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Abstract

Foraging societies present unique ways of living and sociality which are manifested by distinctive practices and use of space. From an archaeological point of view, understanding forager sociality and studying their practices and the resulting material deposition patterns is crucial to reconstruct archaeological site formation processes. When studying archaeological sites in tropical environments, such as rainforests, one must take into account and study the role of the tropics in the formation of the archaeological record. Human adaptation to tropical environment influences people's practices, use of space and materiality. In addition, the environmental setting plays a significant role in post-depositional processes which may alter, preserve or disrupt archaeological materials. This study involves a long-term ethnographic research among a contemporary forager group in South India, which allowed us to associate the social aspects of forager ways of living - such as mobility, immediacy and adaptation to the tropical forest - with patterns of use of space and material deposition. Excavations of an abandoned open-air site and a rock-shelter of the same group included field observations and sediment sampling, followed by laboratory analyses which enabled the investigation of post-depositional processes on both the visible and invisible (microscopic and sub-microscopic) scales. Overall, although forager ways of living and the environmental conditions in tropical forests challenge the formation of well-preserved archaeological evidence, an integrated approach examining the different scales of the archaeological record can successfully reconstruct the formation processes of archaeological sites in tropical forests and associate the archaeological evidence with social aspects of forager ways of living.

Keywords	Foragers; Tropical forests; Ethnoarchaeology; Archaeological Site formation processes; South Asia; Material deposition patterns

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Foragers, tropical forests and the formation of archaeological evidences: an ethnoarchaeological view from South India

1. Introduction

Tropical forests have been an important habitat for various human societies since the Late Pleistocene (Mercader, 2002; Gosden, 2010; Perera, 2010; Summerhayes et al. 2010; Barker, 2013; Roberts and Petraglia, 2015). Although some have questioned the ability of foragers to live independently in tropical forests (Hart and Hart, 1986; Bailey et al., 1989; Headland and Reid, 1989; Bailey and Headland 1991), more recent studies have shown through archaeological, ethnological, ecological and linguistics evidence that tropical forests could be and have been a rich ecological environment for human habitation (Dufour, 1990; Bahuchet et al. 1991; Colinvaux and Bush, 1991; Endicott and Bellwood, 1991; Stearman, 1991; Willis et al., 2004; Roberts et al. 2015). Nonetheless, the direct archaeological evidence for human occupation of tropical forests remains sparse and is mostly confined to caves and rock-shelters (Mercader, 2002; Roberts and Petraglia, 2015).Few studies also presented archaeological evidences preserved in open-air sites (e.g., Mercader et al., 2002; Simpson et al., 2008; Perera, 2010; Summerhayes et al. 2010). This situation raises the question whether the archaeological record presents evidence of absence or absence of evidence. While the former has significant implications regarding the role of tropical forests as a habitant for human dispersal and evolution, the latter option may simply be the result of research bias or post-depositional processes.

The ethnographic and historical data from the last centuries point out that the majority of forager groups in South and Southeast Asia tropical forests live in open-air sites (e.g., Endicott, 1979; Morris, 1982; Bhanu, 1989; Lye, 2004; Gardner 2000, 2012; Bird-David, 2009). Thus, there is no reason to assume that prehistoric foragers differed and avoided open-air sites in tropical forests (Anderson, 1997). However, apart from few sites in Papua New Guinea (Gosden 2010; Summerhayes et al. 2010),

archaeological evidence for open-air sites associated with foragers activity in tropical Asian forests is almost completely absent. It is believed that the environmental conditions in tropical environments do not favour the preservation of open-air sites as opposed to caves and rock-shelters (Tappen, 1994; Mercader et al., 2003; Taylor, 2011). However, the few geoarchaeological studies which have examined the post-depositional processes of archaeological materials in open-air sites in tropical environments have shown that anthropogenic materials (mainly charcoal, phytoliths and chemical residues) *can* be preserved (e.g., Mercader et al., 2002; Simpson et al., 2008; Perera, 2010). We are therefore most probably facing research bias or intensive post-depositional formation processes, which have led to the underrepresentation of open-air sites associated with foragers in tropical forests, rather than facing a true reflection of a preference made by past human populations.

In this paper we examine the archaeological site formation processes related to foragers' ways of living in a tropical forest and how their daily practices and adaptation to the environment influenced the formation of the archaeological evidence. We present an ethnoarchaeological case study from South India as part of an integrated project involving social anthropology, ethnoarchaeology and geoarchaeology. Here we present the results from our long-term ethnographic work among a contemporary forager community and the excavations of their abandoned sites located deep in the forest (For detailed description of the laboratory-based analyses see Friesem et al. submitted). We use the ethnographic data in order to link the social behaviour of the studied group with patterns of material deposition and then study the potential of these deposits to preserve archaeologically in open-air sites in tropical forests.

1.1. Archaeological Site Formation

Archaeologists encounter human occupation sites long after their abandonment. Many different agents and processes might have altered, preserved or disrupted the archaeological material and site since its initial occupation phase, via its abandonment until it is unearthed by archaeologists (Schiffer, 1987). While most of the

archaeological investigation is of the formation of the archaeological record, which can be directly associated with past human behaviour, it is evident that the environmental setting plays a significant role in the formation of the current archaeological context. Many geoarchaeologists who study site formation processes distinguish between natural and anthropogenic formation processes, while acknowledging their interaction and relations (Butzer, 1982; French, 2003; Goldberg and Macphail, 2006). Nonetheless, a clear distinction between natural and anthropogenic (human-related) formation processes might oversimplify their complex relationships in terms of archaeological site formation processes. Environmental influence can be observed through human adaptation to the environment. In certain environments there would be specific materials and resources available to humans. On the other hand, human habitation modifies and alters the landscape. Post-depositional and post-abandonment processes may occur both as a result of human activity as well as due to the natural environmental conditions. Thus, archaeological sites are formed as a result of a complex interplay between humans and their environment (Butzer, 1982; French, 2003; Goldberg and Macphail, 2006). This paper examines the archaeological formation processes resulting from forager social and ontological ways of living in a tropical forest in South Asia.

1.2. The study area

The study area is located in the forested hills of the Western Ghats in South India (Figure 1). These forests form parts of the Nilgiri Biosphere Reserve (NBR) (10º 45'N to 12 º N and 76º E to 77º 5' E) on the borders between the States of Karnataka, Kerala and Tamil Nadu. Sites were located at an altitude of 700-900 meters above sea level. The natural vegetation type depends on the area and altitude. Generally, the natural vegetation types of the NBR range from wet evergreen tropical forests to thorn forests (Varghese et al. 2015). The temperatures range from 17 to 37°C, with an average annual precipitation of 2600mm. Most precipitation falls during monsoon season, from June to September (Jayakumar and Nair 2013).

Fieldwork was conducted among a Nayaka community. The Nayaka were classified as immediate-return forest dwelling hunter-gatherers by Bird-David (see selected publications Bird-David 1990, 1992, 1994, 1999). Apart from the studied community, other forager groups have been studied in this region (e.g., Misra, 1969; Morris, 1982; Bahnu, 1989; Demmer, 1997; Gardner, 2000, 2012; Norstrom, 2003; Naveh, 2007), which exhibit significant similarity in their social perceptions and ways of living. While this study presents a case study from our work among one Nayaka community, the social and material features presented are by no means unique to them and can be observed to a large extent in many other foraging societies in general and in particular among South Indian forest dweller foragers. This by no means implies that all the forager groups around the world or even among the Western Ghats are the same, but we do, as other scholars have (Gardner 2012), think that there are many similarities which override the differences, especially when compared to other societies around them.

The study presented here is based on a long-term ethnographic work through numerous visits to the same Nayaka community, in 2010, 2012 and 2014, each time for a period of two, four and six months respectively, including living in the contemporary dwelling site, participating in everyday social life and activities, observations and interviews. Although this locality once consisted of grass and bamboo houses, today concrete houses are built by external development institutions and few people practice to some extent agriculture and animal husbandry (both saplings and animals were provided by development agencies). Recent studies (Lavi, 2012; Lavi and Bird-David, 2014) demonstrated how the perception, interaction and use of farming-related materials among the Nayaka cannot be simply read as a transition toward farming, encompassing a new social order, practices and world views. Rather, the way the Nayaka perceive and relate to these recent changes reveals much more complex processes of inner-social dynamics, interpretation and negotiations based on their own ways of living. The ethnographic data presented here focuses on peoples' sociality,

materiality, use of space and adaption to the environment in relation to their everyday life in a tropical forest.

In addition, field observations, excavations and sediment sampling were conducted in 2015 in abandoned sites of the same group in the same forest area. An open-air site and a rock-shelter, abandoned ca. 20-30 years ago, were recognized and introduced to us by elder Nayaka, pointing us to the location of the site covered by dense vegetation. The sediments samples were then analysed in a geoarchaeological laboratory in order to trace microscopic anthropogenic materials. This geo-ethnoarchaeological approach (Friesem, 2016) provided invaluable information regarding the post-abandonment site formation processes. A detailed report of the excavations and geochemical analyses of sediments from the abandoned sites is reported elsewhere (Friesem et al., submitted).

2. Nayaka ways of living in tropical forests

2.1. Material availability

Many have argued that the 'simple' lithic industry of the Late Pleistocene period in tropical Southeast Asia reflects a very partial aspect of forager material culture, while a rich and complementary industry was made of degradable plant materials (Boriskovsky, 1967; Gorman, 1969, 1971; Solheim, 1972; Hutterer, 1976; White, 1977 Pope, 1989; Schick, 1994; Reynolds, 2007; Brumm, 2010; Lycett and Bae, 2010; Bar-Yosef et al., 2012; Xhauflair, 2012, 2016). In terms of human adaptation to tropical forests and the formation and preservation of an archaeological record, the use of plant material bears significant implications (Summerhayes et al., 2010). In this section we wish to draw on the Nayaka's materiality from an ethnographic point of view while discussing its implications for the formation of the archaeological record.

Living in tropical forests, Nayaka materiality is obviously shaped by the local resources. Although today and in the near past, Nayaka have metal machetes bought or traded in the nearby market, the vast majority of their tools and construction materials

are still made out of forest timber. One of the elders in the site where we lived told us how they used bamboo for making vessels:

> In those times there was a lot bamboo. Like that, for four persons, [we would take] four bamboo. [We would] put food inside. Build a fire and put the four bamboo on the fire. The bamboo would be in the centre surrounded by firewood. So when the fire goes, this [the bamboo] will boil. [But we were careful] not to make too much fire because if the bamboo catch [the] fire the food will be ruined, the bamboo will crack and turn into ash. Only limited fire [is needed, and placing] the bamboo on the surface surrounded by charcoals. Like that we [then] sat there. Even for [cooking] meat [there was] no need to add water, [as] the bamboo gave liquids with heat and cooked the food. It was very tasty, much more than [today's] market food. Like that we lived in those days. For drinking, like [with] a glass we would cut [a bamboo] and drink. How we made vessels, you know? We would cut a bamboo and get two pieces. [We used it] for washing and drinking water; this is what we did. Everything was [made out of] bamboo. Like that, we took honeycombs and squeezed them like milk [into the bamboo] and put it in the fire. Many people were coming, asking for it because they wanted to eat it. It is very good for body pain. For us, we do not need any [market] vessels. This (the bamboo) is enough. With the bamboo we would also make baskets, like a tomato basket [you find now in the market]. Inside we put a leaf and cover the whole bamboo and made a vessel. And with that [basket] we carried everything in the forest. From there to the house nothing will happen to it.

Not only were tools made out of plant materials, houses, when built by the Nayaka themselves (as opposed to houses built by development agents from NGOs or the government), are constructed with a wooden frame made of thick branches or bamboo poles. Walls are made of woven bamboo and in some cases partly by sun-dried mud

bricks. Thatched roofs are made with grasses (For detailed description on Nayaka architecture see, Bird-David 2009; Lavi and Bird-David 2014).

An interesting and important aspect of material use among the Nayaka is their immediate discarding of materials after use. When asked if they would reuse old construction materials once they abandon a house and build a new one, they wondered and simply answered that there is no need: 'there will always be more wood and bamboo' (see also Endicott and Bellwood 1991and Endicott 1984 about a similar attitude among the Batek in Malaysia). Houses are, therefore, abandoned whole, left to decay and disappear under the quickly regenerating forest vegetation.

In order to better understand Nayaka materiality and ways of living in the forest we must dwell upon their perceptions and relationship with the environment. The Nayaka, like many other forest dweller foragers, perceive their environment and its beings in terms of sociality and engagement, as part of their social landscape, rather than as a detached physical locality (see Bird-David 1990 among the Nayaka; Howell 1996 among the Chewong in Malaysia, and Ingold 1996 for a more general discussion). Bird-David (1990) coined the term 'the giving environment' as a way to describe Nayaka relationships with the forest. She argued that the forest is perceived in terms of a parent-relation, a relative-figure who gives *unconditionally* and supplies resources to its children. In turn this also constructs Nayaka egalitarianism, as all group members are perceived as siblings sharing what they received from their parent/forest. The forest therefore is a fundamental part of the social landscape, a relation which in turn constructs other relations (between humans and between humans and forest beings such as animals, plants, hills, etc.), as well as an endless source of resources. Maintaining relationships with the environment and its beings is of central importance for the Nayaka and also a way to form knowledge (Bird-David 1999). By being in the forest, strolling its paths and repeatedly using its products, the Nayaka maintain an intimate relationship with the forest and its beings, as well as gain knowledge (both social and practical) about it. Relations among kin are characterised by expectation of unconditional giving. This in turn allows and requires people to carry on sharing and

giving whatever they have when they have it, rather than storing or reusing it themselves. In the case of forest materials, the perception of forest-giving allows people to share their food immediately with others with no regard to storage, and to abandon building materials, knowing – in both cases – that there will always be more available to them.

From an archaeological point of view, this perception and relation implies an intensive use of forest materials, mainly plant materials, which are more prone to poor preservation, and the discarding of materials, which on the other hand might suggest the deposition of anthropogenic residues.

2.2. Activity areas

Many ethnoarchaeological studies have looked into forager use of space as a proxy for their sociality, economy and adaption to the environment (Yellen, 1977; Binford, 1978, 1980; Gould, 1980; Wiessner, 1982; Whitelaw, 1983; Fisher and Strickland 1989; Gould and Yellen, 1987; O'Connell, 1987; Kent, 1989; Gamble and Boismier, 1991; Kroll and Price, 1991; Galanidou, 2000). Nayaka use of space within their residential sites is dictated by their sociality and ways of living.

Like many other forager groups, the Nayaka are highly mobile. Although mobility is often assumed to be the abandonment and shift of an entire campsite into a new locality, ethnographic accounts have shown that mobility is mostly expressed by people's movements within a site and individuals' – rather than groups' - movements between sites (see Turnbull, 1965; Woodburn, 1968, 1972 for the Mabuti and Hadza respectively in Africa; see Briggs, 1970 for the Autako in Northern America; see Myers, 1986; Jackson, 1995 for the Walpiri and Pintupi respectively in Australia; see Bird-David, 2009; Lavi and Bird-David, 2014 for the Nayaka in India). In addition, examining the reasons for foragers' mobility, anthropologists have pointed out social reasons above any other economic or ecological ones (Turnbull, 1965; Woodburn, 1968, 1972; Hewlett et al., 1982; Myers, 1986; Lavi and Bird-David, 2014). For one to be part of a social unit and obtain knowledge of others, s/he must constantly be *with*

others and share. The social unit and kin relations are based primarily on the people with whom one shares rather than on *a priori* fixed categories such as birth and shared blood (Bird-David, 1992; 1999). Among Nayaka, relatives share not only things, but also spaces, actions and experiences (Bird-David 1992, 1994, 1999). Being-together and physical closeness is therefore a fundamental social demand. Those who share gradually become kin and – in turn – kin are required to constantly share with each other. This is a social world in which shared activities and lives constitute people as related (Myers 1986), and "'relating' makes 'relatives'" (Bird-David 1994). This constant demand for sharing and being-together creates and shapes the social unit and in turn was required to maintain it. Among the Nayaka, this is reflected in the flexible and ever changing social composition of residential sites, as people endlessly moved between villages and within the dwelling units in order to establish and maintain social and kin relations with many others (Bird-David, 2009; Lavi and Bird-David, 2014).

Nayaka use of space, then, stems from this social requirement to constantly share spaces and actions. Their site structure and architecture reflect the importance of being together (Bird-David, 2009; Lavi and Bird-David 2014). Rarely, if ever, is any activity, besides sleeping in cold or windy nights, carried behind closed walls. Houses are never completely sealed. In most cases, they are completely open with no walls or have only partial walls. The vast majority of Nayaka activity takes place outside in full visibility on the exterior terrace of the site, which allows people to share their lives and selves with many others in the village. In a typical Nayaka forest site between two to tens houses are built on terraces which were cut into the forest hill slope. The number of people using those houses, however, is constantly changing as people move from one site to another and between houses, to visit their relatives and be with them. Sites vary in their size. The number of inhabitants in each site changes according to the frequent coming and going of people, and ranges from few individuals to less than a hundred on a special occasion (e.g., a festival, ceremony, or being the closest to the town on a market day).

The majority of Nayaka activity in the village and its vicinity can be generalised to the processing of food and its consumption, production and maintenance of tools (e.g., tools made of wood from the forest and metal machetes), cleaning practices (e.g., sweeping of floors, washing), gathering food in the forest and collecting firewood, tools and construction materials . On more rare occasions, houses are built and ceremonies are performed usually, within the residential sites. Yet the most valued activity which people spend most of their time doing is associated with socializing with their immediate relatives around them.

Activity areas were formed according to the social dynamics in a given moment. People chose the location of their activity according to the ever-changing composition of the people around them in order to be with some or to avoid others. Every task or activity took place in a different location according to people's social choice of with whom they wish to share their space and actions at that specific moment. Just as social relations and social grouping were flexible and changing, so were the locations of people's activities, which changed frequently along social considerations. Overall, there were no designated areas for specific activities in the site. People cooked, made crafts, socialized and even built light structures in different locations around the site, according to their immediate social relations and the ever-changing composition of people coming from and going to the site. Below is an ethnographic description presenting how the location of a specific activity has been dictated by the social dynamics at the site:

> A long wood branch was used for sharpening knives. It was a noticeable object of seven centimetres in diameter and one and a half meter long. To use it, people crushed a hard rock (composed of quartz) into powder, and applied the powder on the branch to assist the sharpening. They had to sit on the branch, levelling it with their body and sliding the knife over and again on a worn surface of the branch until it was sharp enough. One morning, an old man who needed to use the branch dragged it closer to his home, where two old

> women who lived with him at the time were sitting and preparing food. He worked while talking to them and later went away, leaving the branch in front of the house. Some days later, a young couple with a small child arrived at the site. One afternoon, they were standing at the edge of the terrace, looking down at the forest to spot elephants and jeeps passing by. The old man, having to sharpen his knife again, dragged the branch to the spot where they were standing and settled down to work near them, while exchanging opinions on the view. The next day, a different young man took the branch to work in front of another house, so that he could continue his conversation with the people who happened to be sitting there. The branch remained there and was picked up some days later by a child aged five, who took his father's knife and wanted to play with it. A few more children were playing nearby and the child invested great efforts to drag the heavy wood to them. They all played, imitating adult behaviour. Some pretended to be cooking, others 'came to visit relatives' and he was play-sharpening the big knife. Overall, the location of the sharpening log reflected the social interaction happening at a specific moment. It was clear that people did not allocate a specific place for the task nor have a certain place to store or leave their tools. Those were left in the last place where they were used. When another person was in need of this tool, s/he just wandered around the houses looking for where it was last used and left.

While this is just one example, no exceptions were observed regarding other activities. Fireplaces presented a similar dynamic pattern. Hearths were ephemeral and could be abandoned after a single use or after a week (for other ethnoarchaeological accounts regarding ephemeral hearths, see O'Connell 1987 for the Alyawara in Australia; Fisher and Strickland, 1989 for the Efe in Zair; O'Connell et al., 1991 for the Hadza in Tanzania). Like tools, hearths were added or abandoned according to the *ad hoc* presence of people and the relationships between them. This pattern resulted in fireplaces being deposited and abandoned throughout the terrace without having a designated location. They could also change their location due to rain or wind, shifting

to a more convenient location. But even in those cases, it was the social consideration that dictated where this location would be. Fire could be shifted to an entirely new place, or subtly moved half a meter to the side, always responding to social requirements. If, for example, new visitors came to settle in a house, an existing fire on the other side of the site might be abandoned, if the people who used it wanted to spend time with the newcomers. If two neighbours' relations tightened, fires might shift slightly so that the people sitting around them will be close enough to socialize with each other. In contrast, if two neighbours had an argument, they might shift both their cooking and their evening fires so that each will sit with his own relatives, and they won't be in close proximity with each other (as this implies relatedness).

In most cases, thin branches and twigs collected from the forest ground were used as fuel, occasionally with a few larger logs. This left a relatively thin accumulation of ashes and charcoal on the terrace floor. But due to site cleaning, ashes and charcoal were not to be seen in the place of an abandoned hearth. A daily routine included the cleaning of the site with a broom made of thin twigs (see also O'Connell, 1987 for the Alyawara in Australia; Fisher and Strickland, 1989 for the Efe in Zair; O'Connell et al., 1991 for the Hadza in Tanzania). This practice of sweeping removed most macroscopic activity remains and re-deposited them beyond the edge of the terrace, thus forming a waste area (a midden) on the slope (Figure 2a). Sweeping of the hearth re-deposited charcoal and ashes within the waste area over the terrace on the slope (Figure 2b). People also dumped other types of waste beyond the terrace, such as fruit and tuber husks, food remains and other unneeded items. A rather enlarged waste area was formed around the edges of the site's terrace, as people just swept the surface and threw their waste over the terrace wherever they were standing at the moment. The formation of refuse or dump areas at the edge of forager sites is one of the most prominent features seen in the site (and was reported by many ethnoarchaeologists, see Binford, 1978 for the Nunamiut in Alaska; O'Connell, 1987 for the Alyawara in Australia; Fisher and Strickland, 1989 for the Efe in Zair; Gargett and Hayden, 1991 for the Pintupi in Australia; O'Connell et al., 1991 for the Hadza in Tanzania).

3. Formation of the Nayaka archaeological record

3.1. Material deposition patterns

Nayaka sociality dictates the performance of all activities outdoors, not necessarily without a roof but certainly not within closed houses. The way the Nayaka used space and acted resulted in a dynamic material deposition pattern. Thus, as activity areas are formed as a result of the immediate social dynamics, they do not reflect a designated spatial division according to an *a priori* perception of space-activity. This in turn meant that activity residues were never intensively accumulating in one locus. Residues from production and maintenance of tools, food processing and consumption of food, as well as charcoal and ashes, were all deposited throughout the terrace and later removed by cleaning and sweeping and re-deposited in the waste area beyond the terrace. The latter practice, however, did leave a rather intensive accumulation of activity residue but in a secondary context. Following the abandonment of a site, construction materials and the last phase of activity (e.g., hearths) were left *in situ*, exposed to the elements.

In order to evaluate the formation of archaeological evidence resulting from Nayaka ways of living and our ability to trace the associated material deposition pattern, we excavated an open-air site and a rock-shelter abandoned by the same group of people ca. 20-30 years ago. The sites were the home of some of the elders who now live in the contemporary site uphill. They were located on a slope of a forested hill, not far away from the contemporary site. The exact time of abandonment is difficult to estimate accurately, but from various external sources, we are certain that the open-air site was no longer occupied in the 1980s and the rock-shelter might have been sporadically used by people when they sought for shelter from elephants, not later than the 1990s. When we reached the sites, they were all covered by dense forest vegetation (Figure 3). Although the site was covered by modern vegetation, the incision of the hill slope and the formation of a flat terrace - on which the houses were built and where people used to act and live – presented a distinctive feature in the tropical forest landscape.

Next, the clearing of the vegetation, sampling and trenching of the sites took place. The only anthropogenic features which could be identified by the naked eye were found on the terrace of the open-air sites, under the dense vegetation, where we could observe debris of degraded mud bricks and the remains of a low stone wall (Figure 3b and 3d). The degradation of mud structure is known to be a major factor in the formation of archaeological mounds (Friesem et al. 2014), yet since most of the Nayaka houses were built from plant material, the majority of the structures described to us by our informants (e.g., houses in the open-air site and a lean-to thatched roof in the rock-shelter) could not be identified in the field. Apart from those features, no artefacts were observed on the surfaces of the sites, in the excavation trenches or in the sites' vicinity.

The results from the laboratory-based analyses of sediments collected from the sites exhibited several anthropogenic materials which could be associated with Nayaka activity. Overall, no activity remains were found in any of the houses' interiors in the open-air site, while the exterior activity terrace presented high concentrations of phytoliths and chemical residues, suggesting human activity taking place outdoors (Figure 4). Within the decayed mud brick house two microscopic layers of clay indicated cycles of cleaning with some water spread over the house's earth floor. Between the two cleaning events dust had accumulated and been trampled into the floor, indicating the absence of activity remains within the house. On the other hand, high concentrations of heavy metals found in the exterior terrace were associated with sharpening of knives. Concentrations of phytoliths due to human activity were also revealed only on the exterior terrace (Figure 4), most probably as a result of deposition of plant materials (e.g., baskets, mats, vegetal construction materials, etc.). While ashes, bones and charcoal were not found anywhere within the terrace sediments, charcoal was observed in large quantities in the slope beyond the terrace edge.

Within the rock-shelter, micromorphological analysis of the microstratigraphy was able to distinguish between various episodes of material deposition (Figure 5). A thin horizon of well-preserved charcoal was interpreted as a hearth left as people abandoned the site. Following the abandonment sediment from the rock weathering

accumulated above the last hearth used at the site. Since people did not take construction materials as they left a site, the lean-to thatched roof used at the rock-shelter collapsed after a while, leaving a layer with very high concentrations of organic matter. Following the roof collapse, more sediments accumulated at the site and some post-abandonment activity was identified by the presence of charcoal.

Our work shows that the laboratory-based analyses exhibit a richer microscopic archaeological record associated with human activity than could have been observed by the naked eye in tropical forests.

3.2. Taphonomic Processes

Taphonomic processes play a major role in the formation of archaeological evidence for human activity, in particular in tropical forests (e.g., Tappen 1994). The humid conditions in the forests of South India, coupled with the heavy monsoon rains and hot temperatures, result in specific taphonomic processes. First, the forest vegetation grows relatively rapidly after abandonment of the site, making it very difficult to be identified under the dense vegetation cover (Figure 3). The environmental conditions promote intensive biological activity within the sediments (Figure 6a). The soil fauna cause disruption to the archaeological layers and enhance the degradation of organic matters (Lewis, 2007; Simpson et al., 2008; Kourampas et al., 2009). The degradation of the organics in addition to the sediments being saturated with water during the monsoon rains commonly result in tropical forests in the removal of iron oxides and re-impregnation of iron (Vitousek and Sanford, 1986; Chacon et al., 2006). Clay and secondary iron appear to replace the organic matter (Figure 6b). The presence of secondary iron in archaeological sites in Southeast Asia is in some cases used as an indicator for the location of occupation levels (Stephens et al., 2005; Lewis, 2007; Simpson et al., 2008; Kourampas et al., 2009).

The most noticeable and significant taphonomic process occurring in tropical forests are a result of the acidic conditions (pH below 6) within the sediments. Under such conditions carbonates will dissolve. From an archaeological point of view this

includes important activity remains such as bones and wood ash, which in the case of Nayaka sites were dissolved a few days after initial deposition (Figure 7). In some cases, although ash was not present in archaeological sites in tropical Southeast Asian forests, macroscopic bones were found while microscopic bone remains showed advanced signs of dissolution (Simpson et al., 2008; Kourampas et al., 2009). While bone and ash tend to dissolve in acidic sediments, charcoal and phytoliths preserve well in such conditions (Weiner, 2010). Thus, intensive deposition of charcoal can be used as a reliable indicator for human activity in tropical forests (Stephens et al., 2005; Lewis, 2007; Simpson et al., 2008; Kourampas et al., 2009).

4. Discussion

Forager lifeways in tropical forests pose significant challenges for archaeologists attempting to identify evidence of human occupation. Yet, this ethnoarchaeological study has shown that by an integrated approach archaeological evidence for foragers' activity in tropical forests is possible to detect. We argue that the deposition patterns of materials associated with human activity can reflect social aspects of foragers' ways of living.

Recently more studies have shown that microscopic material associated with human activity can preserve in prehistoric sites located in tropical forests (e.g., Barton et al., 2005; Stephens et al., 2005; Lewis, 2007; Simpson et al., 2008; Kourampas et al., 2009) and even in open-air sites (Summerhayes et al., 2010). For example, the lithic industries of the Late Pleistocene, associated with modern humans in tropical South and Southeast Asia, pose great difficulties to the understanding of the complexity of modern human behaviour based on archaeological materials and in particular from examining the lithic industry. The 'bamboo hypothesis' suggested that prehistoric foragers had been extensively using degradable plant materials such as bamboo, producing sophisticated tools, while their lithic industry remained rather 'simple' (Boriskovsky, 1967; Gorman, 1969, 1971; Solheim, 1972; Hutterer, 1976; White, 1977 Pope, 1989; Schick, 1994; Reynolds, 2007; Brumm, 2010; Lycett and Bae, 2010; Bar-

Yosef et al., 2012; Xhauflair, 2012, 2016, this volume; Summerhayes et al., this volume). While indirect evidence for the use of plant materials can be found in archaeological sites and archaeological experiments have proven the feasibility of producing such tools, the question regarding why people preferred plant materials over lithic still remains (Brumm, 2010; Lycett and Bae, 2010; Bar-Yosef et al., 2012). Although Nayaka cannot be used as a living model for prehistoric foragers, their case study highlights the importance of their social perceptions in their exploitation of materials. While some materials are introduced by relations and trade with non-Nayaka people, still Nayaka's relations with their environment have resulted in significant reliance on plant materials, over more durable materials, from the forest and its constant sharing (Bird-David, 1990; see also Endicott and Bellwood, 1991 for similar case among foragers in Malaysia). The perception of the forest, as a parent-figure giving unconditionally, also implies, in the Nayaka's view, the endless availability of forest resources and results in rapid discarding of forest materials. It therefore allowed the use of expendable forest materials, without the need to store, recycle or reuse it. Although this alone cannot explain the lack of complex lithic industry, it can – if nothing else – remind us that the exploitation of resources in people's world is never merely economic, ecological nor functional.

Nayaka sociality, as that of many other immediate-return foragers (as classified by Woodburn, 1982), is characterised by immediacy and mobility (Bird-David 1994, 1999). These are not only economic aspects of behaviour. Immediacy is expressed by the immediate *ad hoc* social interaction and relationships, acquisition of knowledge and use of space. Therefore mobility in Nayaka's social world, and elsewhere (see Turnbull, 1965; Woodburn, 1968, 1972; Hewlett et al., 1982 for the Mabuti, Hadza and Aka respectively in Africa; see Briggs, 1970 for the Autako in Northern America; see Myers, 1986; Jackson, 1995 for the Walpiri and Pintupi respectively in Australia), is not only the movement of a site or a person but more importantly, a practice which allows a person to constantly share with her/his relatives things, actions and spaces within her/his dwelling site and in others' sites. Mobility and sharing, then, constitute the

social unit, which is ever-changing according to immediate relations (Bird-David, 1994, 1999). Archaeologically, these allegedly intangible social values and practices such as being-together, sharing, mobility and immediacy can be inferred from spatial analysis of material deposition patterns. We demonstrate that Nayaka activity remains were found only outdoors on the terrace as a reflection of their wish to be with many others in full visibility and allow constant sharing (for other examples for forager activities taking place outdoors see Yellen, 1977; Weissner, 1982 for the San in Botswana; O'Connell, 1987 for the Alyawara in Australia; Fisher and Strickland, 1989 for the Efe in Zair; Bird-David, 2009; Lavi and Bird-David, 2014 for the Nayaka). Immediacy and mobility are mostly expressed by the ever-changing location of activity areas within a site. This dynamic material deposition pattern, although more challenging to observe archaeologically, can be identified as a rather heterogeneous deposition of remains throughout the occupation surface. We suggest that such deposition pattern will appear as occupation residues spread over the site rather than being confined to a single locality. The intensity of the deposits in such sites will be rather low. We therefore argue that intensive accumulation of occupation residues in a specific space may also reflect different social emphases and ways of living. Applying spatial analysis and reconstruction of activity areas in archaeological sites may reveal transitions away from or differences in the social order, sharing practices, intra-site mobility and immediacy as manifested by the ethnographic data.

While site maintenance and cleaning practices pose a serious challenge for the preservation of *in situ* activity remains, their secondary deposition in a waste area characterized by rapid burial on a slope bears great potential to preserve activity remains from which archaeologists can infer activities taking place in forager open-air sites. Post-depositional processes such as intensive biological activity within the sediments, rapid degradation of organic matters and acidic conditions disrupt the formation of well-defined archaeological layers and materials. These processes are obviously enhanced in open-air sites compared to caves and rock-shelters, which are more protected from the elements. In the case of high altitude open-air sites better

preservation may appear due to the colder environment discouraging biological activity within the sediments (e.g. Summerhayes et al., 2010). Nonetheless, taking into account the taphonomic processes in tropical forests, several key factors should be considered. While organic plant materials do not preserve well in such tropical environments, phytoliths do. Since structures are usually left to decay *in situ*, phytoliths can and should be used as an indicator for human activity in general and in particular for structure remains, especially those composed of grasses. The acidic conditions of archaeological deposits can be reduced in a carbonate-rich environment (e.g., karstic formation, limestone, abundance of shells, bones and other carbonates). Bones and even ashes were found in such caves in South and Southeast Asia (Stephens et al., 2005; Lewis, 2007; Simpson et al., 2008; Kourampas et al., 2009; Perera et al. 2011; Barker, 2013; Roberts et al. 2015; Rabett et al. this volume). Even in the case of bone and ash dissolution, charcoal and phytoliths preserve relatively well and by applying an integrated approach combining macroscopic analysis and microscopic and chemical analysis, we showed that the identification of archaeological evidence for human behaviour *is* possible.

5. Conclusions

The ethnoarchaeological evidence from the tropical forests of South India highlights the potential of open-air sites to preserve, at least to some extent, archaeological evidence. Social aspects of forager sociality such as social organisation (egalitarian/hierarchic), sharing and non-sharing, inter-site mobility and immediacy (or alternatively delay-return systems) can be inferred by studying material deposition patterns, in particular the formation of activity areas (e.g., dynamic vs. designated areas, outdoor vs. indoor activities) and the context of microscopic residues (i.e., the location and intensity of occupation residues). Geoarchaeological analyses indicate that while taphonomic processes in tropical forests may result in enhanced degradation of organic matter and the complete dissolution of carbonates (e.g., bones and ash), charcoals and phytoliths tend to preserve well and can be used as reliable indicators of human activity.

Caves and rock-shelters and sites located within carbonate-rich setting, will present better preservation of archaeological materials.

Future research should strive to focus more on open-air sites, while embracing a multi-disciplinary investigation, which will maximise our findings and understandings. In addition, it is useful for the study of foragers' sites in tropical forests, and in general, to try to link the spatial distribution of activity remains with foragers' sociality and ways of living.

Acknowledgements

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References

Anderson, D.D., 1997. Cave Archaeology in Southeast Asia. Geoarchaeology 12, 607–638.

Bahuchet, S., McKey, D., De Garine, I., 1991. Wild Yams Revisited: Is Independence from Agriculture Possible for Rain Forest Hunter-Gatherers?. Human Ecology 19, 213–243.

Bailey, R., Head, G., Jenike, M., Owen, B., Rechtman, R., Zechenter, E., 1989. Hunting and Gathering in Tropical Rain Forest: Is It Possible?. American Anthropologist 91, 59–82.

Bailey, R.C., Headland, T.N., 1991. The Tropical Rain Forest: Is it a Productive Environment for Human Foragers?. Human Ecology 19, 261–285.

Barker, G., (Ed.), 2013. Rainforest Foraging and Farming in Island Southeast Asia, Vol. 1: The Archaeology of the Niah Caves, Sarawak. McDonald Institute for Archaeological Research, Cambridge.

Bar-Yosef, O., Eren, M.I., Yuan, J., Cohen, D.J., Li, Y., 2012. Were bamboo tools made in prehistoric Southeast Asia? An experimental view from South China. Quaternary International 269, 9-21.

Bhanu, B.A., 1989. The Cholanaicken of Kerala. Anthropological Survey of India, Calcutta.

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

Binford, L.R., 1980. Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. American antiquity, 4-20.

Bird-David, N., 1990. The Giving Environment: Another Perspective on the Economic System of Gatherer-Hunters. Current Anthropology 31, 189-196.

Bird-David, N., 1992. Beyond 'the hunting and gathering mode of subsistence': culture-sensitive observations on the Nayaka and other modern hunter-gatherers. Man 27, 19-44.

Bird-David, N., 1994. Sociality and immediacy: or, past and present conversations on bands. Man 29, 583-603.

Bird-David, N., 1999. "Animism" Revisited. Current Anthropology 40, 67-91.

Bird-David, N., 2009. Indigenous architecture and relational senses of personhood: a cultural reading of changing dwelling styles among forest-dwelling foragers. Design Principles and Practices: an International Journal 3, 203-10.

Boriskovsky, P., 1967. Problems of the Palaeolithic and of the Mesolithic of the Southeast Asia. In: Solheim, W. (Ed.), Archaeology at the Eleventh Pacific Science Congress, Asian and Pacific Archaeology Series, vol. 1. Social Science Research Institute, University of Hawaii, pp. 41-46.

Brumm, A., 2010. The Movius line and the bamboo hypothesis: early hominin stone technology in Southeast Asia. Lithic Technology 35, 7–24

Briggs, J.L., 1970. Never in anger: Portrait of an Eskimo family. Harvard University Press, Cambridge.

Butzer, K.W., 1982. Archaeology as Human Ecology. Cambridge University Press, Cambridge.

Chacon, N., Silver, W.L., Dubinsky, E.A., Cusack, D.F., 2006. Iron reduction and soil phosphorus solubilization in humid tropical forests soils: the roles of labile carbon pools and an electron shuttle compound. Biogeochemistry 78, 67-84.

Colinvaux, P.A., Bush, M.B., 1991. The Rain-Forest Ecosystem as a Resource for Hunting and Gathering. American Anthropologist 93, 153–160.

Demmer, U., 1997. The social structure of the Jenu Kurumba: A South Indian Gatherer/Hunter Society. In: Pfeffer, G. (Ed.), Contemporary Society: Concept of tribal society, volume 5. Concept Publishing Company, New Delhi, pp.230-264.

Dufour, D.L., 1990. Use of Tropical Rainforests by Native Amazonians. BioScience 40, 652–659.

Endicott, K., 1979. Batek Negrito religion: The world view and rituals of a hunting and gathering people of Peninsular Malaysia. Clarendon Press, Oxford.

Endicott, K., 1984. The economy of the Batek of Malaysia: annual and historical perspectives. Research in Economic Anthropology 6, 29-52.

Endicott, K., Bellwood, P., 1991. The possibility of independent foraging in the rain forest of peninsular Malaysia. Human Ecology 19, 151-185.

Fisher, J.W., Strickland, H.C., 1989. Ethnoarchaeology among the Efe Pygmies, Zaire: Spatial organization of campsites. American Journal of Physical Anthropology 78, 473-484.

Friesem, D.E., 2016. Geo-Ethnoarchaeology in Action. Journal of Archaeological Sciences 70, 145-157.

Friesem, D.E., Karkanas, P., Tsartsidou, G., Shahack-Gross, R., 2014. Sedimentary processes involved in mud brick degradation in temperate environments: a micromorphological approach in an ethnoarchaeological context in Northern Greece. Journal of Archaeological Science 41, 556-567.

Friesem, D.E., Lavi, N., Madella, M., Ajithprasad, P., French, C., Submitted. Site Formation Processes related to Hunter-Gatherers' Use of Space in a Tropical Environment: A Geo-Ethnoarchaeological Study from South India. Submitted to PLoS ONE.

French, C., 2003. Geoarchaeology In Action. Studies in Soil Micromorphology and Landscape Evolution. Routledge, London.

Galanidou, N., 2000. Patterns in caves: foragers, horticulturists, and the use of space. Journal of Anthropological Archaeology 19, 243-275.

Gamble, C.S., Boismier, W.A. (Eds.), 1991. Ethnoarchaeological approaches to mobile campsites: hunter-gatherer and pastoralist case studies. No. 1. International monographs in prehistory, Ann Arbor.

Gardner, P.M., 2000. Bicultural versatility as a frontier adaptation among Paliyan foragers of South India. The Edwin Mellen Press, Lewiston.

Gardner, P., 2012. Seventy years of south Indian hunter-gatherer research. Before Farming, 2012, 1-10.

Gargett, R., Hayden, B., 1991. Site structure, kinship, and sharing in aboriginal Australia. In: Kroll, E.M., Price, T.D. (Eds.), The Interpretation of Archaeological Spatial Patterning. Plenum Press, New York, pp. 11-32.

Goldberg, P., Macphail, R., 2006. Practical and theoretical geoarchaeology. Blackwell, Oxford.

Gorman, C.F., 1969. Hoabinhian: a pebble-tool complex with early plant associations in southeast Asia. Science 163, 671-673.

Gorman, C.F., 1971. The Hoabinhian and after: subsistence patterns in southeast Asia during the Late Pleistocene and early recent periods. World Archaeology 2, 300-320.

Gosden, C., 2010. When humans arrived in the New Guinea highlands. Science 330, 41-42.

Gould, R.A., 1980. Living archaeology. Cambridge University Press, Cambridge.

Gould, R.A., Yellen, J.E., 1987. Man the hunted: determinants of household spacing in desert and tropical foraging societies." Journal of Anthropological Archaeology 6, 77-103.

Hart, T.B., Hart, J A., 1986. The Ecological Basis of Hunter-Gatherer Subsistence in African Rain Forests: The Mbuti of Eastern Zaire. Human Ecology 14: 29–55.

Headland, T.N., Reid, L.A., 1989. Hunter-Gatherers and Their Neighbors from Prehistory to the Present. Current Anthropology 30: 43–66.

Hewlett, B., van de Koppel, J.M.H., Cavalli-Sforza, L.L., 1982. Exploration ranges of Aka Pygmies of the Central African Republic. Man 17, 418-430.

Hutterer, K.L., 1976. An evolutionary approach to the Southeast Asian cultural sequence. Current Anthropology 17, 221-242.

Ingold, T., 1996. Hunting and gathering as ways of perceiving the environment. In: Ellen, R.F., Fukui, K., (Eds.), Redefining nature: ecology, culture and domestication. Berg, London, pp. 117-155.

Jackson, M. 1995. At home in the world. Duke University Press, Durham and London.

Jayakumar, R., Nair, K.K.N., 2013. Species diversity and tree regeneration patterns in tropical forests of the Western Ghats, India. ISRN Ecology 2013, 1-14.

Kent, S., Vierich, H., 1989. The myth of ecological determinism-anticipated mobility and site spatial organization. In: Kent, S. (Ed.), Farmers as hunters: the implications of sedentism. Cambridge University Press, Cambridge, pp. 96-130.

Kourampas, N., Simpson, I.A., Perera, N., Deraniyagala, S.U., Wijeyapala, W.H., 2009. Rockshelter sedimentation in a dynamic tropical landscape: Late Pleistocene–Early Holocene archaeological deposits in Kitulgala Beli-lena, southwestern Sri Lanka. Geoarchaeology, 24, 677-714.

Kroll, E.M., Price, T.D. (Eds.), 1991. The Interpretation of Archaeological Spatial Patterning. Plenum Press, New York.

Lavi, N., 2012. At home in a Changing World: External changes and cultural continuity in the life of the Nayaka (a hunter-gatherer group) in South India. M.A. Thesis, University of Haifa.

Lavi, N., Bird-David, N., 2014. At home under development: a housing project for the hunter-gatherers Nayaka of the Nilgiris. The Eastern Anthropologist 67, 407-432.

Lewis, H., 2007. Preliminary soil micromorphology studies of landscape and occupation history at Tabon Cave, Palawan, Philippines. Geoarchaeology 22, 685-708.

Lycett, S., Bae, C., 2010. The Movius Line controversy: the state of the debate. World Archaeology 42, 521–544

Lye, T.P., 2004. Changing pathways: forest degradation and the Batek of Pahang, Malaysia. Lexington Books, Lanham.

Mercader, J. (Ed.), 2002. Under the Canopy: The Archaeology of Tropical Rain Forests. Rutgers University Press, Piscataway.

Mercader, J., Martí, R., Martínez, J.L., Brooks, A., 2002. The nature of 'stone-lines' in the African Quaternary record: archaeological resolution at the rainforest site of Mosumu, Equatorial Guinea. Quaternary International 89, 71-96.

Mercader, J., Martí, R., González, I., Sánchez, A., García, P., 2003. Archaeological Site Formation in Rain Forests: Insights from the Ituri Rock Shelters, Congo. Journal of Archaeological Science 30, 45–65.

Misra, P.K., 1969. The Jenu Kuruba. Bulletin of the Anthropological Survey of India 18, 183-246.

Morris, B., 1982. Forest traders: A socio-economic study of the hill Pandaram. Athlone Press, London.

Myers, F., 1986. Pintupi country, Pintupi self: Sentiment, place, and politics among Western Desert Aborigine. Smithonian Institution Press and Australian Institute of Aboriginal Studies, Washington.

Naveh, D., 2007. Continuity and change in Nayaka epistemology and subsistence economy: A hunter gatherer case from South India. Ph.D. dissertation, University of Haifa, Haifa.

Norstrom, C., 2003. "They call for us": Strategies for securing autonomy among the Paliyans, hunter-gatherers of the Palni hills South India. Stockholm University Press, Stockholm.

O'Connell, J.F., 1987. Alyawara site structure and its archaeological implications. American Antiquity 52, 74-108.

O'Connell, J.F., Hawkes, K., Jones, N.B., 1991. Distribution of refuse-producing activities at Hadza residential base camps." In: Kroll, E.M., Price, T.D. (Eds.), The Interpretation of Archaeological Spatial Patterning. Plenum Press, New-York, pp. 61-76.

Perera, N., 2010. Prehistoric Sri Lanka: Late Pleistocene Rockshelters and an Open Air Site. BAR International Series. Archaeopress, Oxford.

Perera, N., Kourampas, N., Simpson, I.A., Deraniyagala, S.U., Bulbeck, D., Kamminga, J., Perera, J., Fuller, D.Q., Szabó, K. and Oliveira, N.V., 2011. People of the ancient rainforest:

Late Pleistocene foragers at the Batadomba-lena rockshelter, Sri Lanka. Journal of human evolution 61, 254-269.

Pope, G.G., 1989. Bamboo and human evolution. Natural history 10, 49-57.

Reynolds, T.E.G., 2007. Problems in the stone age of South-east Asia revisited. Proceedings of the Prehistoric Society 73, 39-58.

Roberts, P., Perera, N., Wedage, O., Deraniyagala, S., Perera, J., Eregama, S., Gledhill, A., Petraglia, M.D., Lee-Thorp, J.A., 2015. Direct Evidence for Human Reliance on Rainforest Resources in Late Pleistocene Sri Lanka. Science 347: 1246–1249.

Schick, K.D., 1994. The Movius Line Reconsidered: Perspectives on the Earlier Paleolithic of Eastern Asia. In: Corruccini, R.S., Ciochon, R.L. (Eds.), Integrative Paths to the Past: Palaeoanthropological Advances in Honor of F. Clark Howell. Advances in Human Evolution Series, Paramount Communications, New Jersey, pp. 569-596.

Schiffer, M.B., 1987, Formation Processes of the Archaeological Record. University of New Mexico Press, Albuquerque.

Simpson, I., Kourampas, N., Perera, H.N., 2008. Bellan-bandi Palassa, Sri Lanka: Formation processes of a Mesolithic open-air site identified through thin section micromorphology. Archaeologia: Journal of Archaeology 4, 3-18.

Solheim, W.G., 1972. The "new look" of Southeast Asian prehistory. The Journal of the Siam Society 60, 1-20.

Stearman, A.M., 1991. Making a Living in the Tropical Forest: Yuquí Foragers in the Bolivian Amazon. Human Ecology 19, 245–60.

Stephens, M., Rose, J., Gilbertson, D., Canti, M.G., 2005. Micromorphology of cave sediments in the humid tropics: Niah Cave, Sarawak. Asian Perspectives 44, 42–55.

Summerhayes, G.R., Leavesley, M., Fairbairn, A., Mandui, H., Field, J., Ford, A. and Fullagar, R., 2010. Human adaptation and plant use in highland New Guinea 49,000 to 44,000 years ago. Science 330, 78-81.

Tappen, M., 1994. Bone Weathering in the Tropical Rain Forest. Journal of Archaeological Science 21, 667–73.

Taylor, N., 2011. The Origins of Hunting and Gathering in the Congo Basin: A Perspective on the Middle Stone Age Lupemban Industry. Before Farming 2011, 11–20.

Turnbull, C.M. 1965. Wayward servants: The two worlds of the African Pygmies. Natural History Press, Garden City, New York.

Varghese, A., Ticktin, T., Mandle, L., Nath, S., 2015. Assessing the effects of multiple stressors on the recruitment of fruit harvested trees in a tropical dry forest, Western Ghats, India. PLoS ONE 10, e0119634. . doi:10.1371/journal.pone.0119634

Vitousek, P.M., Sanford, R.L. 1986. Nutrient cycling in moist tropical forest. Annual Review of Ecology and Systematics 17, 137–167

Weiner, S., 2010. Microarchaeology: beyond the visible archaeological record. Cambridge University Press, Cambridge.

White, P.J., 1977. Crude, colourless and Unenterprising? Prehistorians and their views on the stone age of Sunda and Sahul. In: Allen, J., Golson, J., Jones, R. (Eds.), Sunda and Sahul. Prehistoric Studies in Southeast Asia, Melanesia and Australia. Academic Press, London, New York, San Francisco, pp. 13-30.

Whitelaw, T., 1983. People and space in hunter-gatherer camps: a generalizing approach in ethnoarchaeology. Archaeological Review from Cambridge 2, 48-66.

Wiessner, P., 1982. Beyond willow smoke and dogs' tails: a comment on Binford's analysis of hunter-gatherer settlement systems. American Antiquity 47, 171-178.

Willis, K.J., Gillison, L., Brncic, T.M., 2004. How 'Virgin' Is Virgin Rainforest?. Science 304, 402–403.

Woodburn, J., 1968. Stability and flexibility in Hadza residential groupings. In: Lee, R.B., DeVore, I. (Eds.), Man the hunter. Aldine, Chicago, pp. 103-110.

Woodburn, J., 1972. Ecology, nomadic movement and the composition of the local group among hunters and gatherers; An East African example and its applications. In: Ucke, P.J. (Ed.), Man, settlement and urbanism. Duckworth, London, pp. 193-206.

Woodburn, J., 1982. Egalitarian societies. Man 17, 431-451.

Xhauflair, H., Pawlik, A., Dizon, E., 2012. How can stone tools help to understand the importance of plants in the subsistance strategies of prehistoric hunter-gatherers in the Philippines and Southeast Asia?. In: Tjoa-Bonatz, M.L., Reinecke, A., Bonatz, D. (Eds.), Crossing Borders, vol. 1. NUS Press, Singapore, pp. 26-34.

Xhauflair, H., Pawlik, A., Gaillard, C., Forestier, H., Vitales, T.J., Callado, J.R., Tandang, D., Amano, N., Manipon, D., Dizon, E., 2016. Characterisation of the use-wear resulting from bamboo working and its importance to address the hypothesis of the existence of a bamboo industry in prehistoric Southeast Asia. Quaternary International, doi:10.1016/j.quaint.2015.11.007

Yellen, J.E., 1977. Archaeological Approaches to the Present: Models for Reconstructing the Past. Academic Press, New York.

Figure caption

Figure 1. Map showing the location of the study area (in white circle) in the mountain ridge of the Western Ghats in South India. The Blue Marble Next Generation data is courtesy of Reto Stockli (NASA/GSFC) and NASA's Earth Observatory. NASA/Goddard Space Flight Center Scientific Visualization Studio. The country data is taken from the: CIA World DataBank II.

Figure 2. The waste area at the edge of the terrace. (a) The waste area in the contemporary site showing plant material refuse and re-deposition of ashes from different hearths. Note that the original location of the hearth is no longer visible on the terrace. The width of the photograph is c. 3m. (b) Charcoal and ashes are redeposited on the waste area slope. Note how the charcoal accumulates at the base of the slope. The width of the photograph is c. 1m.

Figure 3. The abandoned sites. (a) Open-air site 1 before excavation, showing dense vegetation cover, and (b) after clearing the vegetation. Note the mound in the background as a result of mudbrick degradation. The width of both pictures is c. 10m. (c) Open-air site 2 before excavation and (d) after clearing the vegetation. The arrow points out the location of stone wall remains. The width of the terrace is ca. 5m (e) The rock-shelter before excavation and (f) after clearing the vegetation. The width of the front part of the picture is ca. 3m.

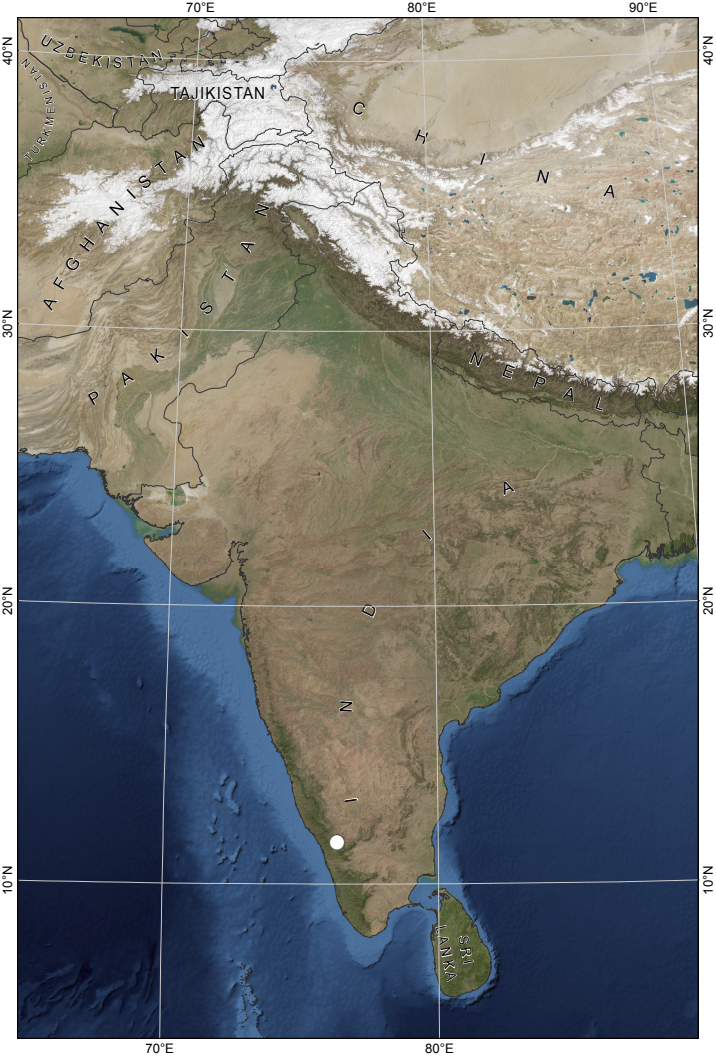
Figure 4. Schematic illustration of the excavated trenches and the location of materials associated with human activity. (a) Open-air site 1 showing the presence of charcoal only on the slope. Concentrations of heavy metals (Cu and Pb) and high concentrations of phytoliths were found at the same layer in the profile of the trench in the exterior terrace. (b) Open-air site 2 showing high concentrations of phytoliths on the exterior terrace while the samples from where the structure was show lower concentrations of phytoliths. (c) The rock-shelter showing elevated concentrations of microscopic and chemical residues associated with human activity. The presence of organic matter, phytoliths and charcoal in the western part of the site are associated with an *in situ* hearth buried under a collapsed thatched roof (see Figure 5 for details).

Figure 5. Thin section from the rock-shelter showing the various microstratigraphic layers and the interpretation of each layer according to the micromorphological analysis.

Figure 6. Taphonomic processes in tropical forest sediments. (a) Thin section from open-air site 2 terrace showing a disrupted, open and granular microstructure caused by intensive biological activity within the sediment. (b) A microphotograph showing organic matter being replaced by clay and secondary iron. Photograph was taken in Plain Polarized Light (PPL). (c) The same microphotograph as ‘b’ only in Crossed Polarized Light (XPL).

Figure 7. A Fourier-Transform Infrared (FTIR) spectrum from an ashy material collected from the living terrace where an hearth was abandoned few days earlier. The spectrum showing calcium carbonate (i.e., calcite – the mineral wood ash is composed of) as the major component with

indicative absorbance bands at 1432, 874, 713cm^{-1}. This is the only sample among the sediments of the living and excavated sites which still had ash and carbonates preserved suggesting that while ash *is* deposited as result from Nayaka activity, it is rapidly dissolved due to post-depositional processes. In addition, the absorbance bands at 1042cm^{-1} and the doublet at 603 and 573cm^{-1} indicate the presence of carbonate fluorapatite (i.e., francolite). This mineral form as a result of bone degradation (Weiner, 2010) and demonstrate the very rapid dissolution of bone material in the tropical forest environment.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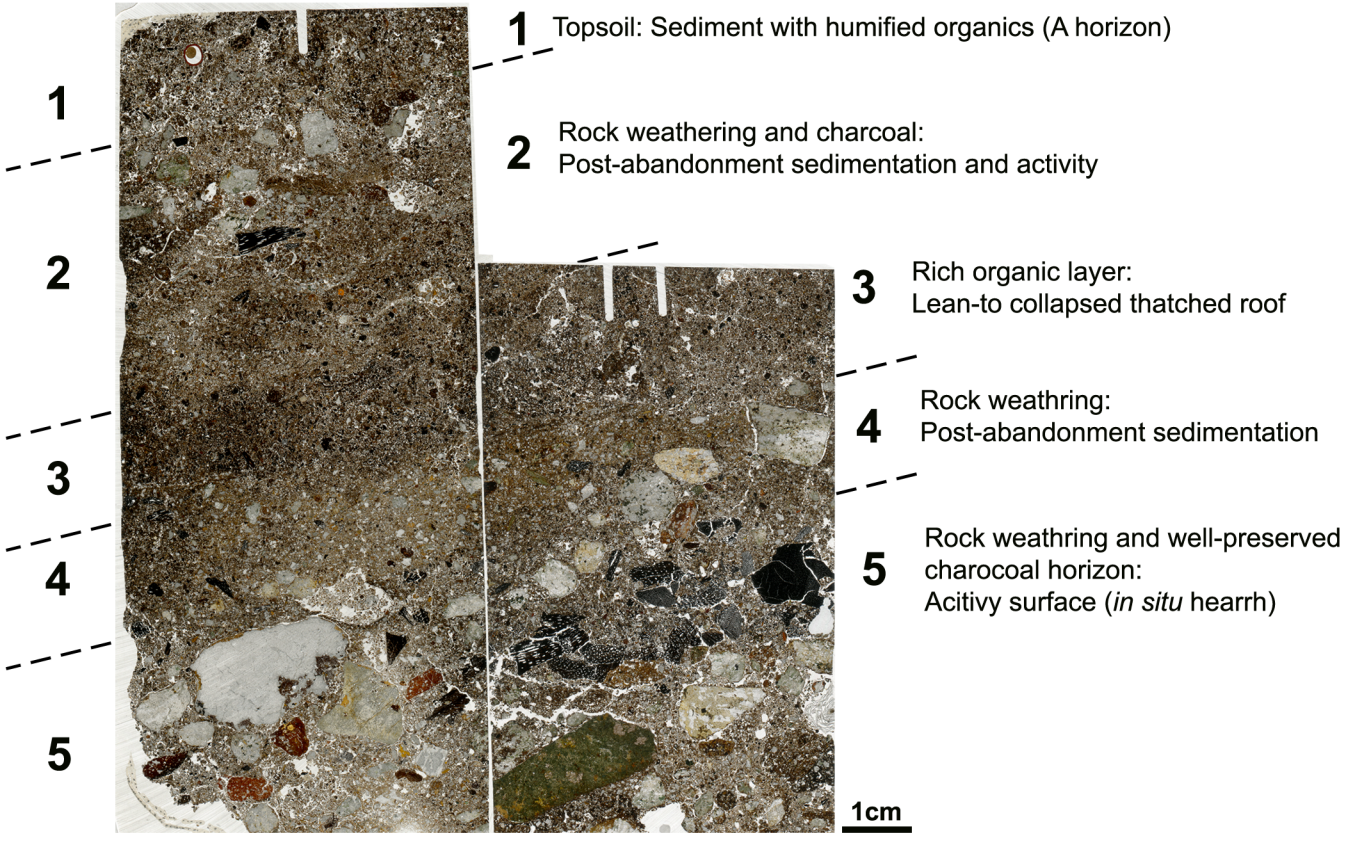
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1 Topsoil: Sediment with humified organics (A horizon)
2 Rock weathering and charcoal:
Post-abandonment sedimentation and activity
3 Rich organic layer:
Lean-to collapsed thatched roof
4 Rock weathring:
Post-abandonment sedimentation
5 Rock weathring and well-preserved
charocoal horizon:
Acitivy surface (*in situ* hearrh)
1cm


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