300 BP and 2600 BP and from 1900 BP onwards. However, this conclusion is not supported by figures for the more certainly wet-indicating taxa. Cyperaceae had their highest concentrations at *c.*10,300 BP and between 9600-8600 BP, *Potamogeton* between *c.*10,000-9300 BP, and Nymphoides between 10,300-7600 BP (when sea level, and presumably groundwater table level, was rising). Then at *c.*6600 BP, 4000 BP, 3300-1900 BP and around 760 BP. Given that only two radiocarbon dates cover the last 11,000 years, that more are needed to establish the ages of samples reliably, and more samples need to be counted for pollen diagram resolution, there is a reasonable correlation between the *Nymphoides* data and the sea level curve suggesting that times of high sea level or strong isostatic rebound were also times of high lake level. But it is difficult to draw firm conclusions about regional climatic changes at this preliminary stage in the interpretation.

CONCLUSION

Evidence for regional climatic change cannot be readily detected from this pollen diagram as there is no indication for lowered vegetation belts before the opening of the Holocene and there is no information on any climatic controlled vegetation zonation that might have existed. The topography of Nong Thale Song Hong is such that most of the pollen, and probably all of the pteridophyte spores, derive from within the lake basin. It therefore appears to be a superb site for detection of small scale human impact on the vegetation, but the likely incidence of natural, dry season, fires makes it difficult to disentangle the impact of human usage of fire from its natural occurrence. It is clear, however, that the vegetation has never been stable over the last 10,600 years. There are a series of possible forest clearance phases predating 4000 BP while the demise of *Borassodendron machadonis* thereafter could be partly due to human impact, the rise of *Artocarpus* type pollen may indicate that horticulture was practised, possibly associated with local scale shifting cultivation of dry rice, and large trees might have been conserved. The latest part of the diagram certainly suggests that some conservation was occurring and that useful plants, such as *Areca*, were being planted.

The absence of Hymenophyllaceae spores suggests that the forest was never very wet but a number of tree taxa attributed here to swamp forest can also grow in tropical evergreen rainforest. There are indications of local hydrological changes which may relate to a rising watertable as rivers graded to a higher sea level, but more radiocarbon dating and better sample resolution is necessary to correlate lake level and sea level changes.

It would be unwise to use this palaeoecological record as proxy archaeology, particularly as the pollen of crop plants cannot be determined. The situation at Khok Phanom Di was preferable, because palaeoecological and archaeological findings could be correlated; here they cannot.

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