



Palynological Evidence from Sediment Samples Associated with the early Holocene Human Skeleton from Fa Hien Rock Shelter, Sri Lanka

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Abstract

This paper highlights the value of pollen-analytical studies in the prehistoric archaeological context at the Fa Hien rock shelter. The Fa Hien rock shelter located in the Wet Zone of southwestern Sri Lanka has been occupied by the earliest anatomically modern humans in South Asia, dating from the late Pleistocene to the middle Holocene. The pollen evidence from the samples associated with the early Holocene human skeleton from this site has been used to assess the burial context and palynological taphonomy. Pollen data analysis indicates that high taphonomic impact occurred on the pollen grains in the depositional context, possibly due to reworking, burning, mechanical pressure and other possible human and animal activities. Furthermore, the pollen assemblage appears to have been primarily derived from the lowland rainforest, including disturbed habitats. Along with archaeological stratigraphy and radiometric dating, the pollen assemblage can be used to make broad inferences on the burial contexts and environment of the rock shelter occupants, while discussing the significance of forensic palynology in the Fa Hien archaeological context.

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Introduction

Palynological studies address human-environmental issues in archaeology, geology, palaeoecology, and forensic anthropology. Palynological findings can be used to develop an extensive understanding of past human activities in palaeoecological and mortuary contexts of Sri Lanka (Premathilake, 1997; 2000; 2003; 2006; 2012; Premathilake & Gunathilaka, 2013; Premathilake & Seneviratna, 2015). Archaeological palynology is essentially no different from forensic archaeological palynology, where it has contributed to the knowledge of past human-environmental contexts, including the subsistence mode of ancient human communities, landscapes, ritual practices and the social and religious development of past societies. Detailed palynological investigations for understanding ritually sacrificed, ritual and criminal cases from archaeological contexts have been conducted in several countries in the west (Leroi-Gourhan, 1975; Erdtman, 1969; Frei, 1982; Stead et al., 1986; Stanley, 1987), but to date, there have been no detailed investigations using palynological evidence from archaeological burial contexts of Sri Lanka. This paper highlights the value of palynological research in archaeological studies while providing insights for consideration in forensic archaeological contexts.

Palynology is primarily the study of pollen and spores derived from flowering and non-flowering plants. However, many other minute plant-like bodies, such as dinoflagellate cysts, acritarchs, algal and fungi spores, arthropod organs (such as insect mouthparts), chitinozoans and sporopollenin-based microforms fall under this category and are collectively termed palynomorphs. Usually, pollen grains and spores are the fertile bodies of plants. They are small, ranging from 6 to 120 μm (1 μm = thousandths of a millimetre), produced in vast numbers, widely disseminated, and highly resistant to degradation due to the chemical composition of the structure of pollen and spore walls. The walls of these palynomorphs are made of sporopollenin – one of the most potent biopolymers in the world – which permit them to be preserved in geological and soil-sediment contexts for an extended period (Moore et al., 1999). Thus, pollen analysis is the collective study of all kinds of palynomorphs.

Based on detailed records of pollen/spore morphology (e.g., pollen/spore wall structures, wall architectural elements, aperture conditions, aperture diversifications, size and shape), the pollen and spores of different plants are very distinctive to varying degrees and can be identified to the family, genus, or species level. In the archaeological context, the pollen assemblage, defined as the total number of pollen grains, spores and other sporopollenin based materials (e.g., palynomorphs) identified in a sample, is a direct function of vegetation and palynological taphonomy of the study site. Well-defined assemblages indicate various complex issues related to the human-environmental context such as the use of forest vegetation, wild or domestic varieties, the subsistence patterns of people, and past environmental conditions.

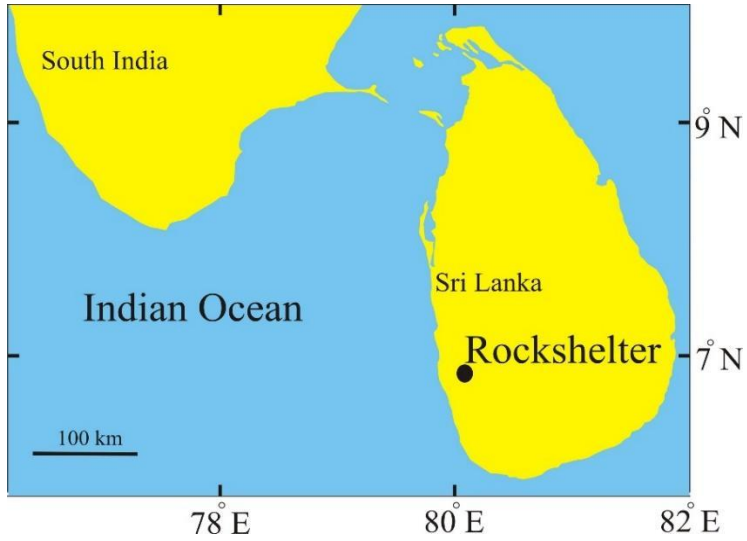


Figure 1. Location of Fa Hien rock shelter in Sri Lanka



Figure 2. Sri Lanka's lowland rainforest ecology where the Fa Hien rock shelter is located

The human skeleton excavated from Fa Hien rock shelter in the Wet Zone of Sri Lanka has been dated to 10,640 -10,139 cal BP (Perera, 2015, Stock et al., 2022). The palynological record from the samples associated with this skeleton are used to answer the following questions: (1) Was the human skeleton deliberately concealed or buried within the rock shelter? (2) Was the human skeleton buried within a deliberate grave cut? (3) Was the human skeleton laying in a natural depression? (4) Were there any blown sediments or/and botanical materials not typically found in the area (e.g., flowers, leaves, wood) associated with the skeleton?

Fa-Hien rock shelter and chronology of the study samples

The Fa-Hien rock shelter is among the oldest dated habitation cave sites in South and Southeast Asia. Located in southwestern Sri Lanka (Figure 1), lowland rainforest is the most common vegetation type in the surroundings of the cave (Figure 2). The cave has been investigated since 1986 onwards (Wijeyapala, 1986; Deraniyagala, 1992, Perera, 2010, Premathilake and Hunt, 2018a, b). Investigations indicate that this cave site has been home for the earliest anatomically modern humans in South Asia. Human habitation deposits at the site have been reported throughout the archaeological stratigraphy ranging from 48,000 BP to 3,900 BP (Figures 3 and 4). This includes five different layers (1-5) with ten (I-X) archaeological phases where the archaeological phase VI has been characterised as a period of intensive habitation dated to 12,000 BP based on eight AMS (Atomic Mass Spectrometry) radiocarbon dates (AMS-RD) (Stock, 2022; Perera, 2015; Premathilake and Hunt, 2018 a, b).



Figure 3 (a). The larger cave chamber of Fa Hien rock shelter



Figure 3 (b). The area located to the east of the larger cave chamber that was excavated with detailed archaeo-stratigraphies reported. Excavation penetrated ca. 2.40 m of deposits.

Researchers found fragmentary skeletal and dental remains of an adult female aged 18-22 years at the time of death in a set position in a pit, The context of this burial have been described by Stock and colleagues (2022) and radiocarbon dates of charcoal directly associated with the burial have been dated to 10,640 - 10,139 cal BP (Perera, 2015, Stock et al., 2022). This burial has been identified as FH 8 and has been described as a relatively complete primary interment of an adult female skeleton (Stock et al., 2022).

Materials and methods

Two monolith samples (250x120x100 mm) were taken directly from the sediment profile covering phase VI, including contexts 139 and 142, where the human skeleton was found. Under the *in-situ* conditions at the Laboratory for Palaeoecology of the Postgraduate Institute of Archaeology, University of Kelaniya, two separate sub-samples obtained from the monoliths were used to extract palynological records (Premathilake, 2003).



Figure 4. (a) Stratigraphy in the excavated area. Major layers (L1-L5) with the context numbers. **(b)** Black boxes indicate monolith sampling (250x120x100 mm) taken through the sediment profile for palynological investigation. **(c)** Sampling context in association with the human skeleton (cf. Stock et al., 2022).

The Postgraduate Institute of Archaeology (PGIAR), University of Kelaniya, in Sri Lanka, has excellent laboratory facilities for conducting diverse archaeo-palynological and palaeo-palynological investigations, as well as palaeoclimate, palaeo-vegetation reconstructions and archaeological landscape reconstructions. However, work undertaken on forensic palynology in archaeological contexts has been limited. This study fills a gap, whereby palynological records from the archaeological contexts at the Fa-Hien rock shelter is explored.

Results

The sample from context 139 commonly contained well-preserved pollen from different species of the Dipterocarpaceae family. A lower number of Palmae (*Caryota* sp.) pollen finds, Poaceae and a clump of tine Dipterocarpaceae pollen were also identified. Thermally mature and highly degraded Dipterocarpaceae pollen were found from context 142, where only several pollen grains of *Artocarpus* sp., together with full woody charcoal and thermally matures, were reported (Table 1 and Figure 5).

Table 1. Pollen and spore samples analysed from radiocarbon-dated contexts associated with the human skeleton.

Context 139	Palynomorphs	Counts
	Dipterocarpaceae	51
	Palmae/ <i>Caryota</i> sp	05
	Poaceae	04
	Clump of tine Dipterocarpaceae	02
	Trilete and monolete spores	13
	Micro-charcoal	230
	Thermally matures	55
Context 142		
	Dipterocarpaceae	71
	<i>Artocarpus</i> sp	04
	Trilete and monolete spores	80
	Micro-charcoal	220
	Thermally matures	46

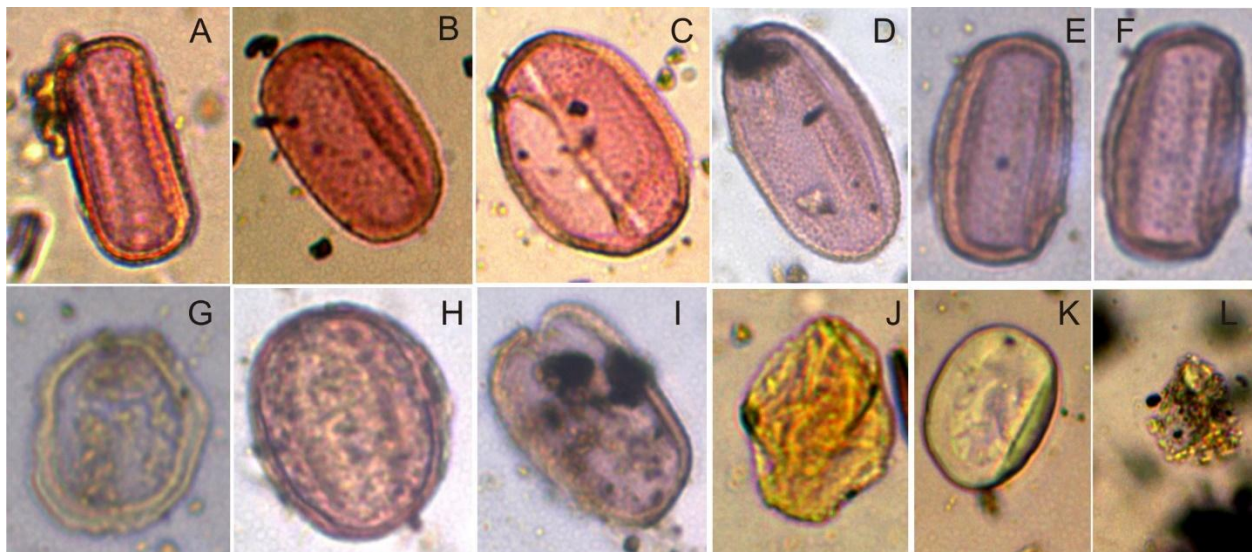


Figure 5. A-F: Well-preserved pollen from Dipterocarpaceae family and G-L: taphonomically altered pollen from the samples studied

Discussion

The most common pollen grains from sediment samples associated with the human skeleton were from the species of Dipterocarpaceae, which is a widely spread large woody element group in the lowland rainforests of Sri Lanka. Trilete and monolete spores derived from pteridophytes, together with pollen from *Caryota* sp. (Palmae) and Poaceae taxa, indicate rainforest and disturbed rainforest habitats. Pollen from *Artocarpus* spp. one of the common taxa in the lowland rainforest, were also found. These pollen and spore incorporations into the sediments could have been due to either natural and/or cultural events relating to the sediment formation process in Phase VI, dated to ca. 12,000 BP. Anthropogenic pollen markers such as *Artocarpus* spp., *Caryota* sp. (Palmae) and Poaceae taxa, together with archaeological finds, suggest that this sediment formation is likely to have been associated with cultural events.

Distractive exine ornamentation, exine damage (erosion and broken pollen), folding on exine and thermally mature exine as indicated by the lack of staining with safranin (yellow coloured pollen) suggest that high taphonomic impact must have occurred on the pollen grains in the depositional context, possibly due to reworking, burning, mechanical pressure and possibly other human and animal activities. Thermally mature pollen, and the high concentration of charcoal may suggest the impact of fire. Similar pollen and spore assemblages examined from the two contexts suggest that the assemblage derived from the lowland rainforest, including the *Dipterocarpus* spp. forest, and disturbed habitats of *Artocarpus* spp., Pteridophytes, Poaceae and *Caryota* sp. (Palmae).

With the complete list of pollen taxa occurring in the samples, the palynological evidence can be valuable to answer our research questions. The palynomorphs and their taphonomic markers can be used to argue the following complex issues in conjunction with the evidence from human skeleton excavated at Fa Hien-lena. (1) Perhaps the individual been buried deliberately in a grave cut, with floral materials (flowers) from the particular rainforest species, e.g., species from Dipterocarpaceae, Palmae and Poaceae, as part of ritual practices (2) Perhaps these ancient communities practise cutting, burning and gathering from lowland rainforests. (3) Perhaps the death of this individual occurred in a *Dipterocarpus* forest in association with an open habitat and was then later removed to the rock shelter (4) Maybe there were depositional disturbances of digging and filling that mixed the layers (as noted by the excavators, that resulted in several dating reversals? (Perera, 2015; Stock et al., 2022).

Understanding the significance of the pollen assemblages requires increasing the precision of palynological tests applied alongside the detailed knowledge of palynological taphonomy at Fa Hien rock shelter. Combined with stratigraphical and radiometric dating, mortuary context, and the osteological profile (Stock et al., 2022) of this individual, we can make broad inferences on the environment and burial contexts of these early Holocene people of Sri Lanka.

Palynology has excellent potential to be used in forensic archaeology and forensic anthropology to understand past human-environmental contexts. Pollen and spore analysis of sediments can help archaeological researchers understand complex issues involving mortuary behaviours, burial practices, rituals and various taphonomic conditions that occurred in the past. Similarly, these applications can be used in forensic

settings to solve criminal cases where forensic investigators can use pollen analysis from sediments associated with the deceased, revealing valuable clues to solve crimes. Be it from archaeological contexts or from more recent forensic contexts, we propose that palynology receives more attention and a higher profile as a forensic archaeological tool. From our study on the Fa Hien rock shelter archaeological context, we present an example that would be highly relevant to forensic contexts and to the science of forensic palynology.

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