HUMAN BEHAVIOURAL ECOLOGY AND STONE ARTEFACTS IN NORTHWEST THAILAND DURING THE TERMINAL PLEISTOCENE AND HOLOCENE

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Abstract: The extensive seasonal tropical forests and limestone karts of northern Southeast Asia preserve an excellent record of prehistoric hunter-gatherer activity. Recent work by the Highland Archaeology Project in Pang Mapha, NW Thailand has produced a high volume of hunter-gatherer cultural materials from these seasonal forests dating to the terminal Pleistocene and Holocene. These stone artefact assemblages are interpreted using a human behavioural ecology framework to show that assemblage variation is a result of variation in residential mobility, risk and uncertainty in resource availability. The concepts and methods of human behavioural ecology provide rich explanations of assemblage variability and overcome the limitations of formal lithic typological classification systems that show minimal and ambiguous assemblage variation over time and space. This approach has good potential for the analysis and interpretation of other similarly amorphous cobble-based lithic assemblages in mainland Southeast Asia.

Keywords: Stone artefact technology, Human Behavioural Ecology, Thailand, Pleistocene, Holocene.

Introduction

Past archaeological research in Southeast Asia has resulted in a notion of the Hoabinhian as a monolithic label applied to a distinctive stone artefact technology. Shoocondej (2000) has observed that attempts to explain variability within the time and space occupied by Hoabinhian people have not been compelling and she has recommended that the label is problematically homogenising and should be dropped in favour of more detailed efforts to translate artefactual data into past human behaviour. Previous work has focussed on visually distinctive forms of cores that make up relatively small proportions of Hoabinhian assemblages, with the non-formal or debitage component of the assemblage largely neglected by analysts (*e.g.* van Heekeren, Knuth 1967). Differences in the proportions of these cores have been related to different cultural groups (Anderson 1990) or different ecological adaptations (Shoocongdej 1996). In this paper I suggest that significant assemblage variation can be detected in the neglected component of Hoabinhian lithic assemblages. I use two assemblages of non-formal Hoabinhian lithics to test the explanatory potential of models derived from human behavioural ecology.

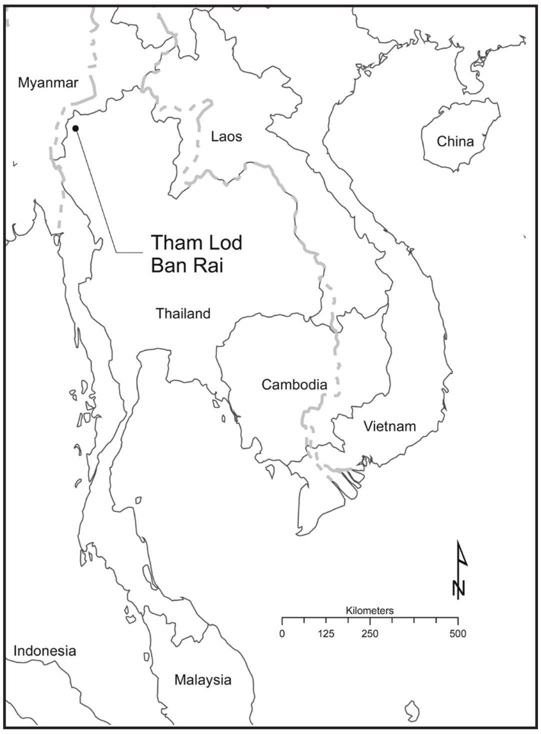

Figure 1: Location of Ban Rai and Tham Lod rockshelters.

Human behavioural ecology and lithic technology

Human behavioural ecology is an approach to the study of human behaviour marked by two commitments. First, human behavioural ecologists think that humans should be studied as living systems operating in complex environments. Second, human behavioural ecologists think that humans are subject to very similar ecological and evolutionary processes as any other species. Of course, humans are unique, and this fact has important consequences. However, ecology and evolutionary theory are important sources of candidate explanations for interesting data about human behaviour (Borgerhoff, Mulder 2005).

Following Julian Stewart, human behavioural ecologists hold that stone artefact technology is a 'window' through which people look at their environment. Human adaptations are mostly technological (but see Gero 1989, Wiessner 1982) and how we interact with any given environment depends first of all on the tools we bring to that environment. Consequently, technology can be viewed as the result of behaviours that are adaptations to the environment. This means that we can model the way that people solved problems relating to maintaining

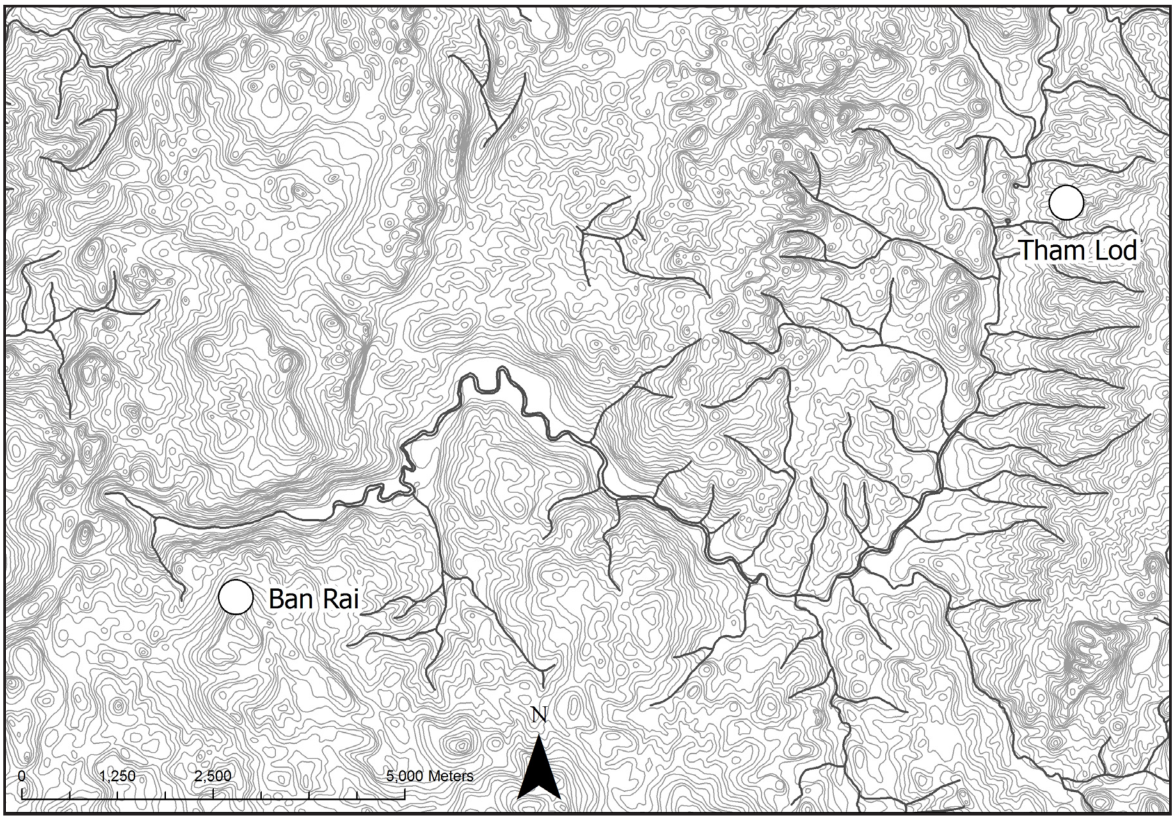

Figure 2: Topographic map showing the locations of Ban Rai (left) and Tham Lod (right). The meandering central linear shape is the Lang River with its many minor tributaries. The course of the river goes underground for about 600 m near Tham Lod. The contour lines between Ban Rai and the Lang River demonstrate the steepness of the slope in that location (each line represents 20 m of elevation).

a constant supply of technology in variable environments using foraging models that predict how foragers should behave in given ecological contexts. Foraging models allows us to develop a large set of fundamental hypotheses that predict which resources foragers will pursue when encountered during a search (diet breadth), or where foragers will travel to search for resources (patch choice models), how long they will stay in these places before moving to other areas (marginal value theorem), how foragers determine the balance of field processing and transportation of resources and responses to resource depression (central place foraging) and how the dispersion of resources relates to forager mobility (the geometric model of optimal dispersion) (Bird, O'Connell 2006, Hames 2001, Smith 1983).

These models derive from evolutionary theory that describes humans as a product of natural selection processes resulting in the biological, social and behavioural flexibility to negotiate fitness related trade-offs in particular socio-ecological contexts (Winterhalder and Smith 1992). These models operate under the assumption that people have the ability to weigh the costs and benefits of adopting particular strategies, and that these decision rules (and the social, physiological and cognitive machinery behind them) have been the focus of selection throughout human evolutionary history (Pyke 1984). The models do not distinguish between biological and cultural origins of behavior, nor do they insist that people really act like this all of the time or even cognize problems in exactly these ways. The models simply help us understand how selection might shape behaviours related to improving foraging returns over time (Clarkson 2006).

Optimality models used in ethnographic and animal ecology studies are usually expressed as formal mathematical equations. These equations are simplified representations of real world complexity for the purposes of analysis (Hawkes, O'Connell 1992, Smith 1983). However they are not required to use the models and the incomplete nature of evidence about past human behaviour and past environments makes it difficult to supply all the inputs at the resolution, precision and accuracy necessary to operate mathematical functions. Instead we can use null hypothesis significance tests to test hypotheses derived from models (Stephens *et al.* 2007).

One of the most productive approaches to modelling behaviours related to lithic technology has been in measuring the degree that people adapted their technologies as the risks of resource failure varied (Clarkson 2006, Mackay 2005). Multivariate studies of large numbers of forager groups around the world suggest that when people have a high degree of risk of resource failure, they increase the effort invested in their tools (Torrence 1983, Collard *et al.* 2005). This correlation provides a useful starting point for investigating technological variation in a number of dimensions (Bousman 1993).

For example, the low-latitude foragers of the Kung have a relatively simple stone artefact technology. If their hunting is not successful because of tool failure, then they can easily fall-back onto abundant plant resources (Lee 1979). Also, they do not need to prepare their tools long in advance, because if a tool fails they can usually make a replacement quite easily (Bleed 1986). They minimise tool setup costs by extending the life of the tools through resharpening and using their tools until they are exhausted (Kuhn

1989). So in this case the risk of failure is low and the amount of effort invested in the tools is also low. On the other hand, the high-latitude Nunamiut Eskimos have a complicated technology involving many kinds of specialised tools (Binford 1978, 1977). They also prepare their technology long in advance of its anticipated use, because they cannot always predict when they will need it. They discard tools long before they are exhausted because the cost of unexpected failure is high. If tools break while on a hunting trips they are very difficult to replace because raw materials and other subsistence resources are often scarce. In this case the amount of effort is relatively high, because the difficult environment makes the risk of resource failure high (Torrence 1989).

In these two ethnoarchaeological examples we can see the general ecological principle of a relationship between risk and specialisation of technological behaviours. In the case of stone artefacts, we can propose a model that shows when the risk of uncertainty in the supply of raw materials increases, so does the amount of effort invested in stone artefacts. This model acknowledges that humans are subject to ecological pressures in a similar way to animals, but measures this pressure through a uniquely human trait; stone artefact technology. From this model we can generate archaeological testable hypotheses to explore the relationship between risk and technology in specific contexts.

Background and Hypotheses of the study

The materials for this study come from two excavations conducted by Rasmi Shoocongdej's Highland Archaeology Project in Pang Mapha, northwest Thailand. Figure 1 shows the location of Tham Lod rockshelter and Ban Rai rockshelter. The sites are in the uplands of mainland Southeast Asia, about 10 km from the sites excavated by Chester Gorman in the 1960s (Spirit Cave, Banyan Valley Cave and Tham Pha Chan). Occupation at Tham Lod begins at about 35,000 years BP (Shoocongdej 2006) and about 12,000 years BP at Ban Rai (Treerayapiwat 2005).

Figure 2 shows the position of the sites on a contour map, with Bai Rai at an elevation of about 900 m above mean sea level and Tham Lod at about 640 m. The two sites are about 10 km apart and both are adjacent to the Lang River. Tham Lod is about 200 m from the river at about 15 m above the mean river level and although Ban Rai is only a little further away on the horizontal plane, it is about 300 m above the river. This means that access to the river from Ban Rai is via a steep slope. Steep slopes are ubiquitous in the high relief topography of the weathered Permian limestone landscape, which results in an extremely rugged landscape where about 47% of the land area has slopes of over 60% (Dunkley 1985, Kiernan 1991).

The ruggedness also results in distinctly different environments at the extremes of elevation. For example, the ridges at 800-1000 m elevation are characterised by open pine forest dominated by *Pinus merkusii* and *Pinus kesiya*. On the slopes are mixed deciduous and dry dipterocarp forests dominated by *Dipterocarpus*, *Tectonis* and various bamboo species. The understory and grasses in the mixed deciduous and dry dipterocarp forests becomes increasingly dense as they approach rivers. This means that the kinds of resources available to foragers occupying the rockshelters are influenced by the altitude of their habitat. This is similar to the 'vertical archipelago' proposed by Murra (1972) in southern Peru, where the main ecological variable is elevation and the landscape can be envisioned as a series of steps or tiers ('pisos ecologicos') with different resources available in each. The ruggedness of the landscape of Ban Rai and Tham Lod means that travelling on foot is expensive on time and energy, so foragers are more dependent on the resources available locally at the particular altitude of the each site.

To summarise the important details of the local environments of the two sites, we can see that there is considerable difference between the two sites in the distances to the river. Tham Lod is very close to the river and easily accessible, but Ban Rai is much further away from the river and up a steep slope. This is crucial for understanding the stone artefact technologies because almost all of the artefacts at these two sites are made from cobbles taken from the river banks. So the river is not only a reliable source of water (especially during the dry season) but a major source of raw materials for making stone artefacts. The differences in the locations of these two sites provide an excellent opportunity to explore the model of risk and effort mentioned earlier. From that model we can derive a hypothesis to test with data from the stone artefact assemblages at the two sites.

The hypothesis predicts that the assemblage from Tham Lod will show relatively <u>less effort</u> invested in making and using stone artefacts compared to Ban Rai. This hypothesis is derived from the the fact that Tham Lod is located relatively close to the river bank which is the source of raw materials for stone artefacts. The central place foraging model predicts that a relatively short transport time results in minimal pre-processing of a resource before it reaches the destination for consumption (Orians and Pearson 1979). Given the proximity of the raw materials to Tham Lod, it is predicted that the organisation of technology will be unconstrained by needs for raw material conservation. The geometric model of optimal dispersion (Horn 1968, Smith 1983) predicts that a stable/evenly dispersed environment, such as close to the river, should result in residential mobility where foragers exploit the river valley resources with short relocations of the residential camp. This is equivalent to Kuhn's (1995) concept of 'place provisioning', a technological strategy suited to low variation in the location and timing of foraging activities is and low mobility. Under these conditions an assemblage should be high in 'tool-making potential' with a high proportion of relatively large pieces that show minimal reduction before entering the site.

On the other hand, Ban Rai is expected to show a <u>greater effort</u> invested in technology. Ban Rai is located relatively further from the river bank cobble deposits than Tham Lod, but the trip from the source of raw materials to Ban Rai involves a sustained steep incline. This topographical detail has direct consequences for technological provisioning at Ban Rai rockshelter. It implies significant transport costs for bringing raw materials to the site and increased risks of time-stress because foraging opportunities may not efficiently coincide with opportunities to reprovision with raw materials. The central place model predicts that longer travel times will result in greater pre-processing of resources before they reach the destination for consumption. The geometric model of optimal dispersion predicts that the more patchy distribution of resources at Ban Rai (because of its greater distance to the river) results in more logistical mobility, with foragers travelling longer distances from a residential camp to encounter resources. This situation can be described using Kuhn's (1995) concept of 'individual provisioning' that represents an adaptation to low levels of predictability in resource availability and long travel times between resource encounters. The archaeological correlate of this adaptation is an assemblage of smaller, lighter pieces that are easier to transport as well as artefacts that are extensively worked to extend their use-life, as compensation for the difficulty in obtaining replacement material (Shott 1989, Hiscock 2006, Macgregor 2005).

Methods

To test this hypothesis we can use some of the variables already suggested, namely artefact size and extent of artefact reduction. While artefact size can easily be measured using metric dimensions and mass, the measurement of reduction intensity is more complex. Measuring reduction in many European, African, American and Australian assemblages is relatively straightforward because of the numerous different kinds of visually distinctive stone artefacts that represent varying levels of reduction (Shott 2005). However, the two assemblages discussed here are typical of many in mainland Southeast Asia in having only a very small proportion of distinctive kinds of artefacts. The great majority of artefacts in these assemblages are unretouched flakes and cores and so methods for measuring reduction intensity in this informal/debitage component must be sought.

Fortunately, archaeological and experimental studies of stone artefact technology have shown that there are a number of attributes on unretouched flakes and cores that are responsive to the amount of reduction an assemblage has undergone (Magne, Pokotylo 1981; Mauldin, Amick 1989; Tomka 1989; Mackay 2005). From this work two useful strategies have been developed. First is diacritical analysis, the analysis of flake scars to determine the order and intensity of flaking activity (Sellet 1993). This analysis relies on the simple and universal changes in flake scar superposition that occur to cores and flakes as reduction proceeds. For example, flakes produced early in the reduction process will have high proportions of cortex on their dorsal surface and platform, but flakes from the later stages will have higher numbers of superimposed flake scars on the dorsal surface and platform (indicating previously detached flakes), non-parallel flake scars on the dorsal surface (indicating rotation of the core to extend use-life, recorded here as the number of flake scar axes seperated by 45° or more) and flake scars with non-feather terminations (indicating that the knapper had difficulty successfully detaching flakes as core interia becomes more difficult to overcome and core geometry becomes more problematic).

The second strategy is experimental replication of archaeological assemblages as a way to determine the relative importance of the numerous core and flake variables that change during reduction. This involves describing the transformations in morphology and attributes of experimentally produced artefacts as an assemblage is reduced. The assumption here is that the experimental flaking is a close analogue of the behaviours that produced the archaeological assemblage. Mawick (2006) has presented the results of an experimental study of Hoabinhian assemblage reduction. In this study, the variables that were most sensitive to assemblage reduction were overhang removal (indicated by the presence of a cascade of small step-terminated flake scars on the dorsal surface near the striking platform of the flake, recorded as present or absent), interior platform angle (the angle between the inside or ventral surface of a flake and its striking platform, recorded to the nearest 10°), percentage of dorsal cortex (the amount of original skin of the rock on the dorsal surface, recorded to the nearest 10%). The good concordence between the variables identified by the experimental findings and the predictions of the diacritical approach suggests that these variables will give robust data on the extent of assemblage reduction (Marwick 2006).

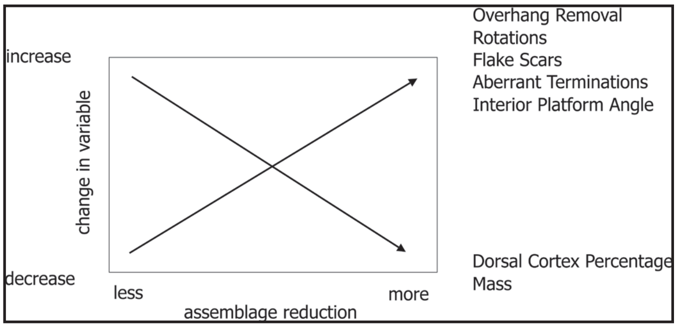

Figure 3: Schematic showing the relationship between the relative intensity of assemblage reduction and the responses of the variables used in this analysis.

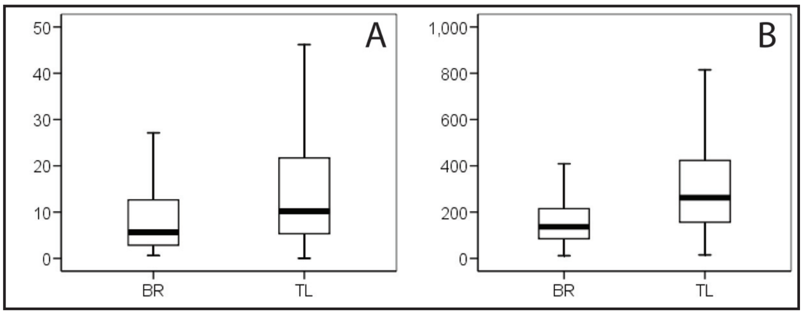

Figure 4: Box and whisker plots comparing mass in grams of (a) complete flakes and (b) mass of cores at Tham Lod (TL) and Ban Rai (BR).

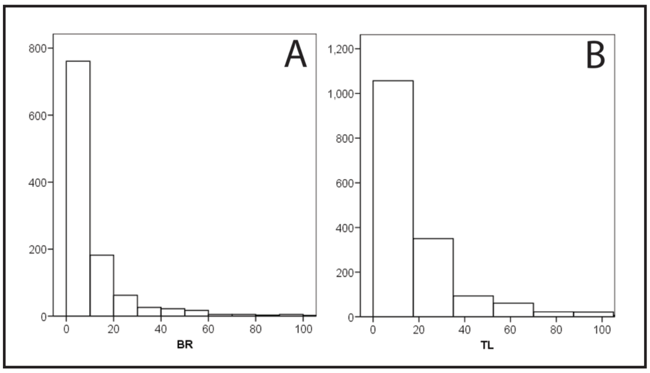

Figure 5: Histograms of complete flake mass at (a) Ban Rai (BR) and (b) Tham Lod (TL) showing skewed distributions.

Figure 3 shows how these variables are expected to change as assemblage reduction increases. We can see that cortex area and mass decreases but values of the other variables should increase as reduction intensity.

Results

Data was collected from 8175 flakes and 428 cores from excavation area one of Tham Lod and 1438 flakes and 125 cores from excavation area three of Ban Rai. The results show that the foraging models are good predictors of how people organised stone artefact technology at Ban Rai and Tham Lod. In general, the assemblage from Ban Rai was more intensively reduced than the assemblage at Tham Lod.

	Overhang Removal	Interior Platform Angle	Dorsal Cortex	Rotations	Dorsal Flake Scars	Aberrant Terminations
Difference	0,046	0,586	13,51	0,048	0,248	0,241
Significance Statistic	7,602	0,839	11,102	-2,902	6,026	8,995
Significant Difference?	Yes	No	Yes	Yes	Yes	Yes

Table 1. Summary of differences in means for flake variables discussed in the text (difference in proportions for overhang removal) and statistical significance tests (chi-square for overhang removal, t-tests for the others).

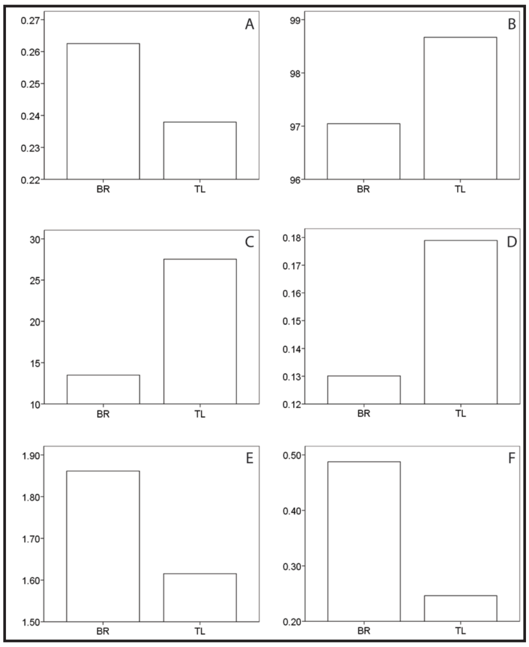

Figure 6: Bar graphs comparing (a) proportions of flakes with overhang removal, (b) mean interior platform angles, (c) mean percentages of dorsal cortex, (d) mean numbers of rotations, (e) mean numbers of flake scars on the dorsal surface and (f) mean numbers of aberrant terminations on flakes at Ban Rai (BR) and Tham Lod (TL).

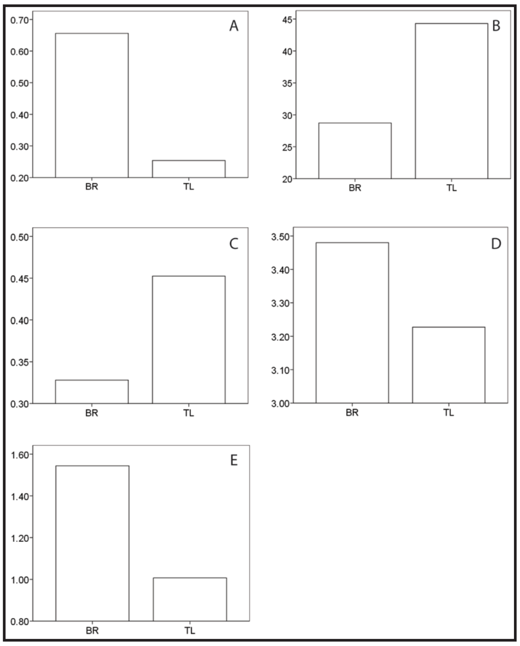

Figure 7: Bar graphs comparing (a) proportions of cores with overhang removal, (b) mean percentages of cortex, (c) mean numbers of rotations, (d) mean numbers of flake scars and (e) mean numbers of aberrant terminations on cores at Ban Rai (BR) and Tham Lod (TL).

Figure 4 shows the mass of cores and flakes at the two sites. The box and whisker plot shows five statistics (minimum, first quartile, median, third quartile, and maximum), with the median values as the horizontal bar inside the box. Median is preferred over mean in this case because the distributions of mass are highly skewed toward lighter artefacts (Fig. 5). The plots in figure 4 show that both cores and flakes are smaller and more restricted in size at Ban Rai compared to Tham Lod. This could result from more extensive reduction at Ban Rai or simply selection of smaller cobbles for use as cores.

Figure 6 shows bar graphs for a series of technological variables of flakes at the two sites. The graphs show comparisons of proportions of flakes with overhang removal, mean interior platform angles, mean percentages of dorsal cortex, mean numbers of rotations, mean numbers of flake scars and mean numbers of aberrant terminations. Table 1 shows the results of statistical tests for significant differences in these variables. These show that there are significant differences between proportions of overhang removal, percentages of dorsal cortex, mean number of flake scars and mean number of aberrant terminations. These differences are all indicative of greater reduction intensity at Ban Rai compared to Tham Lod.

	Overhang Removal	Cortex	Rotations	Dorsal Flake Scars	Aberrant Terminations
Difference	0,401	15,575	0,124	0,252	0,537
Significance Statistic	69,143	-5,447	-1,71	1,198	3,553
Significant Difference?	Yes	Yes	No	No	Yes

Table 2. Summary of differences in means for core variables discussed in the text (difference in proportions for overhang removal) and statistical significance tests (chi-square for overhang removal, t-tests for the others).

The difference in mean interior platform angle is not significant but the difference in mean number of rotations is significant and suggests higher reduction at Tham Lod instead of Ban Rai. However, this anomalous result may be because the flakes at Tham Lod are larger, providing a greater surface area for greater variation in the configuration of flake scars.

Figure 7 shows bar graphs comparing proportions of cores with overhang removal, mean percentages of cortex, mean numbers of rotations, mean numbers of flake scars and mean numbers of aberrant terminations for cores from Ban Rai and Tham Lod. Table 2 shows the results of statistical tests for significant differences in these variables. The proportion of cores with overhang removal, the average number of aberrant terminations per core and the average number of flake scars per core are all significantly greater at Ban Rai. The average number of flakes scars per core is also higher at Ban Rai, but the difference is not statistically significant. The trend in rotation is opposite to the other variables, as it is for the flakes, but for the cores the difference is not significant, and may be ascribed to stochastic variation rather than substantial differences in flaking behaviours. In general the pattern of core variables indicates more intensive reduction at Ban Rai and a greater likelihood of pre-processed pieces entering the assemblage compared to Tham Lod.

Discussion and Conclusion

Returning to the hypothesis presented earlier, the results demonstrate that there was relatively less effort invested in the organisation of stone artefact technology at Tham Lod compared to Ban Rai, where effort has been measured as the intensity of reduction of the assemblage. These results come from measurement of mass, proportions of artefacts with overhang removal, mean interior platform angles, mean numbers of rotations per artefact, mean numbers of flake scars per artefact and mean numbers of aberrant terminations per artefact. The robustness of these variables as measures of reduction is indicated by their good concordance in each assemblage, with seven of the eleven comparisons of variables supporting the hypothesis. The anomalous results are difficult to explain. They suggest that, to a small degree, variables other than risk and economics have influenced stone artefact technologies or that stochastic variation is present in the assemblages.

The evidence at Ban Rai can be interpreted as an adaptation to the increased risks involved in maintaining a supply of technology at some distance from the source and amidst a patchy resource distribution. Conversely, the evidence at Tham Lod indicates that stone artefact technology was less constrained by risks relating to budgeting time and energy spent on resource procurement. Following Kuhn's scheme of technological organisation, the occupants of Ban Rai produced an assemblage that reflects an individual provisioning strategy while the assemblage at Tham Lod indicates that people there pursued a place provisioning strategy. Krajaejun (2006) came to a similar conclusion when applying Kuhn's model to lithics from Tham Lod and Ban Rai. Krajaejun's approach differs from the one presented here because his analysis was concentrated on core tools. The study presented here is significantly different because it has shown that meaningful conclusions about settlement and subsistence behaviours can be drawn from non-formal, non-used manufacturing debris (*cf.* Mackay 2005).

More generally, this study shows that the conceptual framework of human behavioural ecology is a productive and useful source of models and methods for investigating the archaeology of stone artefact technology in mainland Southeast Asia. The approach presented here is a powerful and versatile heuristic that builds on previous efforts (*e.g.* White, Gorman 2004) towards understanding assemblages that have previously been dismissed as 'amorphous' and 'primitive'. These efforts are important because the limited typological variety in the hunter-gatherer archaeology of mainland Southeast Asia has resulted in only limited success in explaining change and variation in lithic assemblages, leaving a vacuum of high-level theory about behavioural adaptations and cultural history.

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References:

Anderson 1990: ANDERSON D. D. (1990) - *Lang Rongrien rockshelter: a Pleistocene-early Holocene archaeological site from Krabi, Southwestern Thailand,* Philadelphia, University Museum, University of Pennsylvania.

Binford 1977: BINFORD L. R. (1977) - Forty seven trips. A case study in the character of archaeological formation processes. In: WRIGHT, R.V.S. (Ed.) (1977) - *Stone Tools as Cultural Markers*. New Jersey, Humanities Press.

Binford 1978: BINFORD L. R. (1978) - Dimensional Analysis of Behavior and Site Structure: Learning from an Eskimo Hunting Stand. *American Antiquity*, 43, 330-361.

Bird, O'Connell 2006: BIRD D., O'CONNELL J. (2006) - Behavioral Ecology and Archaeology. *Journal of Archaeological Research*, 14, 143-188.

Bleed 1986: BLEED P. (1986) - The optimal design of hunting weapons: maintainability or reliability. *American Antiquity*, 51, 737-747.

Borgerhoff Mulder 2005: BORGERHOFF MULDER M. (2005) - Human Behavioural Ecology. *Nature Encyclopedia of Life Sciences*. London, Nature Publishing Group.

Bousman 1993: BOUSMAN C. B. (1993) - Hunter-gatherer adaptations, economic risk and tool design. *Lithic Technology*, 18, 59-85.

Clarkson 2006: CLARKSON C. (2006) - Interpreting Surface Assemblage Variation in Wardaman Country, Northern Territory: An Ecological Approach. In: ULM S., LILLEY I. (Eds.) (2006) - *An Archæological Life: Papers in Honour of Jay Hall*. Brisbane, Aboriginal and Torres Strait Islander Studies Unit, The University of Queensland.

Collard *et al.* 2005: COLLARD M., KEMERY M., BANKS S. (2005) - Causes of Toolkit Variation Among Hunter-Gatherers: A Test of Four Competing Hypotheses. *Canadian Journal of Archaeology*, 29, 1-19.

Dunkley 1985: DUNKLEY J. R. (1985) - Karst and Caves of the Nam Lang - Nam Khong region, North Thailand. *Helictite*, 23, 3-22.

Gero 1989: GERO J. M. (1989) - Assessing social information in material objects: how well do lithics measure up? In: TORRENCE R. (Ed.) (1989) - *Time, Energy and Stone Tools*. Cambridge, University of Cambridge.

Hames 2001: HAMES R. (2001) - Human Behavioral Ecology. *International Encyclopedia of the Social and Behavioral Sciences*. Elsevier Science Ltd.

Hawkes, O'Connell 1992: HAWKES K., O'CONNELL J. F. (1992) - On optimal foraging models and subsistence transitions. *Current Anthropology*, 33, 63-66.

Hiscock 2006: HISCOCK P. (2006) - Blunt and to the Point: Changing technological strategies in Holocene Australia. In: LILLEY I. (Ed.) *Archaeology in Oceania: Australia and the Pacific Islands*. Blackwell.

Horn 1968: HORN H. S. (1968) - The adapative significance of colonial nesting in the Brewer's Blackbird (Euphagus cyanocephalus). *Ecology*, 49, 682-694.

Kiernan 1991: KIERNAN K. (1991) - Tropical Mountain Geomorphology and Landscape Evolution in Northwest Thailand. *Zeitschrift für Geomorphologie NF*, 53, 187-206.

Krajaejun 2006: KRAJAEJUN P. (2006) - People and stone: Human lifeways and adaptation from the terminal Pleistocene to the late Holocene in Pang Mapha District, Mae Hong Son Province. In: SHOOCONGDEJ, R. (Ed.) (2006) - *Social, Cultural and Environmental Dynamics in the Highlands of Pangmapha, Mae Hong Son Province: Integrated Archaeological Research into the Region*. Bangkok, Highland Archaeology Project in Pang Mapha.

Kuhn 1989: KUHN S. L. (1989) - Hunter-gatherer foraging organization and strategies of artifact replacement and discard. In: AMICK, D. S. and MAULDIN, R. P. (Eds.) (1989) - *Experiments in Lithic Technology*. Oxford, *BAR International Series 528*.

Kuhn 1995: KUHN S. L. (1995) - *Mousterian Lithic Technology*, Princeton, Princeton University Press.

Lee 1979: LEE R. (1979) - *The Kung San*, Cambridge, Cambridge University Press.

Macgregor 2005: MACGREGOR O. (2005) - Abrupt Terminations and stone artefact reduction potential. In: CLARKSON C. and LAMB L. (Eds.) (2005) - *Rocking the Boat: Recent Australian Approaches to Lithic Reduction, Use and Classification*. Oxford, Archaeopress.

Mackay 2005: MACKAY A. (2005) - Informal Movements: Changing Mobility Patterns at Ngarrabullgan, Cape York Australia. In: CLARKSON C. and LAMB L. (Eds.) (2005) - *Rocking the Boat: Recent Australian Approaches to Lithic Reduction, Use and Classification*. Oxford, Archaeopress.

Magne, Pokotylo 1981: MAGNE M.P., POKOTYLO D. (1981) - A pilot study in bifacial lithic reduction sequences. *Lithic Technology*, 10, 34-47.

Marwick 2006: MARWICK B. (2006) - A Methodological Study of Technological Attributes in Hoabinhian Lithic Assemblages. In: SHOOCONGDEJ, R. (Ed.) (2006) - *Social, Cultural and Environmental Dynamics in the Highlands of Pangmapha, Mae Hong Son Province: Integrated Archaeological Research into the Region*. Bangkok, Highland Archaeology Project in Pangmapha.

Mauldin, Amick 1989: MAULDIN R.P., AMICK D.S. (1989) - Investigating patterning in debitage from experimental biface core reduction. In: AMICK D.S., MAULDIN R.P. (Eds.) (1989) - *Experiments in Lithic Technology*. Oxford, *BAR International Series 528*.

Murra 1972: MURRA J. V. (1972) - El "control vertical" de un máximo de pisos ecológicos en la economía de las sociedades Andinas. In: MURRA, J. V. (Ed.) (1972) - *Visita de la Provincia de Leon de Huanuco en 1562*. Huanuco, Universidad Nacional Hermilio Valdizan.

Orians, Pearson 1979: ORIANS G.H., PEARSON N.E. (1979) - On the theory of central place foraging. In: HORN D.J., MITCHELL R.D., STAIRS G.R. (Eds.) (1979) - *Analysis of Ecological Systems*. Columbus, Ohia State University.

Pyke 1984: PYKE G.H. (1984) - Optimal Foraging Theory: A Critical Review. *Annual Review of Ecology and Systematics*, 15, 523-575.

Sellet 1993: SELLET F. (1993) - Chaîne opératoire; the concept and its applications. *Lithic Technology*, 18, 106-12.

Shoocongdej 1996: SHOOCONGDEJ R. (1996) - *Forager mobility organisation in seasonal tropical environments: A view from Lang Kamnan Cave, western Thailand*. Ann Arbor, The University of Michigan.

Shoocongdej 2000: SHOOCONGDEJ R. (2000) - Forager Mobility Organization in Seasonal Tropical Environments of Western Thailand. *World Archaeology*, 32, 14-40.

Shoocongdej 2006: SHOOCONGDEJ R. (2006) - Late Pleistocene activities at the Tham Lod Rockshelter in Highland Pang Mapha, Mae Hong Son Province, Northwestern Thailand. In: BACUS E.A., GLOVER I.C., PIGGOTT V. (Eds.) (2006) - *Uncovering Southeast Asia's Past: Selected Papers from the 10th Annual Conference of the European Association of Southeast Asian Archaeologists*. Singapore, NUS Press.

Shott 1989: SHOTT M.J. (1989) - On Tool-Class Use Lives and the Formation of Archaeological Assemblages. *American Antiquity*, 54, 9-30.

Shott 2005: SHOTT M.J. (2005) - The reduction thesis and its discontents: Review of Australian approaches. In: CLARKSON C., LAMB L. (Eds.) (2005) - *Rocking the Boat: Recent Australian Approaches to Lithic Reduction, Use and Classification*. Oxford, Archaeopress.

Smith 1983: SMITH E A. (1983) - Anthropological Applications of Optimal Foraging Theory: A Critical Review. *Current Anthropology*, 24, 625-651.

Stephens *et al.* 2007: STEPHENS P.A., BUSKIRK S.W., DEL RIO C.M. (2007) - Inference in ecology and evolution. Trends in Ecology and Evolution, *In Press*, Corrected Proof.

Tomka 1989: TOMKA S.A. (1989) - Differentiating lithic reduction techniques: An experimental approach. In: AMICK D. S. and MAULDIN R. P. (Eds.) (1989) - *Experiments in Lithic Technology.* Oxford, *BAR International Series 528*.

Torrence 1983: TORRENCE R. (1983) - Time budgeting and hunter-gatherer technology. In: BAILEY G. (Ed.) (1983) - *Hunter-Gatherer Economy in Prehistory*. Cambridge, Cambridge University Press.

Torrence 1989: TORRENCE R. (1989) - Re-tooling: towards a behavioral theory of stone tools. In: TORRENCE R. (Ed.) (1989) - T*ime, Energy and Stone Tools*. Cambridge, University of Cambridge.

Treerayapiwat 2005: TREERAYAPIWAT C. (2005) - Patterns of Habitation and Burial Activity in the Ban Rai Rock Shelter, Northwestern Thailand. *Asian Perspectives*, 44, 231.

Van Heekeren, Knuth 1967: VAN HEEKEREN H.R., KNUTH E. (1967) - *Archaeological Excavations in Thailand. Volume 1. Sai Yok. Stone Age Settlements in the Kanchanaburi Province*, Copenhagen, Munksgaard.

White, Gorman 2004: WHITE J.C., GORMAN C.F. (2004) - Patterns in "amorphous" industries: the Hoabinhian viewed through a lithic reduction sequence. In: PAZ V. (Ed.) (2004) - *Southeast Asian archaeology: Wilhelm G. Solheim II Festschrift*. Quezon City, University of the Phillipines Press.

Wiessner 1982: WIESSNER P. (1982) - Risk, reciprocity and social influence on !Kung economices. In: LEACOCK E., LEE R. (Eds.) (1982) - *Politics and History in Band Societies*. Cambridge, University of Cambridge Press.

Winterhalder, Smith 1992: WINTERHALDER B., SMITH E.A. (1992) - Natural selection and decision-making: Some fundamental principles. In: SMITH E.A., WINTERHALDER B. (Eds.) (1992) - *Evolutionary Ecology and Human Behavior*. Hawthorne, NY, Aldine de Grutyer.