Muséum national d'Histoire naturelle

International Erasmus Mundus Master in

QUATERNARY AND PREHISTORY

Long-term Evolution of Hunter-Gatherer Subsistence Strategies in Southern Thailand: Zooarchaeological Analysis of the Faunal Assemblage from Khao Ta Plai Cave (Chumphon Province)

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Année académique 2024/2025

UNIVERSITAT ROVIRA i VIRGILI

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Abstract

The dynamics of human subsistence and cultural change of hunter-gatherers in Mainland Southeast Asia remain a poorly investigated topic. Although numerous prehistoric archaeological sites have been examined, most existing research has focused on sedentary populations from the later Holocene, yet these aspects remain underexplored. The Khao Ta Plai rock shelter, excavated by the Fine Arts Department of Thailand, is a site located in southern Thailand, where a rich archaeological assemblage dating to the Prehistoric and Protohistoric periods was recovered.

In this thesis, I conducted a preliminary analysis of faunal remains recovered from the second excavation of this site. The aim being to gain insights into subsistence behaviors and animal processing during the occupation of the site. Three distinct sub-assemblages were defined through the zooarchaeological analysis of 8552 bone fragments. Wild taxa were consistently exploited across the stratigraphy but the intensity of exploitation of each of these taxa varies across overtime. In the latest layers, there is evidence of a wider use of reptiles alongside large-sized mammals, whereas the lowest layers are dominated primarily by turtles. One of the most noticeable attributes of the assemblages is the predominance of reptile remains, particularly turtles, across multiple layers. There was no evidence of domestic animals in the studied sample.

The presence of both locally produced ceramics and non-local types called Sa Huynh–Kalanay pottery at the site suggests long-distance contacts. In terms of tools, the transition from lithic to metal technology, together with the significant changes in animal exploitation previously mentioned, highlights the dynamic nature of subsistence strategies over time. Comparison with the other contemporary sites in mainland Southeast Asia indicates that human groups potentially adapted their subsistence strategies to the local conditions, with the adoption of technological innovations such as ceramics and metallurgy.

Acknowledgement

This work involved many people. Hence, I would like to acknowledge and give my warmest thanks to Corentin Bochaton for his guidance, his precious knowledge, and valuable advice throughout these two years of my dissertation and my Master's degree in France.

The person whom I cannot miss is Jane (Jutinach Bowonsachoti), as an alumnus and colleague, for her facilitating the permissions to study the artifacts of the Khao Ta Plai site and her encouragement throughout all the stages of my thesis.

I am grateful to Dr. Prasit Auetrakulvit (my former Thai supervisor) for imparting knowledge and for helping me with mammal references, and Dr. Julien Claude for helping me with the small mammals identification.

Equally thankful to Anna Échassoux, Director of the Institut de Paléontologie Humaine, and Professor F. Sémah and Professor Marta Azarello for allowing me to take part in this Erasmus Mundus master's in Quaternary Prehistory, and Bioarchaeology.

My special thanks go to the University of Montpellier, the Mission Préhistorique Franco-Thaïe, and the French embassy for their strong support with their funding for my stays both in France and Thailand.

I am also deeply grateful to C. Falguères and D. Pleurdeau for their patience and their help during my stay at the Institut de Paléontologie Humaine, and I also thank Rémi Berthon for his assistance, advice, and meticulous handling of paperwork.

Thank you to all of my friends, Noa, Léonard, Devi, Rachel, Martha, Paolo, and all whom I cannot mention one by one.

I appreciate the help of Mr. Phattarapong Kaongern, the director, and Ms. Siriporn Sanghiran, the director of the Archaeology group of the 12th Regional Fine Arts Department, Nakhon Si Thammarat, for their facilitated access to the studied materials of the Khao Ta Plai site.

I am also grateful to the staff of the 12th Regional Fine Arts Department, Nakhon Si Thammarat, with a special thanks to Ree, Care, Yui, Ka, Koi, and Uncle Add for all of your encouragement and your assistance during our fieldwork at the site. And May for her assistance in coordinating all the permission documents between the Fine Arts Department (FAD) and the University of Montpellier.

Finally, the most important people in my life are my family: my mom, dad, and beloved sister. Without their strong support, I could not have made it through every stage from the beginning to the completion of my master's degree. And to Clair and Alice, for their warm welcome and support, including sharing their lovely home during my stay in France.

1

Introduction

Numerous prehistoric archaeological sites across continental Southeast Asia have revealed evidence of continuous human occupation since the Pleistocene, with several cultural phases spanning hunter-gatherer societies to sedentary and historical societies (Add a general reference about the area.). Yet the subsistence behaviors of these different human groups remain underexplored. The Khao Ta Plai rock shelter (southern Thailand) offers a unique opportunity to study this question as it provided an important archaeological assemblage dating from the Prehistoric to the Protohistoric Periods. As of now, the evolution of human subsistence strategies and their interplay with the cultural changes documented from this site are still poorly understood. To fill this gap, I here performed an analysis of the faunal remains collected from the site in order to address this question.

1.1 "Hoabinhian" and the Prehistory of Thailand

In 1932, French geologist Madeleine Colani introduced the term "Hoabinhian" while attending the first Congress of Prehistorians of the Far East. Nonetheless, the Hoabinhian culture generated considerable debate in archaeology. Various aspects of the Hoabinhian populations have been investigated, including their geographic and chronological distribution, definitions, technological and functional attributes of their lithic industries, economic system, and environmental context. (Forestier *et al.* 2021). The chronology of the Hoabinhian period was originally established without the use of radiometric dating. This "cultural history" corresponds to the early post-Pleistocene era, commonly referred to as the Mesolithic in many parts of the world, and specifically as the Hoabinhian period in Southeast Asia. This nomenclature is based on pioneering research conducted in northern Vietnam (Colani 1927, cited in Matthews 1966; van Heekeren & Knuth 1967). The term "Hoabinhian" first emerged from studies of lithic typology, which helped establish a fundamental chronology for the region. Recent studies have greatly improved our understanding of this period. The oldest known Hoabinhian deposit dates back to about 43,000 years ago and is located at the Xiaodong Rock Shelter in Southwest China (Ji *et al.* 2016). In contrast, the site of Huai Hin in Northwest Thailand, dated to around 3,700 years ago, marks the last known production of stone tools while ceramics were also being used (Zeitoun *et al.* 2008; Forestier *et al.* 2013). Hoabinhian sites can be found in many areas across mainland and island Southeast Asia, including Vietnam, Thailand, Sumatra, Cambodia, Laos, and Myanmar. However, the features and significance of Hoabinhian groups differ across these regions, showing the variety of environmental and cultural contexts where they exist. White (2011) suggests that fluctuations in sea level and climate immensely affected human adaptations during this period, particularly through changes in vegetation and resource accessibility. Following the Last Glacial Maximum (LGM), increasing sea level caused to inundation of the Sunda

Shelf, transforming it underwater, such as the Gulf of Thailand and the South China Sea. This inundation had enormous effects on coastal ecosystems, biodiversity, and the abundance of plants and animals that are critical to human survival. The Hoabinhian's cultural and ecological adaptations as a consequence of changes in the environment are currently unreliable. To explore the potential for "cultural diversity" in Southeast Asia, further study on the clusters of lithic industries around the region is essential. Furthermore, extensive zooarchaeological research is important to expanding the comprehension of ancient ecologies and subsistence techniques. Although faunal evidence is particularly relevant for interpreting the chronology and integrity of site occupation, the scope of contemporary analysis is restricted (Forestier *et al.* 2013, 2021; Bochaton *et al.* 2023).

The typical Hoabinhian culture from Thailand is recognized in several notable archaeological sites, including Spirit Cave (Gorman 1970, 1971), Tham Pha Chan (White & Gorman 2004), Banyan Valley Cave (Reynolds 1992), Obluang (Prishanchit *et al.* 1985), and the Ban Rai and Tham Lod Rockshelters (Shoocongdej 2006, 2007) in northern Thailand. In western Thailand, significant sites include Ongbah Cave (SØrensen 1988), the Ban Kao sites (Pookajorn 1979), and Lang Kamnan (Shoocongdej 2000). In southern Thailand, important locations consist of Tham Khao Khi Chan (Reynolds 1989), Lang Rongrien Rockshelter (Anderson 1990, 2005; Mudar & Anderson 2007), and Moh Khiew Rockshelter (Pookajorn 1994; Auetrakulvit 1995, 2004; Auetrakulvit *et al.* 2012), Khao Hua Roop Chang Rockshelter (Fine Arts Department 2014), along with Khao Ta Plai (Bowonsachoti 2023).

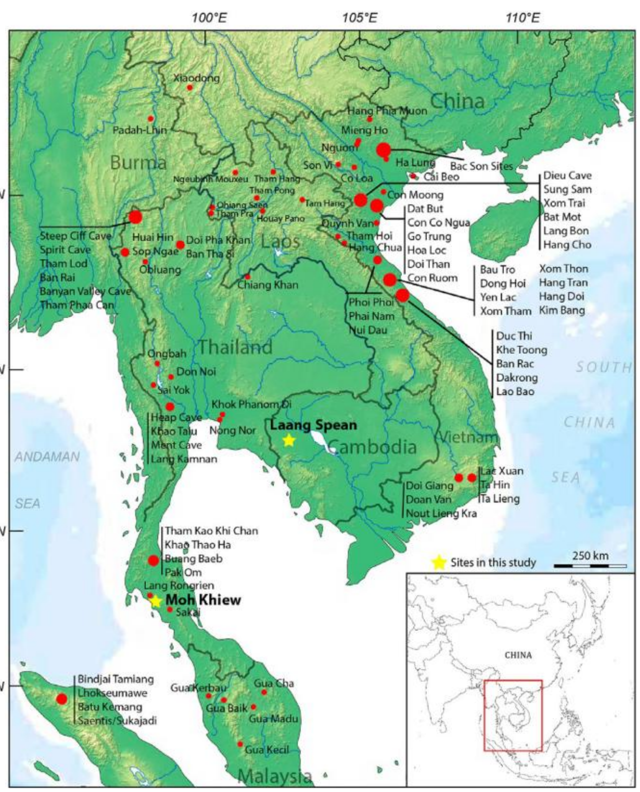


Figure 1 Geographic distribution of major Hoabinhian sites in Asia from (Forestier et al. 2022)

1.2 The protohistory of Southern Thailand

Due to the land form of southern Thailand, which lies on the peninsula between the Gulf of Thailand and the Andaman Sea. This region experiences a tropical climate in the monsoon belt, and it results in heavy rainfall alternating with a short dry season, influenced by both the southeast and northeast monsoons. This climate condition has contributed to the abundance of the region and has been convenient for human settlement in the past. Additionally, this monsoon also played a significant role in facilitating ancient maritime trade. Several bays provided natural harbors for mooring boats. Consequently, became a central hub for trade and transportation between the eastern and western parts of Thailand during the late prehistoric period (approximately 2,500-2,000 years ago). This led to the development of numerous ancient communities that functioned as important trading ports, as evidenced by sites such as Thung Tuk in Phang-nga Province (Chaisuwan & Naiwat 2007), Khlong Thom in Krabi Province (Thongkham & Kangket 2008), Khao Sam Kaeo in Chumphon Province (Bellina 2017), and Chaiya in Surat Thani Province (Thongphuea 2021).

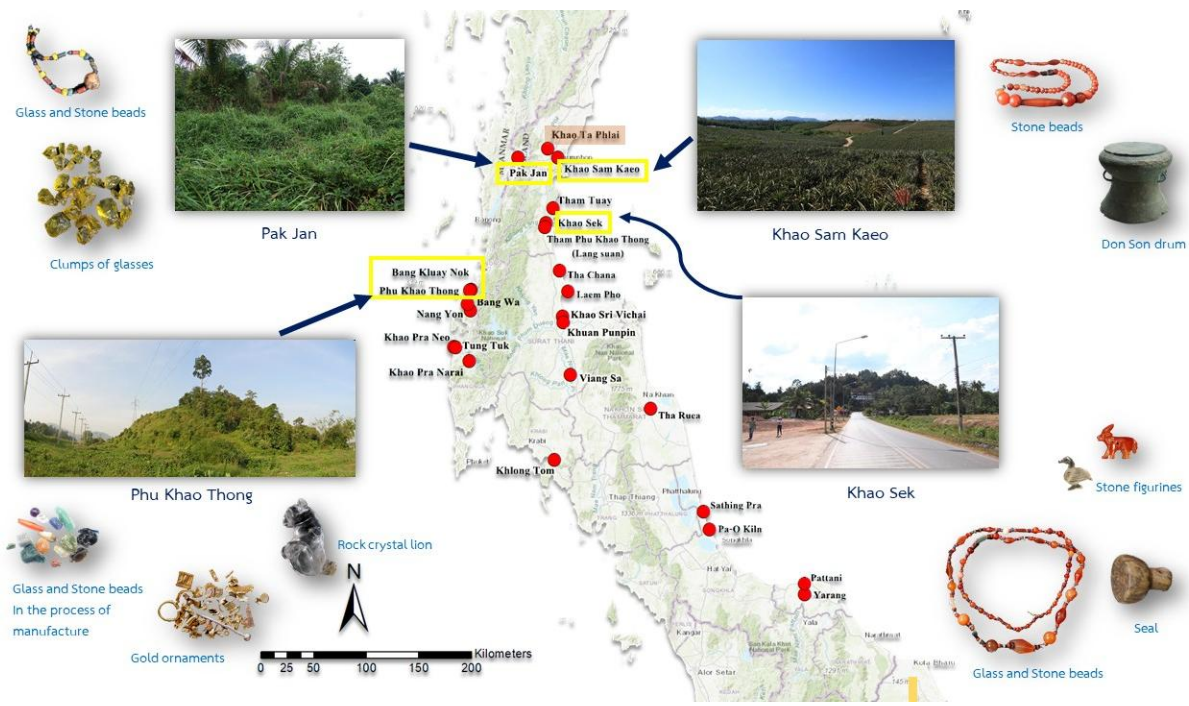


Figure 2 Map of Ancient Ports in Southern Thailand (after Bowonsachoti 2023)

Regarding the significance of the southern peninsula has led many scholars have conduct extensive studies in the area. The trans-peninsular routes between major port cities are one of the topics of interest among them, and it has been widely researched over several decades. The first mention of such a trans-peninsular route appears in the documents of Chinese maritime journeys to India around the 1^{st} century CE (Jacq-Hergoualc'h 2018). The study of the trans-peninsular route has identified at least nine possible paths along the Thai peninsula. Among them, the Khao Ta Plai site is believed to be situated along the Kraburi–Chumphon route. This assumption is supported by the presence of stone and glass beads, metal tools, and distinctive decorated pottery sherds known as *Sa Huynh-Kalanay related potteries*. These artifacts show cultural connections to other significant sites such as Khao Sam Kaeo and Khao Sek, both located along the Gulf of Thailand (Bellina *et al.* 2017).

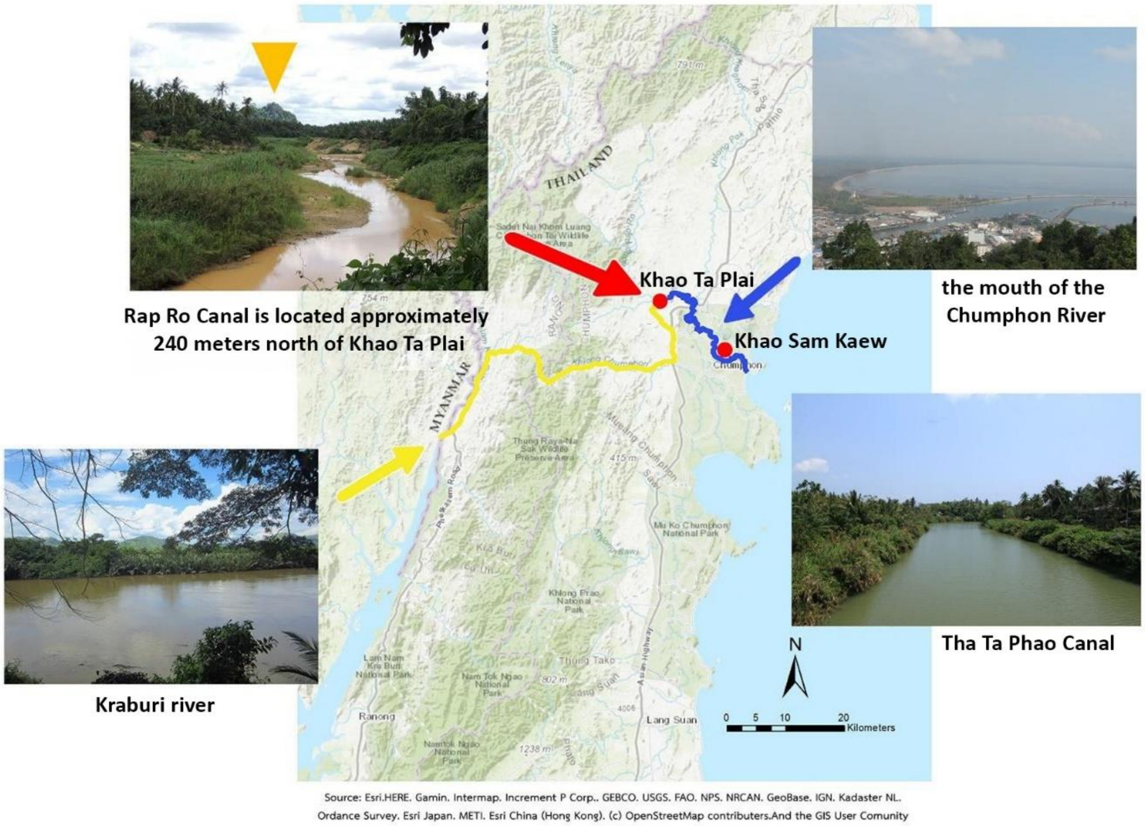


Figure 3 Map showing the routes leading to the Gulf of Thailand and the Andaman Sea from the Khao Ta Plai archaeological site (after Bowonsachoti 2023)

For the Sa Huynh-Kalanay related potteries, they are contemporary with artefacts associated with the Metal Age along with metals such as bronze and iron and red slip potteries, and it is dated to approximately 2,235 – 2,230 years ago. This type of pottery was first published by W.G. Solheim in 1961 (Solheim 1964a) and is notable for its decoration, which resembles the potteries found at the Kalanay Cave in the central Philippines and the Sa Huynh site in Central Vietnam (Favereau & Bellina 2016). This type of pottery can be discovered from several sites in the South China Sea, including the Philippines, Vietnam, Malaysia, and Indonesia, from both terrestrial and island areas such as Taiwan and Hong Kong. Among them, they are related to the Metal Age or around 1,000 - 3,000 years ago (Favereau & Bellina 2020). It is believed that the original human groups who utilized this type of pottery were Malayo-Polynesian, which is a subgroup of Austronesians. For the archaeological sites where the Sa Huynh-Kalanay pottery is distributed in both caves and rock shelters along the coastline, particularly around the Gulf of Thailand, such as archaeological sites of Khao Sam Kaew, Khao Sek, Tham Nang Shee, Tham Tuay, Tham Din, Tham Ta Duang, Tham Mung Korn Dang, Tham Chan Tha in Chumporn province, as well as Koh Din site in Surat Thani province and only few sites in Krabi province where is located along the Andaman coastline (Bowonsachoti 2023).

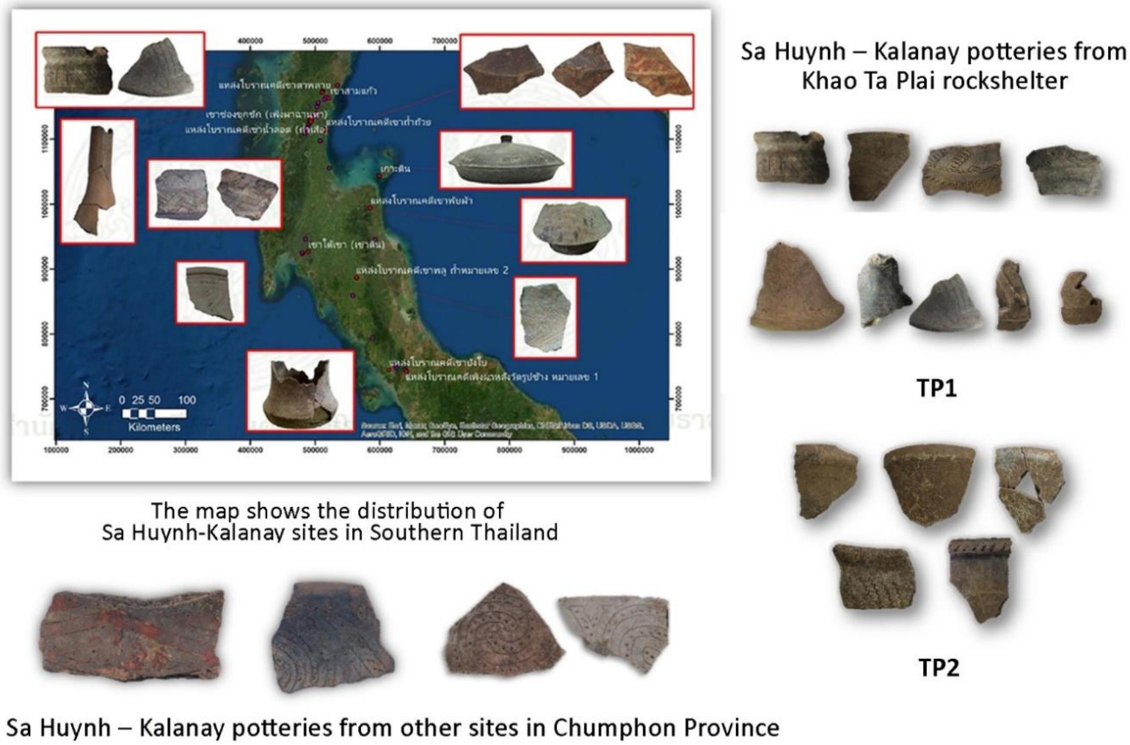


Figure 4 Sa Huynh Kalanay potteries found from Khao Ta Plai and other sites in Southern Thailand (Bowonsachoti 2023)

1.3 Zooarchaeological research in Southeast Asia

Animal bones are among the most common types of archaeological evidence found from prehistoric sites and provide important information to understand the relationship between past human societies and their environments, especially between humans and other animal populations. The diversity of zooarchaeological studies that covers all aspects of the field can be attributed to the application of numerous physical, biological, ecological, and anthropological concepts and methods, and each field brings different perspectives, methodologies, and research goals to the study of animal remains (Reitz & Wing 2008). Due to the diversity of continental Southeast Asia presents challenges in explaining cultural change and continuity, these interactions are complicated, and it is important to consider many roles of animals in past societies. Despite increasing academic interest (Marwick 2009; Amano 2011; White 2011; Piper & Rabett 2014; Conrad *et al.* 2016; Jones *et al.* 2019; Ansyori 2020), study faunal remains in the region still lacks comprehensive analyses (i.e., concerning human and animal interactions, hunting pressure, domestication, paleoenvironmental change) that could benefit the interpretations of broader ecological and cultural questions. Zooarchaeological studies, especially for the evolution of hunter-gatherer subsistence systems, remain challenging in continental Southeast Asia, including Thailand. Throughout history, there have been investigations of hunting behaviors, but they have mostly focused on sedentary populations from the later Holocene (Kijngam 2010; Higham 2013). Although several zooarchaeological studies have been undertaken in Southeast Asia (see Conrad 2015; Conrad *et al.* 2016), the field remains underdeveloped compared with other regions. Most research has reviewed the question of the zooarchaeological studies with few comprehensive and comparative analyses. This limitation restricts our ability in broader understanding of human and animal interactions and subsistence strategies in the regions. Moreover, most rehistoric populations in Southeast Asia are often grouped into a single culture called 'Hoabinhian," which further complicates to interpretation of the variation in human adaptation and resource use.

Due to the complexity of human activities in continental Southeast Asia, scholars face significant challenges when exploring various cultural and environmental topics in the region. As previously mentioned, past human groups developed diverse strategies in response to their environmental conditions. This site provides examples that although local resources were available yet they sometimes exchanged their goods with outsiders as the presence of Sa Huynh-Kalanay. Therefore, a better understanding of human adaptation to various environments could be achieve by conducting zooarchaeological studies, which are essential for the investigation of ancient human subsistence. Recent research has employed more precise techniques to examine animal bones, allowing a multi-faceted perspective on human subsistence patterns and behaviors (e.g., Bochaton *et al.* 2023, 2025; Suraprasit *et al.* 2024).

Previous attempts have been made to analyze archaeological animal remains in Thailand, but until recently, there remains poor data to interpret the diversity regarding environmental conditions and subsistence systems, especially for hunter-gatherer groups in continental Southeast Asia, including Thailand. Early studies in Thailand were conducted by Higham (1975, 2013), Kijngam (1979, 2010), and Higham & Kijngam (1980), focused on domestication, diet, and site chronology, and emphasized Holocene sites with better preservation compared to those from older sites. Initially, the methodology used was mostly focused on taxon lists, including their representations (Anderson 1990).

Currently zooarchaeological studies in Thailand are increasing and developing in scope, with taxonomic identification remaining the dominant focus, incorporated with analyses of faunal abundance, age profiles, taphonomy, domestication, and hunting strategies (e.g., Auetrakulvit 2004; Ampunsri 2007, 2005a; Mudar & Anderson 2007; Mithong 2014; Frère *et al.* 2018; Jeawkok 2020; Khaopee 2023). In addition, some emerging work started to apply isotopic analysis (Suraprasit *et al.* 2019, 2020, 2024), as well as morphometry and improved taxonomic identification using diagnostic criteria (Suraprasit *et al.* 2016; Bochaton *et al.* 2019, 2023, 2025; Chantasri 2024; Seesod 2024). These approaches enhance our ability to interpret past fauna assemblages and to better understand environmental diversity, which could change over time. Furthermore, the incorporation of scientific techniques has greatly improved the reliability and accuracy of the faunal data in archaeological contexts.

Although the study of faunal remains has improved, researchers face significant challenges. These include the limited comparative collections, poor preservation of the bones, which limits the sample size and quality, and historical bias relevant to subsistence, environments, and social practices. One major issue is the lack of comprehensive comparative reference collections of modern animal bones, which are essential for accurate taxonomic identifications. Our research group is currently developing diagnostic criteria for the Bovidae and Cervidae families, but few resources for other taxa are still lacking. Moreover, poor preservation, particularly in Pleistocene contexts, complicates the analyses, as highly fragmented remains that could result from either natural processes or human activities. These challenges highlight the need for careful taphonomic studies and more comprehensive analytical approaches. Therefore, the application of modern analytical techniques (e.g., DNA, stable isotopes, and morphometry) is increasingly important. In addition, further research on the Pleistocene and early Holocene is necessary to refine our comprehension of environmental and cultural developments during these periods. Finally, one of the most important issues is the scarcity of trained zooarchaeologists and specialists in Thailand. According to zooarchaeology is a highly specialized field, yet the understanding of its methods remains limited to many archaeologists in the region. To build local expertise through training programs and knowledge exchange is therefore essential. Improving Thai zooarchaeologists will strengthen research gaps and ensure that the analysis of fauna will be conducted with greater accuracy and contextual understanding.

Research Objectives

The present study of the faunal remains collected in the second pit (TP2) of the Khao Ta Plai site aims to address the following objectives:

1. To identify the animal taxa exploited by human groups and understand animal butchery and carcasses management processes through the study of anthropogenic modifications on bones.
2. To explore the distribution of the faunal remains between the different cultural layer to test the hypothesis of an evolution of the subsistence strategies through time.
3. To study the taphonomy of the bone fragments to understand site formation processes.
4. The above mentioned results will provide new insights into subsistence strategies and vertebrate community composition during the late Pleistocene to Holocene in Southern Thailand, particularly the Gulf of Thailand.
5. In the final step of this work, I will compare the obtained results with other contemporary sites, in Thailand, along with the Laang Spean site in Cambodia.

2

Materials and Methods

2.1 Studied Materials

All materials recovered from the second excavation have been studied except those from squares N2W2, N1W2, and N1W3, which could not be analyzed due to time constraints. All sediments from the site were dry-sieved using a 2 mm mesh. During the excavation, two different strategies were applied to collect animal remains. All large fragmented bones collected by hand were retained as the samples. In addition, all excavation sediments were dry-sieved to retrieve small and fragmented bones. Among these fragmented bones, only the most complete materials were selected as the samples.

2.1.1 Archaeological Context of Khao Ta Plai Rockshelter

Khao Ta Plai Rockshelter is located in Rap Ro Sub-district, Tha Sae District, Chumphon Province in Southern Thailand (E 99° 5.818'; N 10° 36.206') (Figure 5). The site lies within a small limestone hill known as “Khao Ta Plai,” surrounded by a flat area dominated by palm oil and rubber plantations (Figure 6). A small creek runs along the hill's western side and joins the Rap Ro Canal (Figure 6-7). This canal flows into the Tha Sae Canal, which then merges with the Tha Ta Phao Canal, eventually reaching the Gulf of Thailand at the mouth of the Chumphon River approximately 20 kilometers to the east.

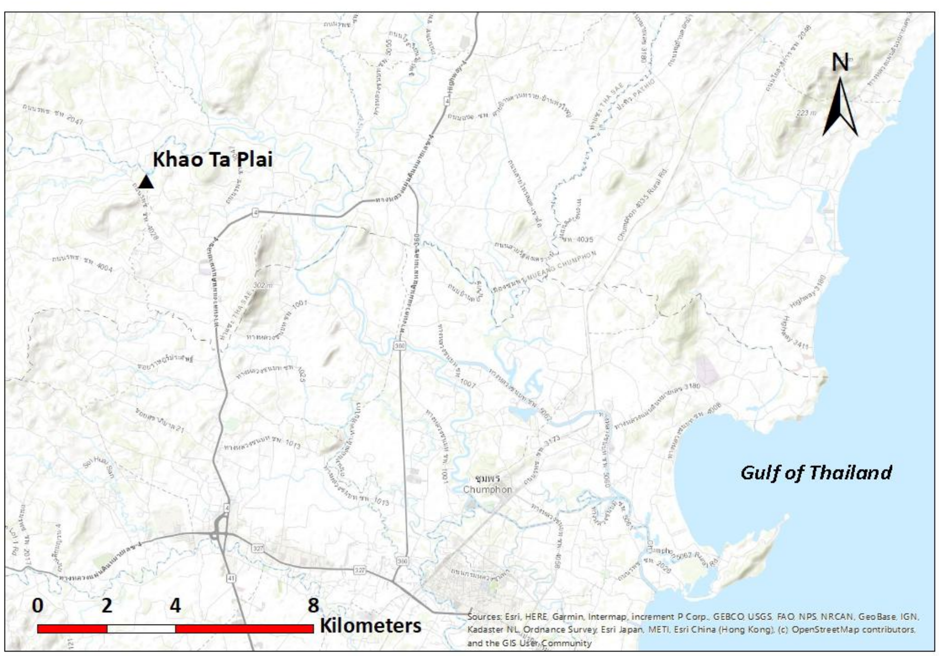


Figure 5 Topo map shows the location of the Khao Ta Plai site

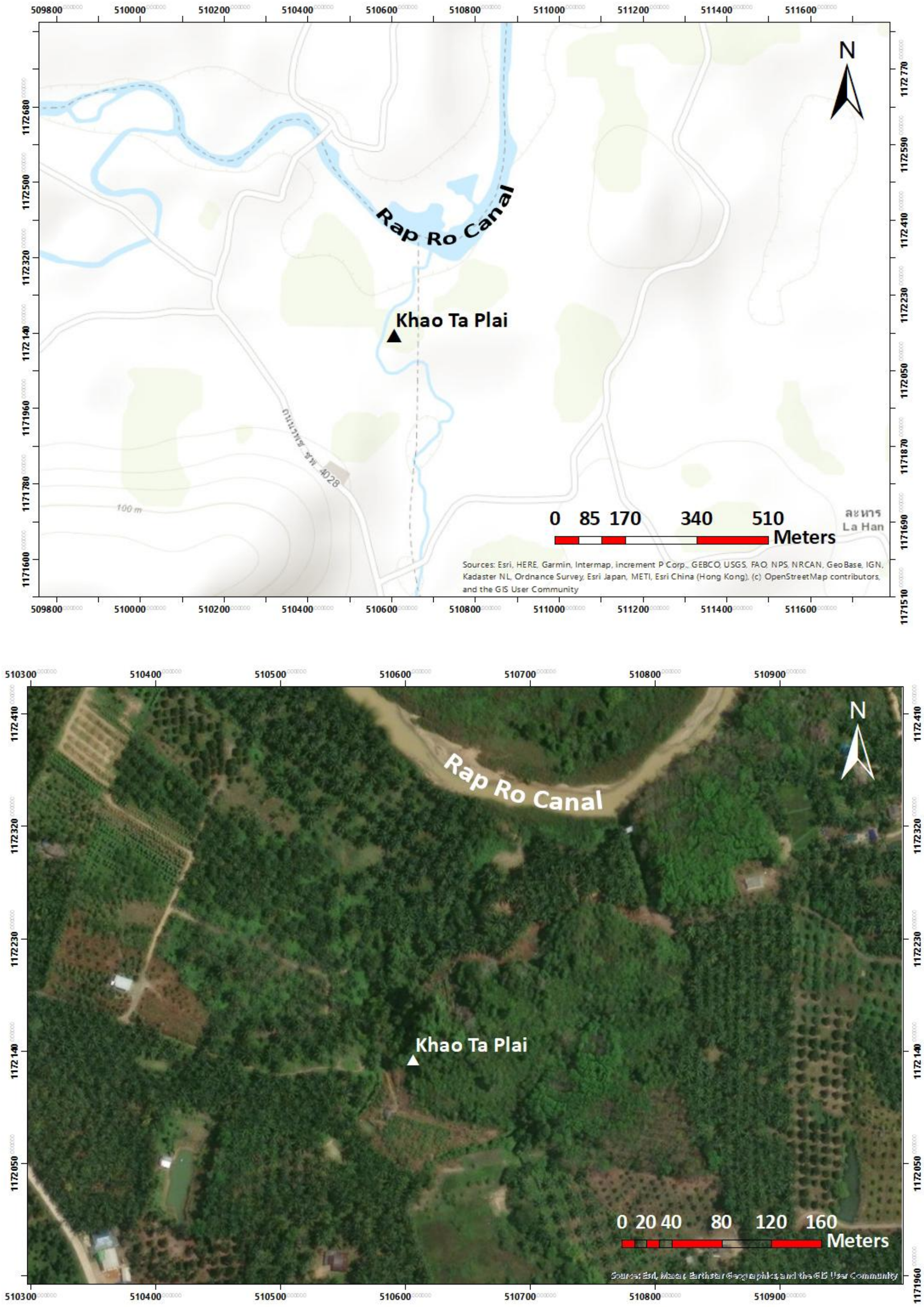


Figure 6 Map shows the location of the Khao Ta Plai site

Khao Ta Plai site

Rap Ro canal

The entrance is east-west of the rock shelter

The second excavation area (TP2)

Figure 7 Pictures shows the landscape and the site of Khao Ta Plai

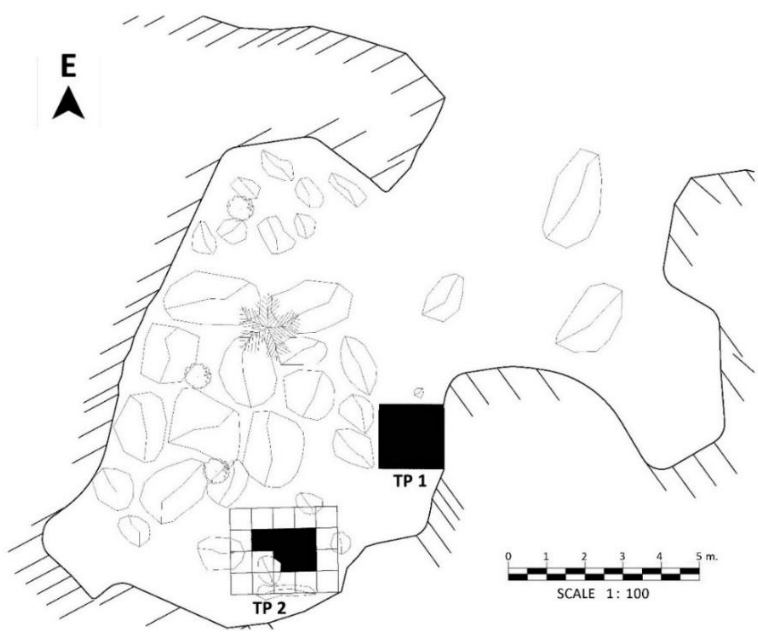


Figure 8 Map shows the relative locations of TP1 and TP2

The 12th Regional Fine Arts Department initially reported the site, Nakhon Si Thammarat, between 2009 and 2014 under the project "Exploration of Prehistoric Archaeological Sites in the Upper Region of Southern Thailand," which focused on areas within Chumphon Province through a survey. Due to minimal disturbances at the site, including significant surface finds such as stone tools, polished axes, decorative earthenware, and faunal remains, the FAD 12 decided to proceed with an excavation at that time.

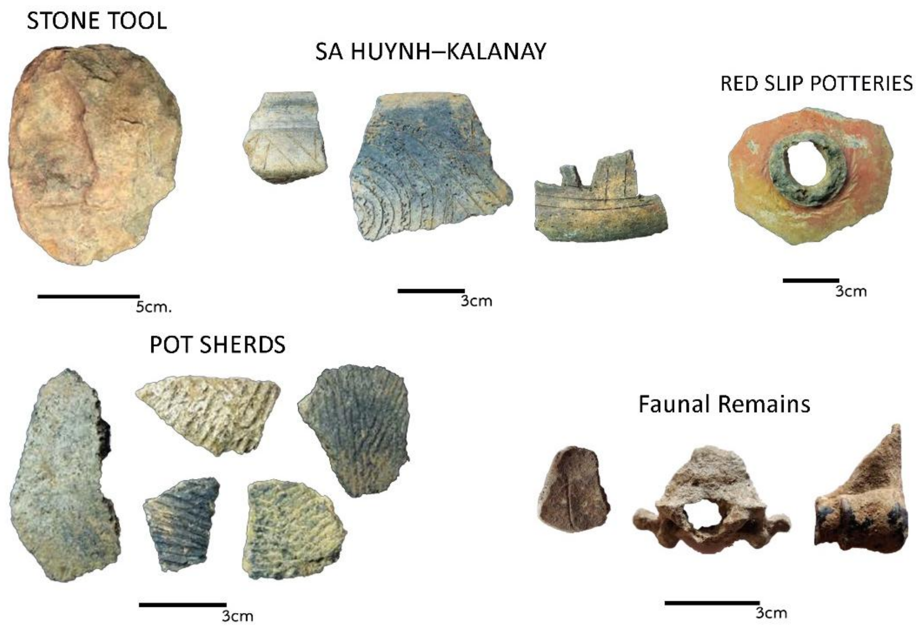


Figure 9 Surface finds through a survey from Khao Ta Plai

In 2014, this site was first excavated (TP1) in two stages in the northwest area of the shelter, measuring 9 m². Artifacts uncovered include flakes, stone tools, polished axes, pottery, tripod pottery, decorative pottery identified as Sa Huynh–Kalanay, fragments of bronze and iron, and beads made of stone, glass, and shell, along with faunal remains. Based on the analysis of the archaeological finds and Thermoluminescence (TL) dating of sediments and potsherds, it is presumed that the site represents human activities across three layers: the first layer dates to around 4,500 years ago, the second to about 2,800 years ago. These two layers can be indicated as hunter-gatherer regarding the representation of lithic tools along with faunal remains. The third layer dates to approximately 2,235–2,230 years ago, is distinguished by the presence of metal objects and carnelian beads. This suggests that while the inhabitants may have still practiced a hunter-gatherer way of life, they likely had contact with external groups, including coastal communities.

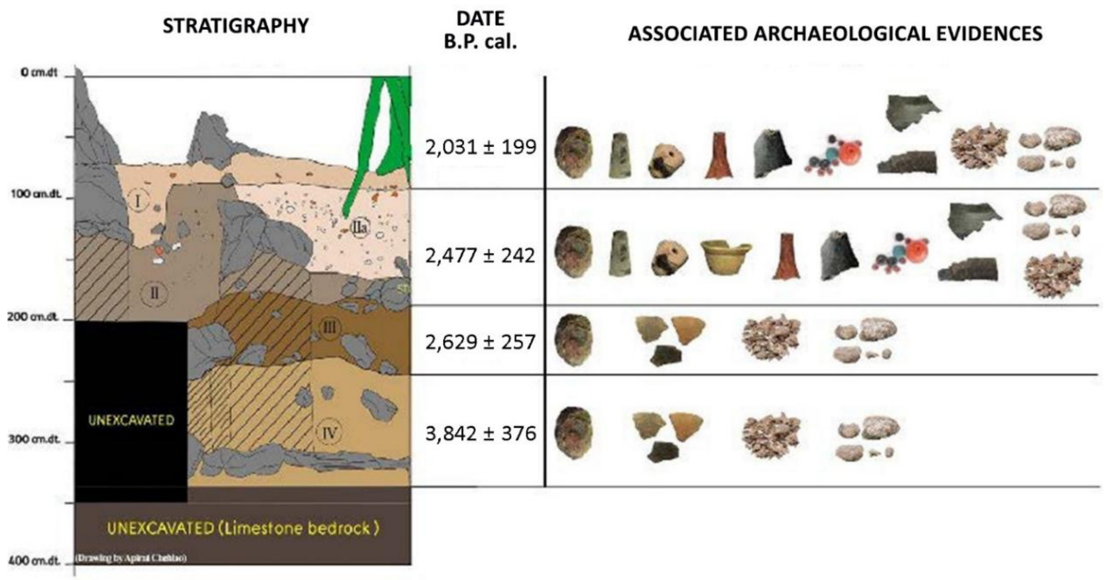


Figure 10 The stratigraphy and associated artefacts recovered from TP1 (Bowonsachoti 2023)

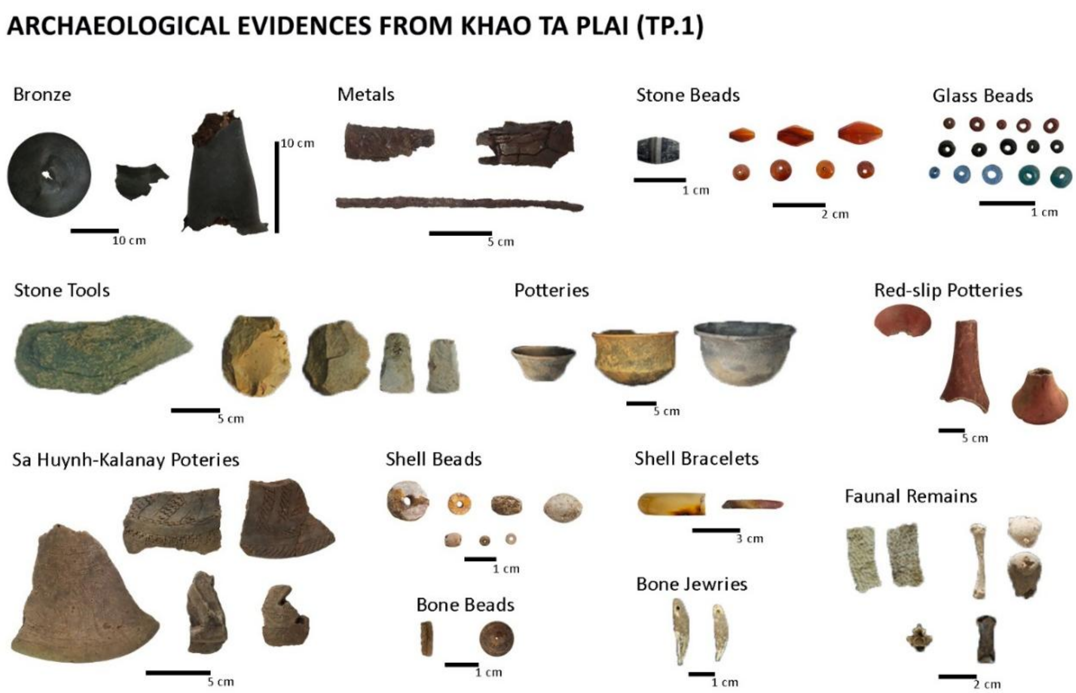


Figure 11 Artifacts from the first excavation (TP1)

The second excavation (TP2) encompassed an area of 20 m². It was performed between 2021 and 2022 and was conducted by BOWORNSACHOTI. This pit is situated approximately five meters west of the TP1. This pit was divided in ten quadrants: N1W2, N1W3, N2W2, N2W3, N3W2, N3W3, N3W4, N4W2, N4W3, and N4W4, plus half of a quadrant (N2W4) (see the table below). Due to time constraints, only N3W4 and half of N2W4 were excavated down to the bottom, reaching a depth of 270 centimeters.

Figure 12 The second excavation area (TP2) before excavation.

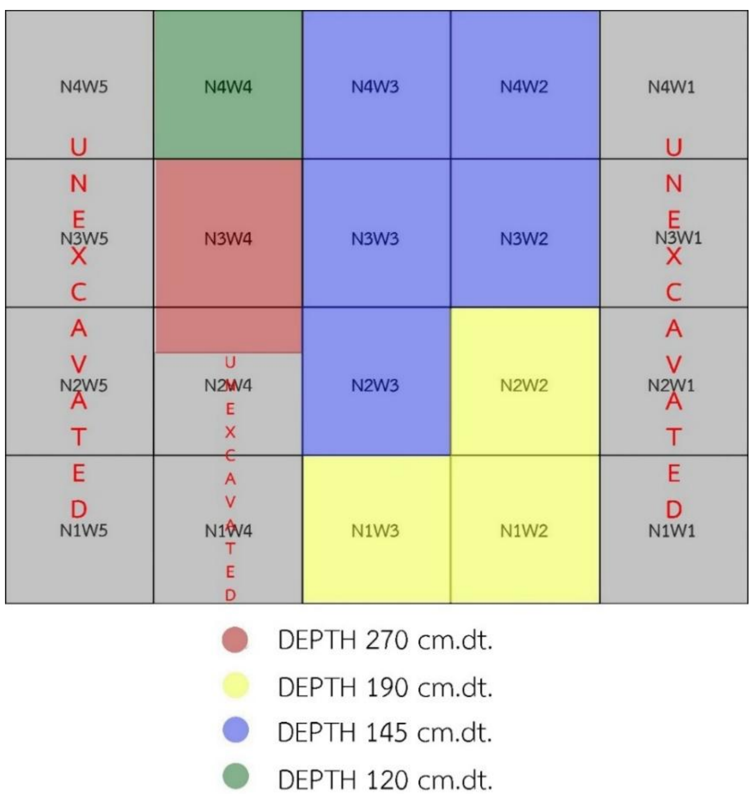


Figure 13 Map shows the layout of TP2 divided into squares and depth (Bowonsachoti 2023)

This excavation revealed four layers: the first layer is 5-10 centimeters deep and is characterized by dark humid sediment mixed with organic materials such as fibrous roots along with limestone flakes (the limestone that probably flowed by water from the northern area of the shelter regarding its weathered surface), pot sherds are mostly found from this layer. According to the presence of Chinese ceramics found in this layer. These two ceramics are attributed to the Qing dynasty according to their techniques and decorations (Thammapreechakorn 2004), leading to very recent human activities (approximately 10-100 years ago). The second layer is 30-50 centimeters deep, dated to 2,235-2,230 B.P. cal. The sediment has a dark brown color and is looser and softer than the layers above. Regarding this pit lies on a slope area, there present numerous artifacts associated with lighter-colored sediment in the center of the pit. In contrast, the sediment in the southern area is denser and darker in color. Additionally, two features were identified: Feature 1 in N3W3 and N3W4, and Feature 2 in N2W3. These features contained various artifacts, particularly pot sherds and Sa Huynh–Kalanay and red slip pottery, along with stone tools, metal fragments, beads, and faunal remains, indicating a metal age. Afterward, the layer 3 corresponds to a depth of 50–80 centimeters, characterized by fewer fibrous roots and fragmented limestone. In the southern area of this layer (square N1W2, N1W3, N2W2, and N2W3), the sediment shows moist conditions along with small orange clay pellets. In contrast, sediments in the southeastern area (N3W2, N3W3, and N2W3) are dustier, drier, and less cohesive, with a range from light to dark brown color. Faunal remains are mainly recovered, particularly testudines, and fish bones are also recovered. Stone tools and pot sherds are decreased compared to the upper layer. The deeper portion of this layer tends to contain a denser concentration of faunal remains. According to the presence of polished hand axes in this layer, indicative of the Neolithic period (approximately 7,425-7,274 B.P. cal). Finally, layer 4 that only excavated in the square N3W4 due to limited time to reach the deepest part of the site in all squares. This layer is 30 centimeters deep and contains very few fibrous roots. Instead, it features numerous fragmented stones and blocks, especially in the south wall of the square. The sediment is denser and appears to be heated, presumably indicating burning. Stone tools are recovered along with faunal remains up to the last 20 centimeters above the bottom and are covered with calcite; this layer is probably correlated with the Hoabinhian group and it's dated to 13,787-13,676 B.P.cal. (see more details in Figure 19)

Figure 14 Distribution of archaeological evidence in Feature no. 1 (100 - 110 cm.dt.)

Figure 15 Distribution of archaeological evidence in Feature no. 2 (110 - 115 cm.dt.), Artefact finds in this area are mixed with limestone flakes

Figure 16 Distribution of archaeological evidence in square N3W4; spit 33 (225 cm.dt.)

The sediment samples dated from the second excavation indicate an older chronology than those obtained from TP.1. Notably, the stratigraphy in both pits (TP.1 and TP.2) exhibits clear signs of bioturbation, including fibrous roots and numerous nests of ants, wasps, and termites. Due to these disturbances, additional data are necessary for cross-verification. Bone samples have already been selected for further dating and are currently being analyzed. *Table 1* below presents the current dating results. However, it should be noted that the dating results between the two pits are significantly different and are not yet considered fully reliable. In exception so far, the dating from sherds (from TP1) is the most reliable. As a result, the analysis of materials that are recovered from the first excavation needs to be compared to this study to see the difference among them and gain an idea of the chronological variation.

Table 1 Thermoluminescence dates (TP1) and Radiocarbon dates (TP2) recovered from Khao Ta Plai Rockshelter by depth from surface

Pits	LAYER	MATERIAL DATED	DEPTH (CM.DT.)	DATE B.P. cal.	Author
1	1 (45 - 150)	sherd	85-90	2,031 ± 199	(Jaelao 2014)
		sherd	85-90	1,172 ± 115	(Jaelao 2014)
		sediment	NA	1,963 ± 192	(Jaelao 2014)
	2/2a (90-190)	Sherd	170-175	2,477 ± 242	(Jaelao 2014)

Pits	LAYER	MATERIAL DATED	DEPTH (CM.DT.)	DATE B.P. cal.	Author
		Sherd	115-120	2,452 ± 240	(Jaelao 2014)
		Sediment	NA	1,609 ± 157	(Jaelao 2014)
	3 (180-280)	Sediment	NA	2,629 ± 257	(Jaelao 2014)
	4 (280-335)	Sediment	NA	3,842 ± 376	(Jaelao 2014)
2	2 (126 cm.dt.)	sediment	125-130	5,720 BC 7,670 ± 40 BP	(Bowonsachoti 2023)
	3 (133 cm.dt.)	sediment	130-130	5295 BC 7245 ± 45 BP	(Bowonsachoti 2023)
	4 (176 cm.dt.)	sediment	175-180	5475 BC 7425 ± 40 BP	(Bowonsachoti 2023)
	4-1 (235 cm.dt.)	sediment	230-235	11837 BC 13787 ± 40 BP	(Bowonsachoti 2023)

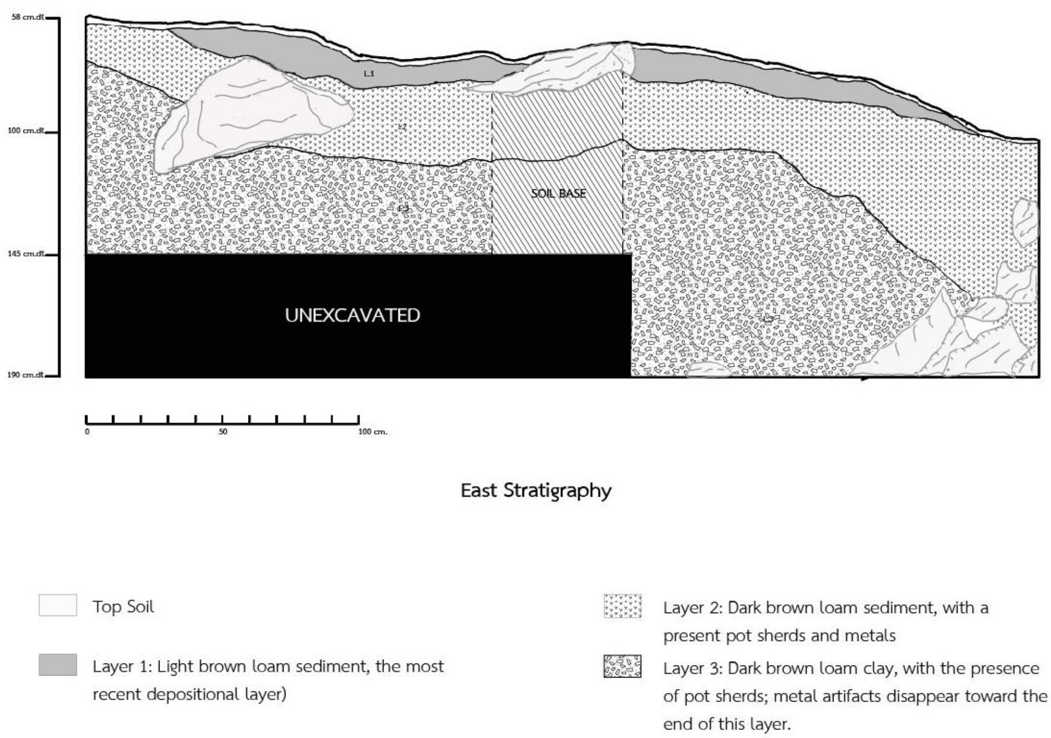


Figure 17 The stratigraphy of TP 2 at Khao Ta Plai (East wall)

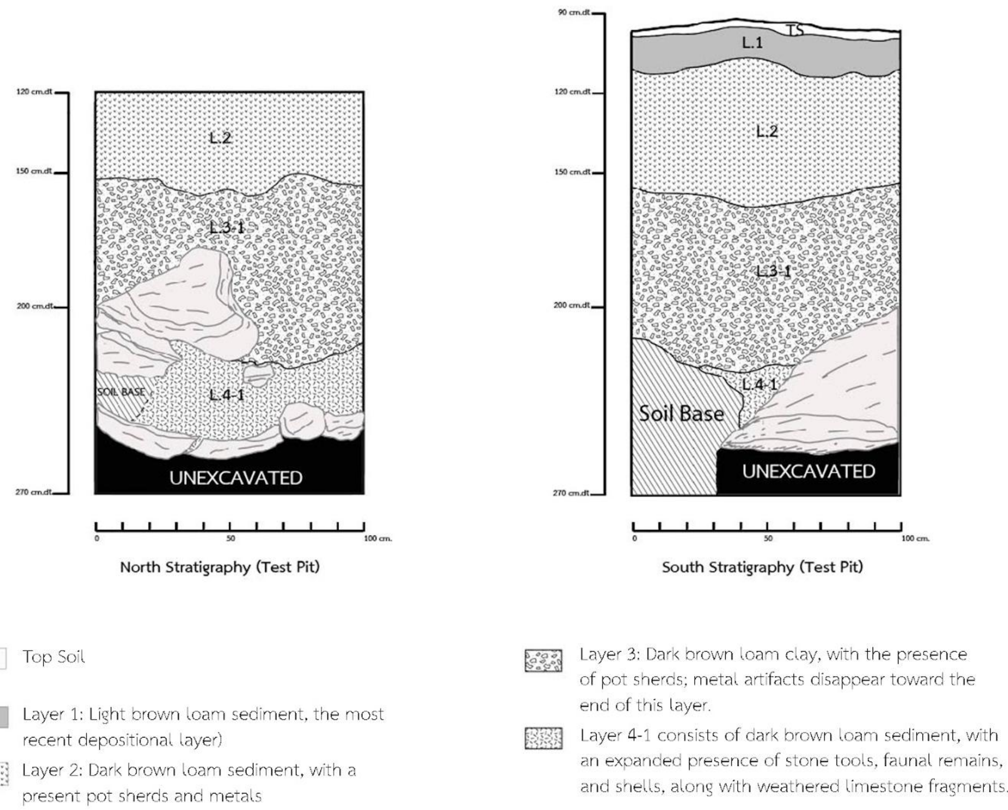


Figure 18 The stratigraphy of TP 2 at Khao Ta Plai (East wall)

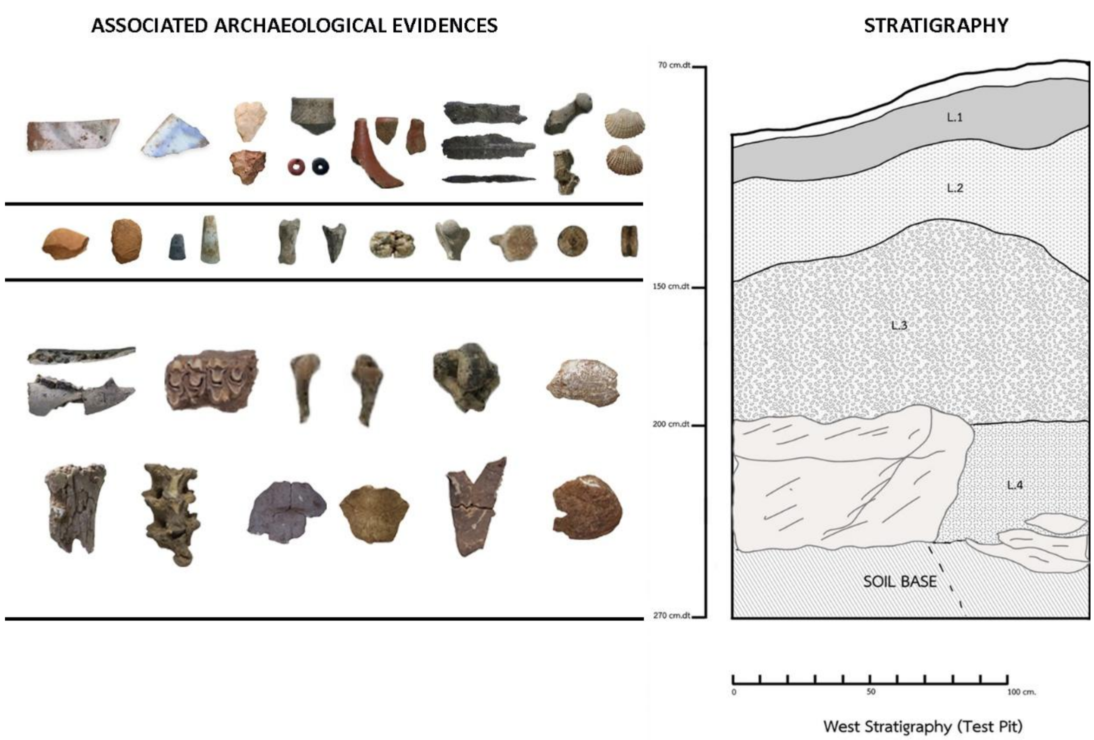


Figure 19 Artefacts recovered from TP2 according to each spit

Artefacts found from TP2 include stone tools. These tools can be categorized into several groups, such as Chopper-Chopper-Chopping, Bifacial tools, Scrapers, Core tools, Flake tools, Polished Adze, Hammerstone, Flakes, and manuport (the unmodified lithic materials; see Leakey 1966; pp. 464). The analysis of the raw materials used for these tools is particularly Quartzite, followed by Andesite, Shale, and Quartz. Pot sherds are the most numerous artefacts found from this excavation, with a total of 3,244 pot sherds. They are primarily concentrated in Layer 2 and gradually decrease in Layer 3. Preliminary analysis of the majority of these sherds relatively coarse, and the decorations observed include rope patterns, smooth surfaces, red slips, and incised lines. Notably, a few finer examples categorized as Sahyunh-Kalanay were also identified. Beads are a few artifacts found, comprising numerous glass beads and only one stone bead. The beads exhibit various shapes, including cylindrical, flat, rounded, and barrel shapes. Numerous metals were also recovered, including 163 bronze and 30 pieces of iron. Most of the metal fragments are heavily degraded, soft, and fragmented. These solution causes it difficult to determine their original forms. Some of the larger bronze fragments appear to be parts of pottery decorations, bracelets, and spearheads. In contrast, the iron pieces are generally smaller but include identifiable forms such as spears, steel rods, and sharp-tipped tools (see more details in figure 12).

Preliminary analysis of faunal remains recovered from the 2014 excavation was performed on layer 1 and layer 2. In the layer 2, large-sized remains were found, often bearing concretions and associated with stone tools. These included both burned and unburned specimens. In contrast, Layer 1 yielded fewer faunal remains (Jaelao 2014). Afterward, a total of 7,863 bone fragments were studied by a bachelor's student in 2020 from square Q1, Q2, Q3, and Q4 of the first excavation (TP1), covering layers from the top soil to the bottom (Jeawkok 2020).

For the second excavation (TP2), I conducted a preliminary analysis of faunal remains from the spit 3 down to spit 42 (52-270 cm in depth). A total of 15,575 faunal fragments were studied. This preliminary study was complemented by C. BOCHATON, who studied the herpetofauna remains from squares N1W2, N1W3, N2W2, and N3W4. His analysis has identified seven anuran specimens and 2,465 testudine remains, including members of Geoemydidae, *Cyclemys* spp., *Heosemys* spp., *Cuora amboinensis*, and *Indotestudo elongata*, as well as softshell turtles (Trionychidae). Additionally, 666 squamate fragments were attributed to Varanidae, some of which were identified as *Varanus bengalensis*, and 110 snake specimens were assigned to *Ophiophagus hannah*, Colubridae, Elapidae, and *Python* sp (Bochaton *et al.* 2023; Bowonsachoti 2023). Notably, the most recent study of testudines also revealed that this site found some extinct species like *Amyda,* which can be observed with significant reductions in geographic distribution (Bochaton *et al.* 2025). Then, another bachelor's student studied faunal remains in 2023, focusing on squares N3W4 (spits 52–270 cm.d.t.) and square N4W4 (spits 52–120 cm.d.t.). This study identified taxa similar to those found in my preliminary analysis, including Bovidae, Cervidae, Tragulidae, Suidae, Canidae, Viverridae, Herpestidae, and Rodentia (e.g., Rhizomyinae, *Rattus* sp., and Hystricidae) as well as Cercopithecidae and avian remains. This study differentiates from the study in 2020 by conducting a size class analysis of the mammalian remains that present animals ranging from large to small. For herpetofauna, she combined her data with Dr. Bochaton's study (Khaopee 2023).

Human remains were recovered from both pits, particularly from 70-145 centimeters depth. Preliminary analysis indicates that they are mostly covered with calcite. However, these bones are not found as sepultures. As a result, there is no evidence to suggest that this site is utilized for mortuary purposes.

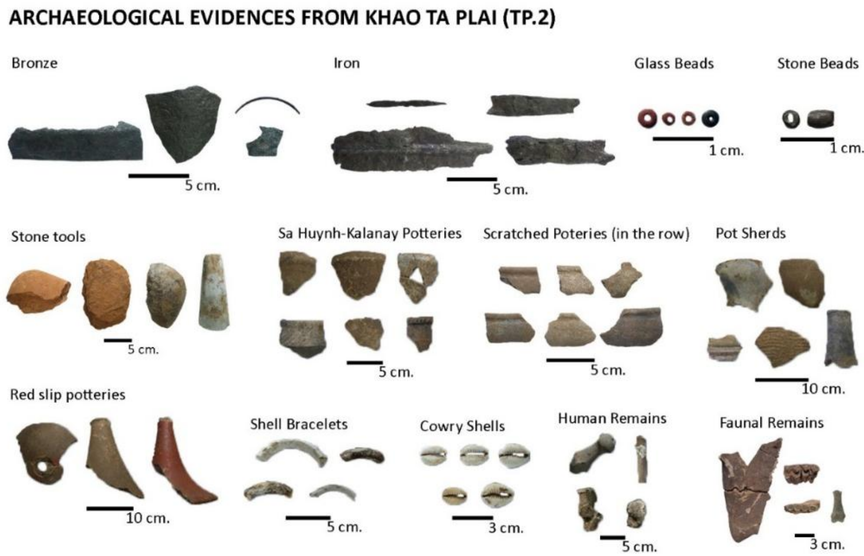


Figure 20 Artifacts from the second excavation (TP2)

The study of faunal remains at the Khao Ta Plai site over several years has provided partially applicable data on faunal remains. However, these studies emphasized taxonomic identification by examining species identification and biodiversity reconstruction to understand the prior connection between humans and animals, including paleoecology and environmental reconstruction. They extensively utilized skeletal comparisons along with the Number of Identified Specimens (NISP) and Minimum Number of Individuals (MNI). Furthermore, evidence of a shift in ecological systems over time, indicated by the distribution of faunal remains in each layer, partially suggests that turtles and softshell turtles are primarily collected from both pits. In contrast to the Neolithic Period, monitor lizards appear in greater quantities in the Metal Period layer, suggesting that habitats are changing, possibly influenced by human resource selections across various periods.

However, further research is necessary to cover current gaps in knowledge. The goal of the statistical analysis of the percentages of completeness is to enhance comprehension of Taphonomic processes. Furthermore, the aim of classifying skeletal remains by size class is to shed light on hunting practices and the resource utilization of humans at the archeological site, particularly in cases where only skeletal components exist. These results can then be compared with TP1 data to acquire a deeper comprehension of how space functions in both test pits. Moreover, this study also focuses on large-sized mammals such as Bovidae and Cervidae, which have not yet been thoroughly studied due to the limited availability of comparative visual collections. As a result, the taxonomic criteria for distinguishing Bovidae divided into bubalis, Bos javanicus, Bos gaurus, and Budorcas taxicolor (Takin), will be addressed, especially as they are often confused with Cervus unicolor (*see* Chantasri 2024). This study aims to fill some information about taxonomic and ecological gaps as these species are uncovered in several sites in southern Thailand, including Moh Kiew site in Krabi province (Auetrakulvit 2004).

Khao Ta Plai rockshelter is a relatively important site that revealed evidence of human occupation during the late Pleistocene to the Holocene. According to previous studies, they highlight a diversity of natural resources, including terrestrial and aquatic animals, which those used by humans. These results provide further comprehension of human subsistence strategies and past environmental conditions. Notably, reptiles, especially turtles, tend to have a higher quantity than mammal remains, which is unique compared to other contemporaneous sites. As a result, further investigation is needed to clarify these patterns and to deepen our understanding of human subsistence and cultural development at Hoabinhian sites on the Thai Peninsula.

2.2 Methods

2.2.1. Taxonomic Identifications

The anatomical nomenclature used to described the anatomical elements is derived from that of Barone (1999). As no collection of modern bones collection was available in Thailand, bone taxonomic identification is based on morphological comparison by using a simple visual comparative approach with modern specimens. To do so, I mostly used a library of bone 3D models built on the specimens curated in the Comparative Anatomy collection of the Muséum national d'Histoire naturelle (MNHN-ZA-AC). This library is currently being built in the framework of several projects conducted at the University of Montpellier and will be made freely available online upon its completion. Published drawing, descriptions, and characters were also considered (Schmidt 1972; Pales & Gracia 1981; Hilson 2005; Suraprasit *et al.* 2021). Measurements taken on mammal bones and teeth follow the standards outlined by von den Driesch (1976), while those of Varanidae and Testudines were from Bochaton *et al.* (2019, 2023). Bovidae and Cervidae were differentiated based on a set of published morphological criteria (Suraprasit *et al.* 2016; Fostowicz-Frelik *et al.* 2018a; Wang *et al.* 2020; Zhang *et al.* 2022; Chantasri 2024). Therefore, due to some bones and teeth that were combined into the same categories will be cross-checked with those from (Suraprasit *et al.* 2021) and (von den Driesch 1976; Bochaton *et al.* 2019, 2023; Seesod 2024).

Bones from which it was possible to assess the taxonomic order and the represented body part, but not least the taxonomic family, were categorized according to three body size groups: 1) large-sized vertebrates, which include large members of the families Cervidae (i. e. *Cervus unicolor)*, Bovidae (i. e. *Bubalus* spp., *Bos gaurus*, and *Bos javanicus)*, and Suidae, and some carnivores (i.e., *Panthera spp*). 2) Medium-sized vertebrates, which include monkeys consist of the family Cercopithecidae (i.e. *Macaca spp.*)*,* some carnivores (i.e., Canidae and Ursidae). Due to only one *Axis spp.* that can be identified based on the tooth morphology and size, the post-cranial remains from this group are also present. For those that can be classified as Tragulidae, *Muntiacus spp*., small monkeys (i.e., *Presbytis spp.*, *and Hylobates sp.*), small carnivores such as Viverridae and Herpestidae, and Microfauna consists of Rodentia, Insectivora, Chiroptera, and Reptilia, will be categorized as small-sized vertebrates. Because of the high frequency of fragmented long bones in the studied assemblage, the considered size class allowed to better assess the composition of the faunal sample in greater detail than using a single category such as "unidentified vertebrate".

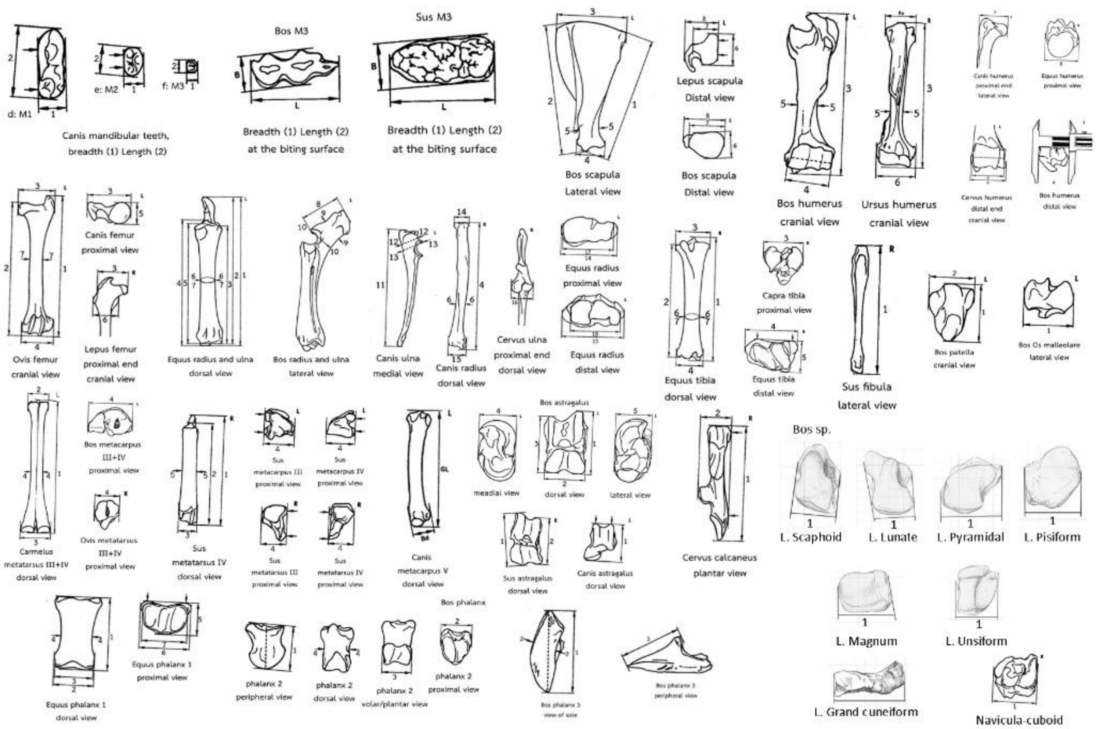


Figure 21 Measurements used in the retained equations of mammals (after von den Driesch 1976)

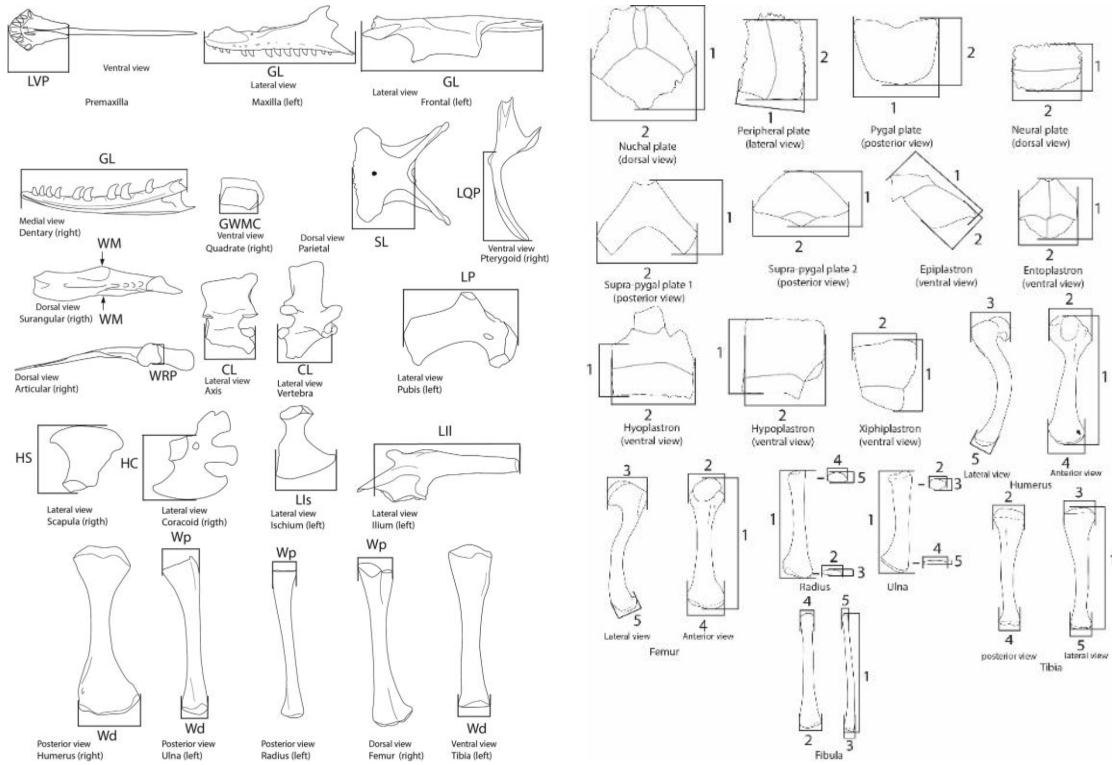


Figure 22 Measurements used in the retained equations of Varanidae (left) and Testudines (right) (Bochaton *et al.* 2019, 2023)

Due to teeth are the best-preserved elements and provide the most reliable basis for taxonomic identification in genera and species, while only a few postcranial epiphyses could have been identified in generic rank. Otherwise, they could only be categorized by size variation. Additionally, due to a lack of anatomical references for carnivores and small vertebrates for most taxonomic groups. The available references for Rodentia allowing for the identification of taxa such as Squiridae, Rhizomyinae, Hystricidae, and Muridae only consider dental morphology and postcranial remains where only classified based on their size.

2.2.2 Quantification Methods

To explain the assemblage that is being analyzed, quantification approaches are essential. So far, numerous quantification approaches have been developed, and each of them has its advantages and disadvantages depending on the goals of each zooarchaeological study. For the study of the faunal bone assemblage from Khao Ta Plai, I choose to consider the quantification units that are the most frequently used in the regional studies.

Estimating Taxonomic Abundances is the primary objective of faunal analysis of material from an archaeological site. It is essential to determine the relative frequency of animals represented in the assemblages of bones recovered from the site. To do so, most studies consider two quantitative units: NISP and MNI (Lyman 2008; Reitz & Wing 2008)

The number of identified specimens (NISP) is the most fundamental unit by which the estimation of the relative frequency of taxa, covering skeletal elements and the taxonomic order, family, genus, or species represented by the specimen (Lyman 2008). However, these estimation approaches have been criticized by some scholars as the skeletal elements might be interdependent and could be from a single individual. As a result, this method could be interpreted by assuming that interdependence is randomly distributed in all taxa in all assemblages (Grayson, 1979 in Lyman 2008) or by using another unit of taxonomic abundance: the Minimum Number of Individuals (MNI).

The Minimum Number of Individuals (MNI) is defined as the smallest number of individuals that is necessary to account for all of the skeletal elements (specimens) of a particular species found in the site (Shotwell 1955, 1958 in Lyman 2008). It is related to the number and identifiability of elements in each animal, site formation processes, recovery techniques, and laboratory procedures (Lyman 2008). However, the MNI also has the problem of the aggregation of sedimentary units, as it can complicate the computation. To solve the problem, it is necessary to be careful definition of aggregates to minimize the sharing of bones from the same individual (Lyman, 1994; 2008; O'Connor, 2000; Grayson, 1979; 1984; Ringrose, 1993).

Furthermore, this study also uses the estimation of the MNE, or *the minimum number of a particular skeletal element* or portion of a taxon. It has been calculated for each anatomical part to assess differences in skeletal element representation across various archaeological contexts. This step involves adding the PCs of a given element and then dividing the result by 100. The results were rounded up to the nearest higher whole number to obtain the MNEs. The anatomical distributions are represented by the Percentage of Representation (PR) of Dodson & Wexlar (1979) using the MNE of each anatomical element and the MNI of the considered assemblage.

To interpret the quantification data, statistical methods will be applied by using the Chi² tests were performed on the Microsoft Excel software 2007 version, and other tests with the basic library Stats of the open-source software R (R Core Team, 2020).

2.2.3 Quantification of fragmentation and surface taphonomic alterations

The reference data of the Taphonomic analysis in this study is derived from Fernández-Jalvo & Andrews (2016). Most of the assemblages recovered from this site are fragmented. For preliminary analysis, taphonomic traces on these bones are categorized into those resulting from human activities, such as burning (in different stages of fire), cut marks, and percussion, and natural processes, which are particularly concretion, followed by weathering and abrasion caused by water effects, and root etching, including bioturbations. Evidence of bioturbations includes porcupine gnawing marks and the presence of holes likely caused by insects, e.g., wasps, ants, or termites.

2.24 Age at Death and Biometry

The age at death of the archaeological individuals was estimated for large mammals (i.e., *Bos sp.*, *Bos javanicus*, *Bos gaurus*, *Bubalus sp.*, and *Cervus unicolor*) based on the postcranial elements' epiphyseal stages and on the dental eruption stages. Although there are references related to the analysis of teeth ((Wattanapituksakul 2006a; b; Suraprasit *et al.* 2021). In Thailand, none of them provides deeply information on the eruption or wear stages of teeth for specimens in Southeast Asia. As appropriate references were not available for the wild mammals of continental Southeast Asia, we adopted the method proposed by Chaplin (1971). Age classes were determined by calculating the percentages of fused and unfused specimens in each age group.

To estimate the mortality profiles of tortoises and monitor lizards, as teeth and epiphyseal stages are not informative for these taxa, we considered the size of the archaeological individuals based on previously established protocols (Bochaton *et al.* 2019, 2023, 2025). The age at death and biometry of taxa (other reptiles, birds, amphibians, and small mammals) that do not represent a significant part of the assemblage were not considered.

3

Results

The animal bone assemblage from the second excavation of the Khao Ta Plai rockshelter consists of 8,552 bone remains, weighing a total of 23,080 grams, and representing at least 110 individuals. Among these bone remains, 2,144 specimens (25% of the full assemblage) could not be attributed to a taxonomic group. The majority of the bone remains were attributed to mammals, accounting for 49% of the Identified Specimens (NISP), followed by non-marine turtle remains for 19%, and monitor lizards for 5.1%. Birds and fish are also found but were very rare (0.4% and 0.04% of the NISP).

Table 2 Number of Identified Specimens (NISP) and Weight of the remains (WR) identified of faunal remains of the different layers of the second excavation of Khao Ta Plai.

	Layer 1/2		**Layer 3**		**Layer 4**		**Total**	
	NISP	**WR**	**NISP**	**WR**	**NISP**	**WR**	**NISP**	**WR**
Bovidae	164	1800.3	54	518.7	61	970	**279**	**3289.0**
Cervidae	185	765.0	82	425.8	102	909.9	**369**	**2100.6**
Tragulidae	2	2.2	0	0	2	3.6	**4**	**5.8**
Artiodactyla ind.	56	167.2	23	72.2	13	63.5	**92**	**303.0**
Sus scrofa	54	217.94	22	76.7	9	33.9	**85**	**328.5**
Rhinocerotidae	1	5.4	0	0	1	9.6	**2**	**15.0**
Primates	20	28.4	24	48.8	13	41.9	**57**	**119.1**
Carnivores	11	16.9	8	17.8	12	22.5	**31**	**57.3**
Chiroptera	1	0.1	0	0	0	0	**1**	**0.1**
Rodentia	49	47.4	10	15.0	23	64.6	**82**	**127.0**
Anura	5	0.7	1	0.3	1	0.43	**7**	**1.4**
Serpentes	55	71.7	13	13.5	26	54.9	**94**	**140.1**
Testudines	594	650.3	233	637.1	778	2054.8	**1605**	**3342.3**
Varanidae	182	287.3	159	187.6	94	199.5	**435**	**674.5**
Small lizard	0	0	0	0	1	0.2	**1**	**0.2**
Squamata ind.	0	0	2	2.4	0	0	**2**	**2.4**
Aves	16	15.1	6	6.3	10	13.8	**32**	**35.2**
Osteichthyes	9	4.4	3	3.0	1	1.1	**14**	**8.7**
Large mammal ind.	1021	3838.3	292	1255	304	1704.5	**1617**	**6797.4**
Medium mammal ind.	876	1286.3	329	538.4	144	306.6	**1349**	**2131.3**
Small mammal ind.	171	112.2	52	49.9	28	26.67	**251**	**188.7**
Unidentified	1131	1421.2	366	578.4	647	1435.7	**2144**	**3435.2**
Total	**4603**	**10738**	**1679**	**4446**	**2270**	**7918**	**8552**	**23102**

3.1 Taxonomical Analysis

3.1.2 Taxonomical Analysis of mammals

Regarding the identification of mammal taxa (table 3), Cervidae represents a consistently major part of the identified bone remains, ranging from 46% and 38% of NISP, 44% to 27% of WR, and 25% to 20% of MNI, depending on the layer. Followed by Bovidae, accounting for 34% to 27% of NISP, 62% to 47% of WR, and 20% to 8% of MNI. The remains of Tragulids, Rhinoceros, and Chiroptera altogether represent only 0.5% of the assemblages in terms of NISP and WR, and the distribution of these groups among the layers is homogeneous. The third most represented mammal group is suids, with *Sus scrofa* being well represented in layers 1-3, where it accounts for 11% of the NISP, 7% of the WR, and 19% of the MNI. This taxon is nearly absent in layer 4 (only 4% of the NISP, 2% of the WR, and 7% of the MNI). Monkeys are also well represented in layers 1/2 and 3, where they account for 10% of the NISP, 4% of the WR, and 20% of the MNI, then decrease in layer 4. For the carnivores, they are poorly represented general.

Mammal remains overall account for 49 % of the NISP and 67 % of the WR, making them a major component of the faunal assemblage. Among them, 11% of the NISP and 26% of the WR can be attributed to taxonomic groups. To better understand the overall body size of the animals represented, the remains were classified into three size categories: large-sized, medium-sized, and small-sized mammals (see details in Lesson 2). These sizes are important, by considering bone density and fragmentation, which can be influence interpretations of species abundance.

<u>Bovidae</u>

Regarding their taxonomic identification, most of the bone remains attributed to the Bovidae family, between 52% and 38% of the bone fragments. For those that could be identified with more precision, the *Bos* genus represents a consistent major part of them, ranging from 59% to 46% of the NISP, 66% to 54% of the WR, and 80% to 56% of the MNI, while the genus *Bubalus* represents only 4% to 2% of the NISP, 6 to 0.8% of the WR, and 40% to 11% of the MNI.

The identification of Bovidae bones was conducted based on direct comparison with pictures and 3D models of most of the Bovidae species currently occurring in Southeast Asia. In addition to these visual aids, the identification criteria based on comparative of dental and postcranial elements were applied, derived from those of (Suraprasit *et al.* 2021; Zhang *et al.* 2022; Chantasri 2024), along with size measurements from osteometric datasets and modern reference specimens derived from (Auetrakulvit 2004; Suraprasit *et al.* 2016; Seesod 2024)

Table 3 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete Bovidae assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			Layer3			Layer4			Total		
	NISP	WR	MNI	NISP	WR	MNI	NISP	WR	MNI	NISP	WR	MNI
Bos sp.	79	899.4	2	33	387.6	1	17	225.7	1	**129**	**1513**	**4**
Bos javanicus	7	88.3	1	5	50.35	2	2	31.93	1	**14**	**170.6**	**4**
Bos gaurus	8	70.9	2	2	24.37	1	10	285.9	2	**20**	**381.1**	**5**
Bubalus sp.	7	101.0	1	2	16.51	1	1	7.1	1	**10**	**124.6**	**3**
Large Bovidae ind.	62	621.1		26	214.1		31	446.1		**119**	**1281**	
Small Bovidae ind.							2	5.99		**2**	**5.99**	
Total	**163**	**1781**	**9**	**68**	**693**	**6**	**63**	**1003**	**5**	**294**	**3476**	**16**

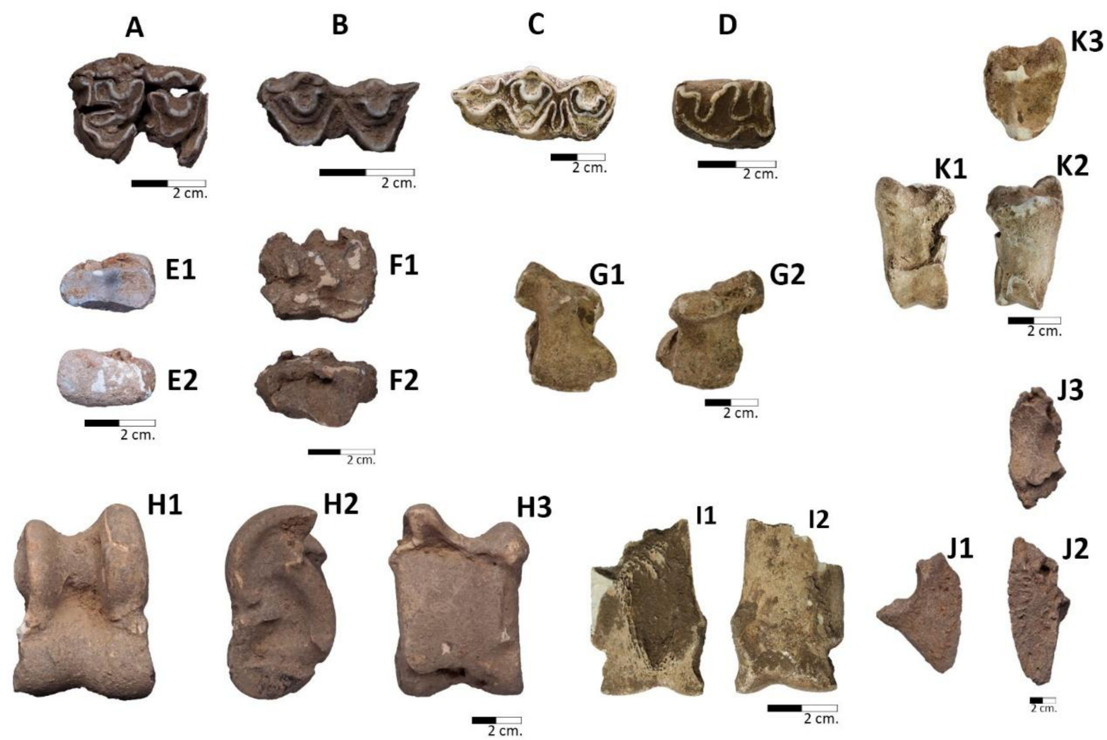


Figure 23 Examples of the studied Bovidae bone remains of Khao Ta Plai: A) Right upper 2nd molar of Bos gaurus (occlusal view); B) Left lower 2nd molar of Bos javanicus (ventral view); C) Right lower 3rd molar of Bubalus sp. (occlusal view); D) Left lower 3rd premolar of Bubalus sp. (occlusal view) **E)** Small sesamoid of Bovidae showing trace of carbonization (grey-white); E1) anterior view; E2) posterior view; **F)** Right malleolar bone of Bos gaurus with concretion; F1) medial view; F2) distal view; **G)** Left lunate bone of Bos javanicus; F1) proximal view; G2) distal view; **H)** Left astragalus of Bos gaurus with concretion; H1) dorsal view;H2) medial view; H3) plantar view; **I)** 1st phalange of Bubalus sp.; I1) palmar view; I2) dorsal view; **K)** 2nd phalange of Bos javanicus with the trace of water effect K1) palmar view; K2) dorsal view; K3) proximal view.

Cervidae

The identification of the bone remains attributed to the Cervidae family; most of them could not be identified below the family level, particularly large and medium-sized individual. The identified genera and species include *Cervus unicolor*, *Axis* sp., *Muntiacus muntjac*, and *Rucervus* sp. *Muntiacus* is the most abundant of them, representing 20% to 18% of the NISP, 13% to 11% of the WR, and 67% to 15% of the MNI, Followed by *Cervus unicolor*, representing 6% 0f the NISP, 11% of the WR, and the most least abundant are *Axis* sp. and *Rucervus* sp., representing less than 1% of the NISP and WR.

The identification of Cervidae bones was conducted based on direct comparison with pictures and 3D models of most of the Cervidae species currently occurring in Southeast Asia. In addition to these visual aids, the identification criteria based on comparative of dental and postcranial elements were applied, derived from those of (Suraprasit *et al.* 2021; Zhang *et al.* 2022; Chantasri 2024), along with size measurements from osteometric datasets and modern reference specimens derived from (Auetrakulvit 2004; Suraprasit *et al.* 2016; Seesod 2024)

Table 4 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete Cervidae assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			**Layer3**			**Layer4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Cervus unicolor	11	36.9	2	8	88.8	2	5	100	1	**24**	**225.7**	**5**
Axis sp.	2	3.0	1	0	0	0	0	0	0	**2**	**3.04**	**1**
Muntiacus muntjak	33	79.1	3	15	44.8	1	21	126	2	**69**	**249.9**	**6**
Rucervus sp.	3	10.9	1	1	14.9	1	0	0	0	**4**	**25.74**	**2**
Large Cervidae ind.	90	458		26	174		71	614.1		**187**	**1246**	
Medium Cervidae ind.	43	165.2		30	86.6		6	16.74		**79**	**268.5**	
Small Cervidae ind.	4	5.1		1	1.9		3	47.4		**8**	**54.4**	
Total	**186**	**758**	**7**	**81**	**411**	**4**	**106**	**904**	**3**	**373**	**2073**	**14**

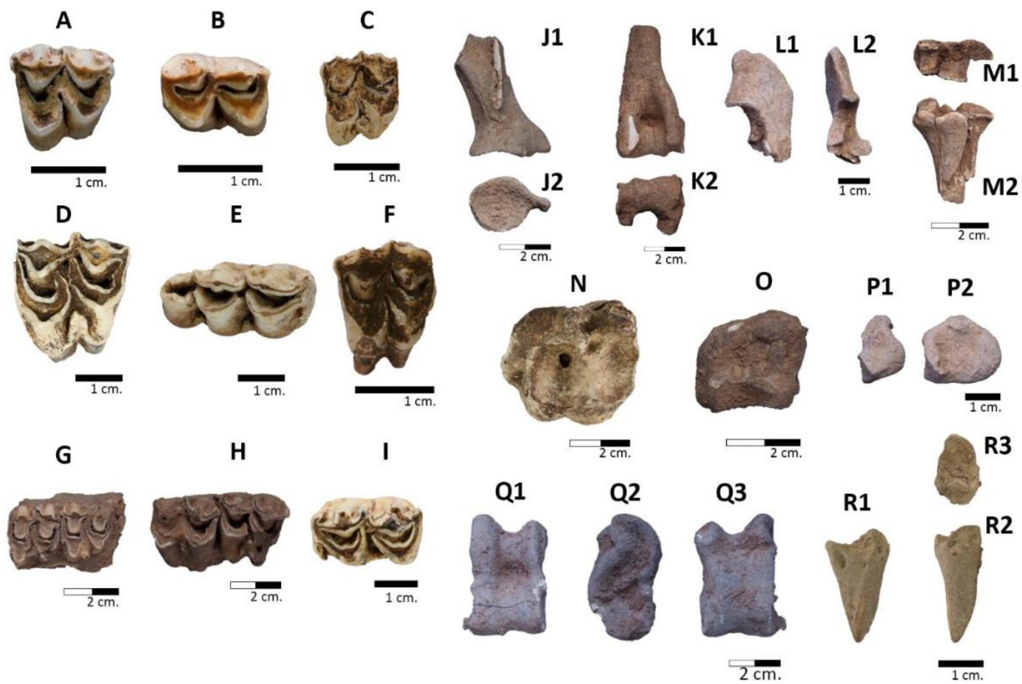


Figure 24 Examples of the studied Cervidae bone remains of Khao Ta Plai: **A)** Right upper 1st molar of Muntiacus muntjac (occlusal view); **B)** Left lower 2nd molar of Muntiacus muntjac (occlusal view); **C)** Left upper 2nd molar of Muntiacus muntjak (occlusal view) **D)** Left upper 2nd molar of Rucervus eldii (occlusal view); **E)** Right lower 3rd molar Rucervus eldii (occlusal view); **F)** Left upper 2nd molar of Axis porcinus (occlusal view); **G)** Left 3rd and 4th deciduous premolar of Cervus unicolor (occlusal view); **H)** Left upper 1st and 2nd molar of Cervus unicolor (occlusal view); **I)** Left lower 2nd molar of Cervus unicolor (occlusal view); **J)** Right scapula of Muntiacus muntjac; J1) lateral view; J2) ventral view; **K)** Right humerus of Muntiacus muntjac; K1) anterior view; K2) distal view; **L)** Left ulna of Muntiacus muntjac; L1) lateral view; L2) dorsal view; **M)** Right radius of Muntiacus muntjac with concretion; M1) proximal view; M2) anterior view; **N)** Right cubo-navicular bone of Cervus unicolor (ventral view); **O)** Right magnum bone of Cervidae with concretion (proximal view); **P)** Left Pisiform of Cervidae with concretion; P1) anterior view; P2) medial view; **Q)** Right astragalus of Muntiacus muntjac with concretion; Q1) dorsal view; Q2) lateral view; Q3) plantar view **R)** 3rd phalange of Cervidae; R1) abaxial view; R2) palmar view; R3) proximal view.

Suidae

Identification of pig family bone remains corresponds to *Sus scrofa*, ranking from 64% to 10% of the NISP, 66% to 10% of the WR, and 50% to 17% of the MNI.

The identification of Suidae bones was conducted based on direct comparison with pictures and 3D models of the Suidae species that currently occur in Southeast Asia. So far, the identification criteria are particularly based on the comparison of dental, derived from those of (Suraprasit *et al.* 2021), along with the comparison of postcranial reference specimens derived from (Suraprasit *et al.* 2016)

Table 5 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete Suidae assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			Layer3			Layer4			Total		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Sus scrofa	54	217.94	3	22	76.7	2	9	33.9	1	85	328.5	6
Total	54	217.94	3	22	76.7	2	9	33.9	1	85	328.5	6

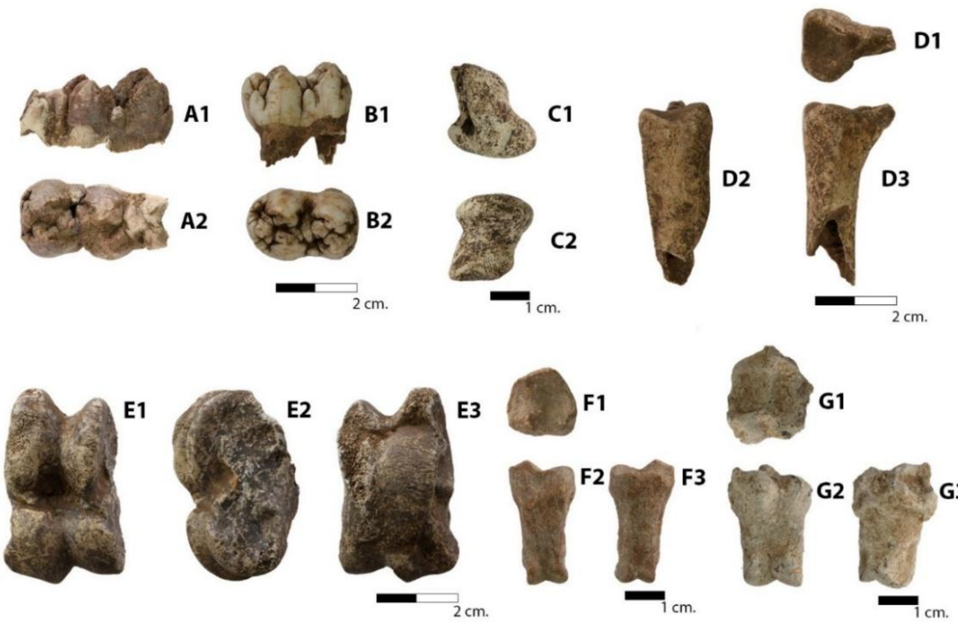


Figure 25 Examples of the studied Sus scrofa bone remains of Khao Ta Plai: **A)** Left lower 3rd molar; A1) lateral view; A2) ventral view; **B)** Left lower 1st molar; B1) lateral view; B2) ventral view; **C)** Left lunate showing water effect trace on surface; C1) proximal view; C2) distal view; **D)** Left 3rd Metatarsus; D1) proximal view; D2) dorsal view; D3) medial view **E)** Left Astragalus (broken In si tu); E1) dorsal view; E2) medial view; E3) plantar view; **F)** Right 5th proximal phalange; ; F1) proximal view; F2) palmar view; F3) dorsal view; **G)** Left 3rd middle phalange showing pathological trace; G1) proximal view; G2) palmar view; G3) dorsal view.

<u>Monkey</u>

The identification of the bone remains attributed to the Cercopithecidae family mostly corresponds to *Presbytis sp.* (33% of NISP and 42% of WR). Among the identified carnivore taxa, they were recognized in several families and genera: *Presbytis sp., Presbytis obscurus*, *Macaca sp.*, *Macaca namestrina*, *Hylobates sp*. Otherwise, some remains can be attributed to unidentified Cercopithecidae. Although monkeys are low in abundance makes it difficult to conclude their distribution across layers.

Regarding the lack of 3D models of monkeys, so far, the identification of monkey bones has been conducted based on direct comparison with pictures of dental references, derived from those of (Suraprasit *et al.* 2021), along with the comparison of postcranial modern reference specimens derived from (Auetrakulvit 2004)

Table 6 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete Cercopithecidae assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			**Layer3**			**Layer4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Presbytis sp.	5	12.14	1	7	12.21	2	5	22.42	1	**17**	**46.77**	**4**
Presbytis obscurus	0	0	0	2	2.19	1	0	0	0	**2**	**2.19**	**1**
Macaca sp.	5	9.33	1	6	22.83	1	2	3.63	1	**13**	**35.79**	**3**
Macaca namestrina	4	1.56	1	0	0	0	0	0	0	**4**	**1.56**	**1**
Hylobate sp.	1	0.59	1	0	0	0	1	5.76	1	**2**	**6.35**	**2**
Cercopithecidae	5	4.76		7	7.81		2	5.71		**14**	**18.28**	
Total	**20**	**28.38**	**4**	**22**	**45.04**	**4**	**10**	**37.52**	**3**	**52**	**110.9**	**11**

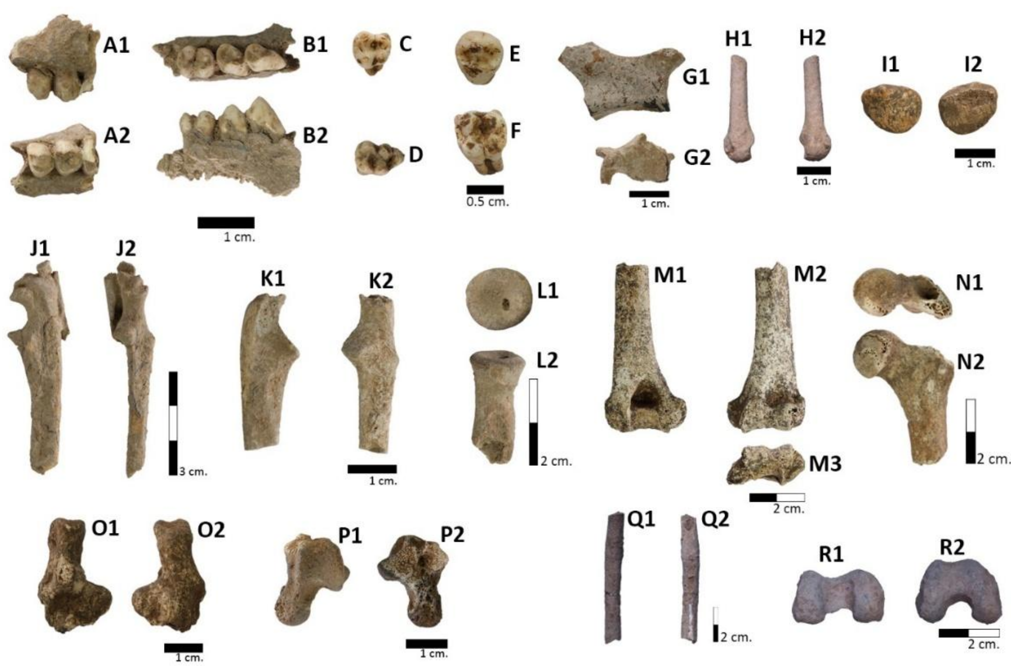


Figure 26 Examples of the studied monkey bone remains of Khao Ta Plai: **A)** Right upper 3rd and 4th premolar of Presbytis obscurus; A1) lateral view; A2) ventral view; **B)** Left lower 3rd and 4th premolar and 1st molar of Presbytis obscurus; B1) lateral view; B2) ventral view; **C)** Left lower 1st molar of Presbytis obscurus (ventral view); **D)** Left lower 3rd molar of Presbytis obscurus (ventral view; **E)** Left upper 3rd premolar of Macaca nemestrina (ventral view); **F)** Right upper 2nd molar of Macaca namestrina (ventral view); **G)** Left scapula of Presbytis sp. showing carbonization trace (black) and concretion; G1) medial view; G2) ventral view; **H)** Left 5th metatarsus of Cercopithecidae H1) dorsal view

H2) plantar view; **I)** Patella of Cercopithecidae; I1) anterior view; I2) posterior view; **J)** Left ulna of Macaca sp.; J1) lateral view; J2) dorsal view; **K)** Left ulna of Presbytis sp.; K1) medial view; K2) dorsal view; **L)** Left radius of Macaca sp.; L1) posterior view; L2) ventral view; **M)** Left humerus of Presbytis sp.; M1) anterior view; M2) posterior view; M3) distal view; **N)** Right femur of Macaca sp.; N1) proximal view; N2) anterior view; **O)** Right calcaneus of Macaca sp.; O1)medial view; O2) lateral view; **P)** Left talus of Presbytis sp. showing carbonization trace (black); P1) dorsal view; P2) plantar view; **Q)** Left radius of Hylobates sp. showing trace of concretion; Q1) anterior view; Q2) posterior view; **R)** Left femur of Macaca sp. (juvenile); R1) anterior view; R2) posterior view.

Carnivores

The identification of the bone remains attributed to the Carnivore family mostly corresponds to Viverridae (33% of NISP and 33% of WR). Among the identified carnivore taxa, they were recognized in several families and genera: Herpestidae, Viveridae, and Mustelidae. Otherwise, some remains can be attributed to unidentified carnivores, which range from large to small-sized. Although carnivore taxa are low in abundance makes it difficult to conclude their distribution across layers.

Due to the lack of pictures and 3D models of carnivores that currently occur in Southeast Asia. So far, the identification of carnivore bones has been conducted based on direct comparison with pictures of dental and postcranial references, derived from those of Auetrakulvit (2004)

Table 7 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete Carnivore assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			**Layer3**			**Layer4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Herpestidae	1	3.4	1	0	0	0	4	4.9	2	5	8.3	3
Mustelidae	1	2.6	1	2	5.4	1	2	8.2	1	5	16.2	3
Viverridae	0	0	0	5	8.9	2	4	9.5	1	9	18.4	3
Large carnivore ind.	1	1.9	1	0	0	0	0	0	0	1	1.9	1
Medium carnivore ind.	1	0.8	1	0	0	0	0	0	0	1	0.8	1
Small carnivore ind.	4	4.5	1	0	0	0	2	5.3	1	6	9.8	2
Total	**8**	**13.18**	**5**	**7**	**14.28**	**3**	**12**	**27.87**	**5**	**27**	**55.33**	**13**

Figure 27 Examples of the studied carnivore bone remains of Khao Ta Plai: unidentified carnivore (A-C), Mustelidae (D), Large-sized carnivore (E), and Viverridae (F-G) A) Left mandible; A1) ventral view; A2) lateral view; **B)** Right humerus with burning trace and concretion; B1) anterior view; B2) posterior view; B3) distal view; **C)** Right ulna; C1) lateral view; C2) anterior view; **D)** Left 5th metacarpus with concretion; D1) palmar view; D2) dorsal view; D3) proximal view; **E)** metapodial with trace of carbonization (grey) and concretion; E1) ventral view; E2) lateral view; **F)** Left humerus with concretion; F1) anterior view; F2) posterior view; F3) distal view; **G)** Right ulna with concretion; G1) anterior view; G2) distal view.

Rodentia

Identification of rodent family bone remains. The majority of these bones correspond to unidentified specimens (65% of NISP and 39% of WR). Among the identified rodent taxa, they were recognized in several families and genera: Sciuridae; some specimens were identified as *Ratufa indica*. Muridae, including general *Rattus* species, with some bones further identified as *Rattus surifer*. *The* Hystricidae includes specimens identified as *Hystrix brachyura*. Otherwise, some remains could be attributed to *Rhyzomyinae*. With these identified taxa, Muridae is the most abundant of bone remains, representing 38% to 9% of the NISP, 62% to 2% of the WR, and 33% to 20% of the MNI. Although individual rodent taxa are low in abundance in some layers makes it difficult to conclude their distribution across layers. However, the presence of unidentified Rodentia and Muridae remains could indicate that rodents were consistently present in the first layer, and they remain appear until the last layer.

Due to the identification process remains limited as the lack of available pictures and 3D models of rodents. Currently, comparative of dental references from Southeast

Asia species is being by Dr. Julien Claude, thanks to his assistance in the preliminary identification of dental elements. For postcranial elements, they are only based on direct comparison with pictures, along with the criteria identification of some postcranial part derived from those of (Auetrakulvit 2004; Fostowicz-Frelik *et al.* 2018b)

Table 8 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete rodents' assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			**Layer3**			**Layer4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Sciuridae	2	2.7	1	3	5.2	1	0	0	0	**5**	**7.9**	**2**
Ratufa indica	0	0	0	0	0	0	2	2.26	1	**2**	**2.3**	**1**
Muridae	4	0.7	1	3	0.8	1	6	36.6	2	**13**	**38.1**	**4**
Rattus surifer	2	0.6	1	0	0	0	0	0	0	**2**	**0.6**	**1**
Hystricidae	0	0	0	0	0	0	0	0	0	**0**	**0.0**	**0**
Hystrix brachyura	1	6.2	1	0	0	0	0	0	0	**1**	**6.2**	**1**
Rhyzomyinae	0	0	0	0	0	0	4	9.3	2	**4**	**9.3**	**2**
Rodent ind.	38	28.1		2	2.23		9	11.0		**49**	**41.3**	
Total	**47**	**38.34**	**4**	**8**	**8.19**	**2**	**21**	**59.14**	**5**	**76**	**105.7**	**11**

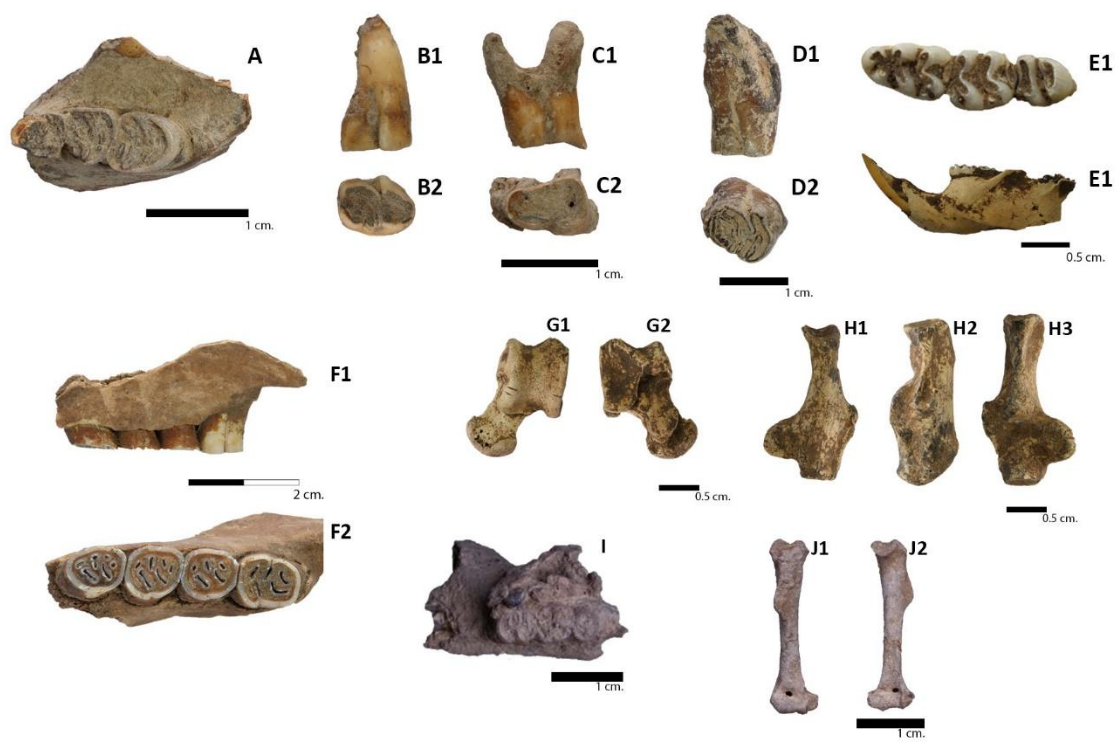


Figure 28 Examples of the studied Rodentia bone remains of Khao Ta Plai: A) Left maxilla-teeth of Hystricidae (ventral view); **B)** Molar of Hystricidae; B1) lateral view; B2) ventral view; **C)** Molar of Hystricidae C1) lateral view; C2) ventral view; **D)** Left 2[nd] molar of Hystricidae showing burning trace with concretion; D1) lateral view; D2) ventral

view; **E)** Left Mandible-teeth of Rattus surifer; E1) ventral view; E2) lateral view; **F)** Left maxilla-teeth of Hystrix brachyura; F1) lateral view; F2) ventral view; **G)** Left talus of Ratufa indica; G1) dorsal view; G2) plantar view; **H)** Right calcaneus of Sciuridae; H1) plantar view; H2) lateral view; H3) dorsal view; **I)** Right maxilla-teeth of Rhizomyinae with concretion (ventral view); **J)** Left humerus of Muridae; J1) anterior view; J2) posterior view.

3.1.2 Taxonomical Analysis of Herpetofauna

A total of 2,135 herpetofauna bone remains, weighing 4,133 grams. The complete assemblage includes bone fragments from at least 97 individuals. The majority of the Herpetofauna sample consists of non-marine turtle remains (75% of the NISP, 81% of the WR, and 64% of the MNI), followed by monitor lizards, which account for 20% of the NISP, 16% of the WR, and 22% of the MNI. Following the table [x], indicating that Turtles show a high quantity across layers. Meanwhile, snakes are well-represented in layers 1/2 and layer 4, but are rare in layer 3. In comparison, monitor lizards are better represented in layer 1/2, but gradually decrease in layers 3 and 4. A rare amphibian is represented in the assemblages, accounting for 0.3% of the NISP, 0.03% of the WR, and 3% of the MNI.

Table 9 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete turtles/tortoises' assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer 1/2			**Layer 3**			**Layer 4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Turtle/Tortoise	587	881.1	23	234	381	13	783	2070	26	**1604**	**3332**	**62**
Monitor lizard	183	287.3	9	159	188	6	94	199.5	6	**436**	**674.4**	**21**
Snake	55	71.68	4	13	13.2	3	20	40.53	4	**88**	**125.4**	**11**
Amphibian	5	0.7	1	1	0.3	1	1	0.43	1	**7**	**1.4**	**3**
Total	**830**	**1241**	**37**	**407**	**582**	**23**	**898**	**2310**	**37**	**2135**	**4133**	**97**

<u>Turtle</u>

The bones attributed to turtles and tortoises, a significant portion, 64% (46% of the WR), could not be identified to the family level. Among these fragments' bones, the family Geoemydidae was assigned for 5% (6% of the WR and 10% of the MNI). The majority of species were attributed to *Indotestudo elongata* (40% of the WR and 50% of the MNI), while *Heosemys grandis* is the least represented (only 0.3% of the NISP, 3% of the WR, and 3% of the MNI). The third most represented species with the percentage of the NISP less than 1 belonged to *Heosemys* sp., *Cyclemys* sp., *Cuora amboinensis,* and *Cuora* sp., respectively. The family of Trionychidae only presents a small percentage (less than 1%). This family can be attributed to *Amyda* sp. (0.7% of the NISP, 0.2% of the WR, and 3.2% of the MNI).

The identification of turtle bones was conducted based on direct comparison with pictures and 3D models of the turtle species that currently occur in Southeast Asia. The identification criteria are derived from those of (Pritchard *et al.* 2019), along with cross-checking against reference data that was conducted by Dr. Bochaton (see Mithong 2014; Bochaton *et al.* 2025).

Table 10 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete turtles/tortoises' assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			**Layer3**			**Layer4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Indotestudo elongata	142	331.1	10	51	131.6	5	220	855.8	16	**413**	**1319**	**31**
Geoemydidae	42	79.17	3	11	17.23	1	33	92.79	2	**86**	**189.2**	**6**
Heosemys sp.	3	8.88	1	2	9.61	1	17	88.39	1	**22**	**106.9**	**3**
Heosemys grandis.	0	0	0	1	5.2	1	4	20.94	1	**5**	**26.14**	**2**
Cyclemys sp.	7	15.33	1	0	0	0	12	48.67	1	**19**	**64**	**2**
Cuora sp.	3	5.12	1	6	10.08	2	1	1.73	1	**10**	**16.93**	**4**
Cuora amboinensis	6	12.19	1	3	5.82	1	6	15.6	1	**15**	**33.61**	**3**
Trionychidae	5	8.73	1	0	0	0	2	17.7	1	**7**	**26.43**	**2**
Amyda sp.	5	5.9	1	2	2.15	1	0	0	0	**7**	**8.05**	**2**
Turtle ind.	374	414.68		158	199		488	928.3		**1020**	**1542**	
Total	**587**	**881.1**	**20**	**234**	**380.7**	**12**	**783**	**2070**	**24**	**1604**	**3332**	**55**

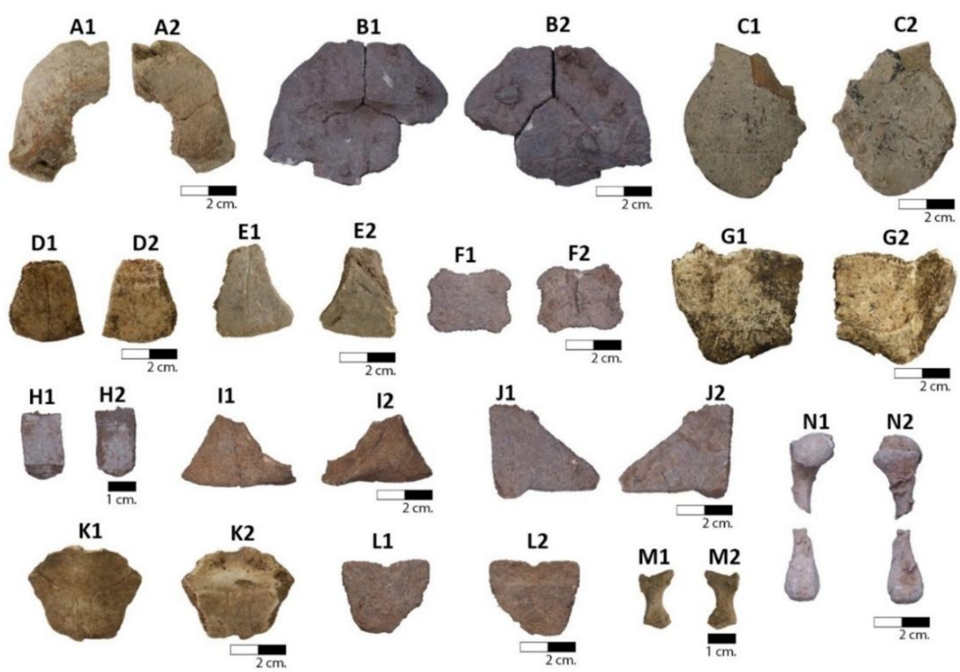


Figure 29 Examples of the studied *Indotestudo elongata* bone remains of Khao Ta Plai: **A)** Left Epiplastron and Hyoplastron in anatomical connection; A1) dorsal view; A2)

ventral view; **B)** Left-Right Epiplastron, and Entoplastron in anatomical connection; B1) dorsal view; B2) ventral view; **C)** Left hypoplastron showing burning trace (black), concretion, and breakage on fresh bone; C1) ventral view; C2) dorsal view; **D)** Left 1st Peripheral plate; D1) lateral view; D2) medial view; **E)** Right 2nd Peripheral plate; E1) lateral view; E2) medial view; **F)** 4th neural plate showing trace of concretion; F1) dorsal view; F2) ventral view; **G)** Right Xiphiplastron; G1) ventral view; G2) dorsal view; **H)** Right 4th or 6th peripheral plate; H1) lateral view; H2) medial view; **I)** Right 8th and 9th Peripheral plates in anatomical connection; I1) lateral view; I2) medial view; **J)** Left 11th Peripheral plate; J1) lateral view; J2) medial view; **K)** Nuchal plate**;** K1) posterior view; K2) anterior view; **L)** Pygal plate showing trace of concretion; L1) posterior view; L2) anterior view; **M)** Right pubis showing trace of concretion; M1) anterior view; M2) posterior view **N)** Left femur showing trace of concretion N1) dorsal view; N2) ventral view.

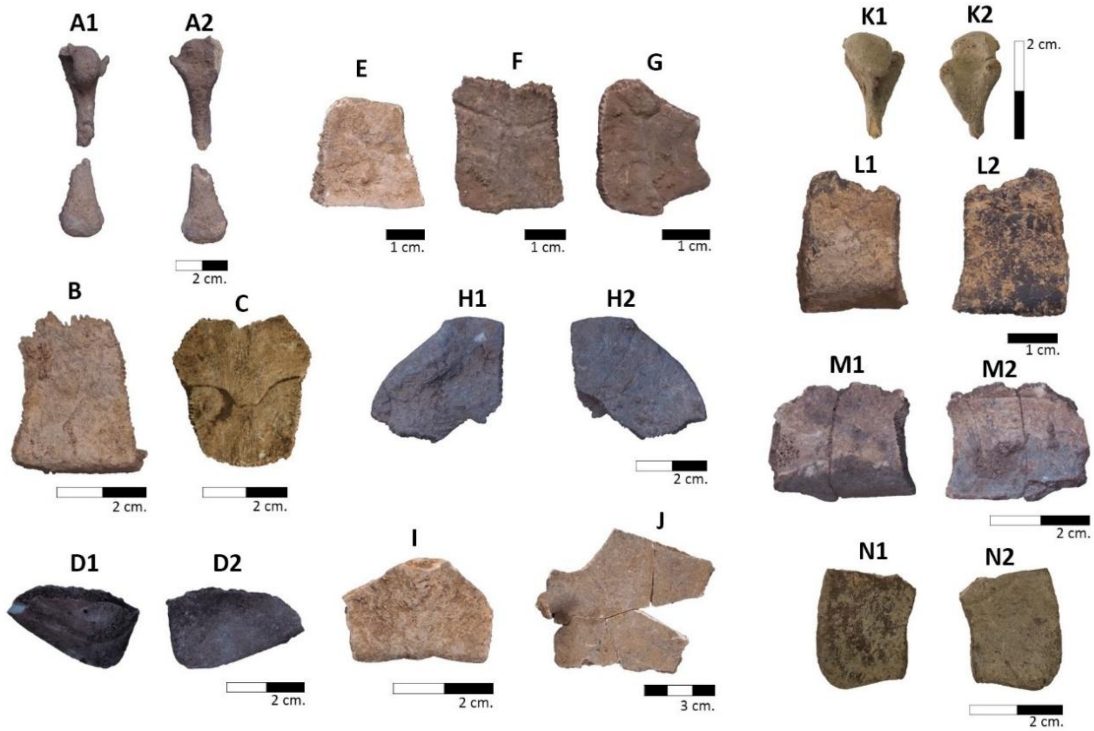


Figure 30 Examples of the studied Geoemydidae (A-D), *Cyclemys* sp. (E-J), and *Cuora* sp. (K-N) bone remains of Khao Ta Plai: **A)** Right humerus with concretion; A1) dorsal view; A2) ventral view; **B)** Bridge of Peripheral plate with concretion (lateral view); **C)** Neural plate (dorsal view); **D)** Left Xiphiplastron; D1) dorsal view; D2) ventral view; **E)** Right 3rd Peripheral plate (lateral view); **F)** Unidentified Peripheral plate with concretion (lateral view); **G)** Left 11th Peripheral plate with concretion (lateral view); **H)** Left Epiplastron with concretion; H1) dorsal view; H2) ventral view; **I)** Nuchal plate with concretion (dorsal view); **J)** Left Hypoplastron with concretion (dorsal view) **K)** Left femur with concretion**;** K1) dorsal view; K2) ventral view; **L)** Unidentified Peripheral plate showing burning trace (black) and concretion; L1) medial view; L2) lateral view; **M)** Unidentified Peripheral plate with concretion in anatomical connection; M1) medial

view; M2) lateral view **N)** Left Xiphiplastron with concretion; N1) dorsal view; N2) ventral view.

Figure 31 Examples of the studied *Heosemys* sp. (A-F) and *Heosemys grandis* (G-K) bone remains of Khao Ta Plai: **A)** Peripheral plate with concretion; A1) lateral view; A2) medial view; **B)** Left 11th Peripheral plate with concretion; B1) lateral view; B2) medial view; **C)** Right 3rd Peripheral plate with concretion; C1) lateral view; C2) medial view; **D)** Supra-pygal 2 with concretion; D1) posterior view; D2) anterior view; **E)** Neural plate; E1) dorsal view; E2) ventral view; **F)** Supra-pygal with concretion; F1) posterior view; F2) anterior view; **G)** Left 3rd Peripheral plate with concretion; G1) lateral view; G2) medial view; **H)** Left 1st Peripheral plate; H1) lateral view; H2) medial view; **I)** Bridge of Peripheral plate with connection; I1) lateral view; I2) medial view; **J)** Supra-pygal 2 with concretion; J1) posterior view; J2) anterior view; **K)** Left Hypoplastron and Xiphiplastron in anatomical connection**;** K1) dorsal view; K2) ventral view.

Figure 32 Examples of the studied Trionychidae (A-B) and *Amyda* sp. (C-E) bone remains of Khao Ta Plai: A) Femur; A1) dorsal view; A2) posterior view; B1-B2) Ischium with concretion; C) Costal plate showing trace of carbonization (black and white); C1) lateral view; C2) medial view; **D-E)** Costal plate.

Varanus

In terms of the bones identified at the family level of the Monitor lizard, 99% were attributed to *Varanus sp.* (99.7% of the WR and 95% of the MNI). These remains represent statistically significant differences across layers; they are abundant in the first two layers and decrease in layer 4.

The identification of *Varanus* bones was conducted based on direct comparison with pictures and 3D models of the turtle species that currently occur in Southeast Asia, along with the identification criteria derived from those of (Bochaton *et al.* 2017, 2019).

Table 11 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete Varanus assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			**Layer3**			**Layer4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Varanus sp.	183	287.3	9	159	187.6	6	93	198.2	6	435	673.1	21
Total	**183**	**287.31**	**9**	**159**	**187.6**	**6**	**94**	**199.5**	**7**	**436**	**674.5**	**22**

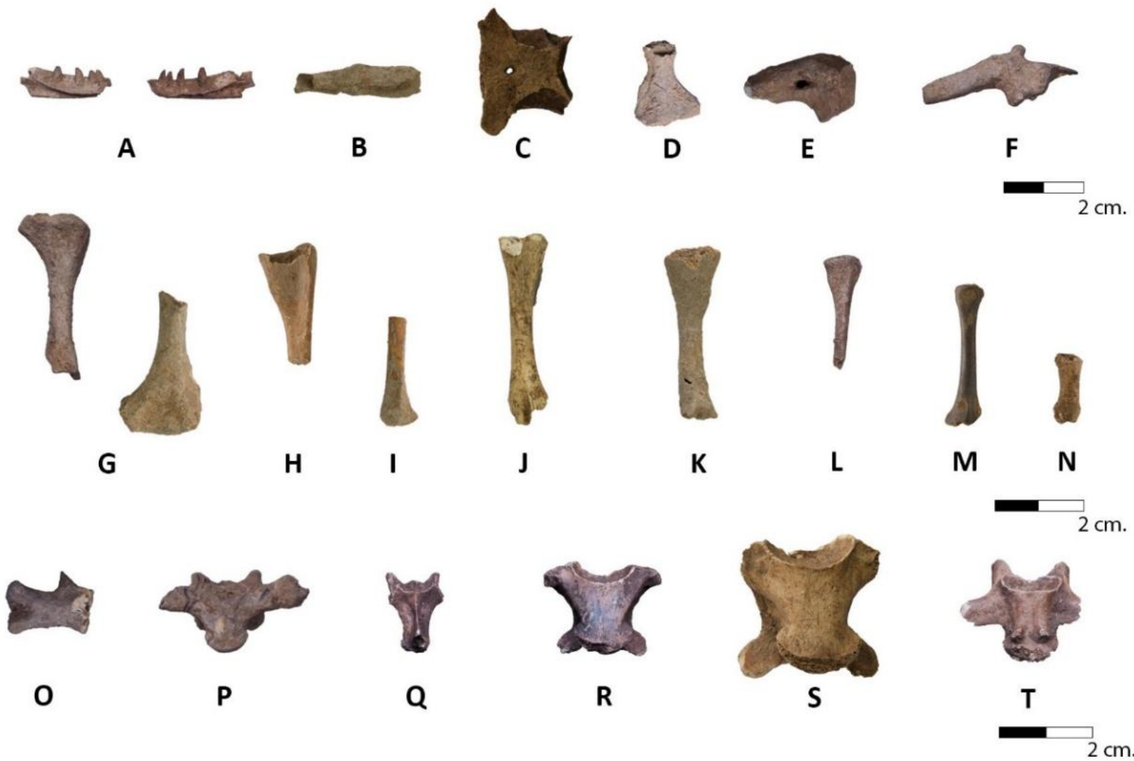


Figure 33 Examples of the studied monitor lizard bone remains of Khao Ta Plai: A) (Left-Right) Dentary (medial view); B) Left Surangular (dorsal view); C) Parietal (dorsal view); D) Left Ischium (lateral view); E) Left Pubis (lateral view); F) Right Ilium (lateral view); G) Left Humerus (posterior view); H) Left Ulna (posterior view); I) Right Radius (posterior view); J) Left Femur (posterior view); K) Left Tibia (posterior view); L) Fibula (posterior view); Metapodial (posterior view); N) Phalange (posterior view); O) Sacral vertebrae 1 (cranial view); P) Sacral vertebrae 2 (ventral view); Q) Cervical vertebrae (ventral view); R) Trunk vertebrae showing burning trace on surface (ventral view); S) Trunk vertebrae of large-sized individual (ventral view); T) Caudal vertebrae (ventral view).

Varanus bengalensis

Apart from the bones identified at the family level of the Monitor lizard, there is only 0.2% of the remains were attributed to the specific family of *Varanus bengalensis* (0.2% of the WR and 5% of the MNI).

Table 12 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete Varanus bengalensis assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			Layer3			Layer4			Total		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Varanus bengalensis	0	0	0	0	0	0	1	1.39	1	1	1.39	1
Total	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1.39**	**1**	**1**	**1.39**	**1**

Figure 34 Examples of the studied *Varanus bengalensis* bone remains of Khao Ta Plai: Left scapula

<u>*Snakes*</u>

Snake bone remains that could not be identified to a specific family level account for 13% of the NISP (8% of the WR). It is worth noting that they can be identified from all of their vertebrae due to their preservation. Among those remains that were identified at least at a family level, the king cobra (*Ophiophagus hannah*) is the most representative (31% of the NISP, 27% of the WR, and 27% of the MNI). Followed by the *Python sp.* and Colubridae (28% and 22% of the NISP, 18% and 22% of the WR, and 27% of the MNI). Only 7% of the NISP were attributed to the Elapidae (9% of the WR and 18% of the MNI).

Due to the lack of snake references, the identification of snake bones was conducted based on identification criteria derived from those of Bochaton & Bailon (2018), along with the assistance in the preliminary identification of their vertebrae by Dr. Bochaton.

Table 13 Number of Identified Specimens (NISP), Weight of the remains (WR), and Minimum Number of Individuals (MNI) identified in the complete snake assemblage of the different layers of the second excavation of Khao Ta Plai.

	Layer1/2			**Layer3**			**Layer4**			**Total**		
	NISP	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**	**NISP**	**WR**	**MNI**
Colubridae	16	14.81	1	2	2.31	1	1	2.18	1	19	19.3	3
Elapidae	2	0.86	1	0	0	0	4	10.06	1	6	10.92	2
Python sp.	21	43.02	1	1	1.7	1	3	7.18	1	25	51.9	3
Ophiophagus hannah	10	9.25	1	8	7.96	1	9	16.32	1	27	33.53	3
Snake ind.	6	3.74		2	1.18		3	4.79		11	9.71	
Total	**55**	**71.68**	**4**	**13**	**13.15**	**3**	**20**	**40.53**	**4**	**88**	**125.4**	**11**

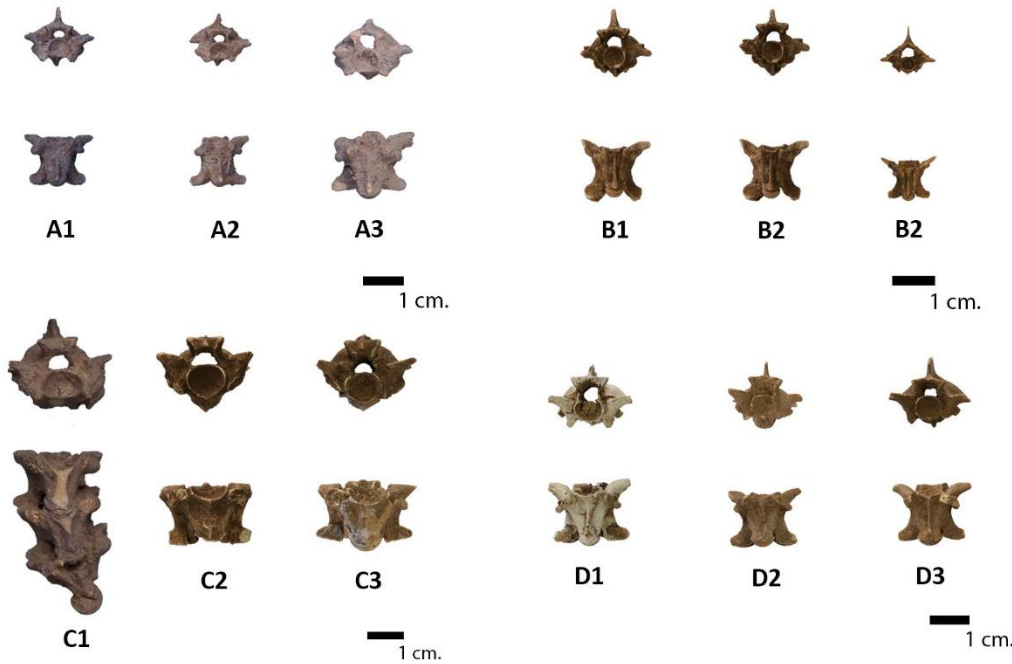


Figure 35 Examples of the studied snake trunk vertebrae (cranial-ventral view) of Khao Ta Plai: **A)** Elapidae; (A1-A2) showing trace of concretion; **B)** Colubridae; **C)** *Python* sp. C1) showing trace in anatomical connection; **D)** *Ophiophagus Hannah*; D1) showing trace of carbonization (white) on surface.

<u>Other Taxa</u>

A small portion of bone remains recovered from this site accounts for only 1% of the NISP (0.3% of the WR). This makes it impossible to calculate the MNI. Among these, including Rhinocerotidae (0.1% of the NISP and 0.03% of the WR), Chiroptera (bat) (0.01% of the NISP and 0.03% of the WR), Anura (frog) (0.1% of the NISP and 0.01% of the WR), Aves (birds) (0.4% of the NISP and 0.2% of the WR), bony fish (0.2% of the NISP and 0.04% of WR), and Agamidae (small lizard) (0.03% of the NISP and 0.001% of the WR). In addition, several unidentified mammal remains were categorized based on size class: large-sized mammals (19% of the NISP and 29% of the WR), medium-sized mammals (16% of the NISP and 9% of the WR), and small-sized mammals (3% of the NISP and 1% of the WR).

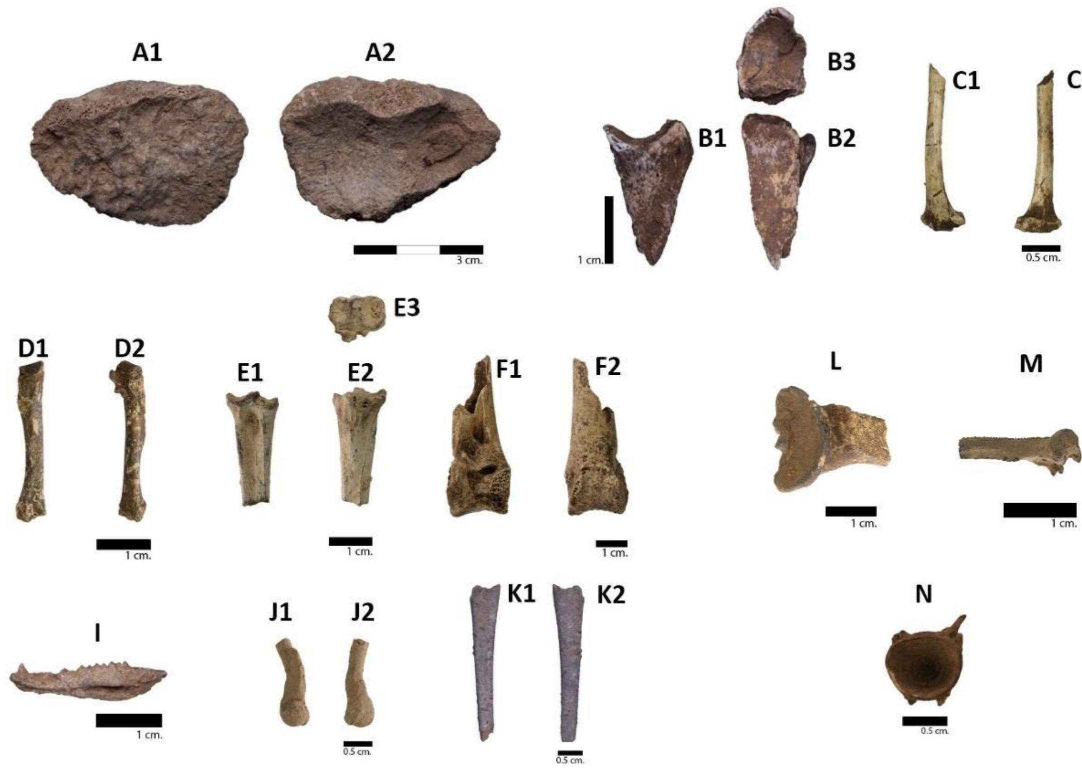


Figure 36 Examples of the studied faunal bone remains of Khao Ta Plai: **A)** Radius of Rhinicerotidae (juvenile) with concretion; A1) proximal view; A2) distal view; **B)** 3rd phalange of Tragulidae; B1) abaxial view; B2) palmar view; B3) proximal view; **C)** Humerus of Chiroptera; C1) anterior view; C2) posterior view; **D)** Carpo-metacarpus of Aves; D1) posterior view; D2) anterior view; **E)** Tibio-tarsus of Aves; E1) posterior view; E2) anterior view; E3) proximal view; **F)** Right Tibio-tarsus of Aves; F1) posterior view; F2) anterior view; **I)** Dentary of Agamidae (medial view); **J)** Humerus of Anura sp.; J1) ventral view; J2) dorsal view; **K)** Tibio-fibula of Anura sp.; K1) ventral view; K2) dorsal view; **L)** Fin spine of Mystus sp.; **M)** Fin spine of Mystus sp. ; N) Vertebra of bony fish.

3.2 Associations of contexts considered for the zooarchaeological and taphonomic analyses

To define the associations of spits that could be considered together in the analyses, we used a combination of a classical archaeological approach based on the typology of the material recovered from each spit (ceramics and metal) and a statistical approach based on three different methods (Chi² tests, Correspondence analyses, and Euclidean distance with Hellinger transformed data). This evaluation was made mandatory by the fact that the stratigraphy of the site mostly reflected bioturbation events and was not useful to define chronological phases based on the morphology and nature of its sediments (pers. comm. Arnaud Lenoble). To make this approach simple, we chose to consider all the studied squares altogether and to focus on the spits alone. The variables used are the NISP counts of the different animal taxa.

First, we considered associations of spits defined using the occurrence of archaeological remains bearing chronological significance:

- Layer 1: Spits 1 to 6 (52 to 95 cm): Recent layers containing Chinese ceramics.
- Layer 2: Spits 7 to 13 (95 to 125 cm): Protohistoric layers containing metal objects and Sa Huynh-Kalanay pottery shards.
- Layer 3: Spits 14 to 17 (125 to 145 cm): Neolithic layers containing red slip potteries and polished axes.
- Layer 4: Spits 18 to 35 (145 to 270 cm): “Paleolithic” layers containing only lithic tools.

In order to compare the faunal assemblages of these layers, we then performed pairwise Chi² tests using the function "chisq.test" of the stats base library of R. To do so, we reduced the number of taxonomic categories considered to avoid null values in the data matrix. The considered variables were the following: Large size Mammal, Medium size Mammal, Small size Mammal, Turtles, Squamates, and Amphibians. These tests indicated that layers 1 and 2 were not statistically different (P-value> 0.05), but that all the others were (P-value < 0.05).

In order to explore the data further, we then performed a Correspondence Analysis considering all the spits individually using the function CA of the package FactoMineR. The only modification we made was to fuse spits with less than 100 remains with the spit right above it. The results matched those of the Chi² test with a good separation between the first 17 spits with a less variable composition and more medium-sized mammals, and the ones below containing more large mammals and turtles.

Figure 37 Correspondence Analysis of all spits treated individually, performed using the CA function of the FactoMineR package.

Finally, we performed the Euclidean confirmed the structuring of the data into two groups prior to and after spit 17, so "post-Neolithic" and "pre-Neolithic". We can also note that the dendrogram indicates another possible subdivision with spits 21 to 25 being similar, but we chose not to consider additional subdivisions of the assemblage considering the limited size of the sample from now on.

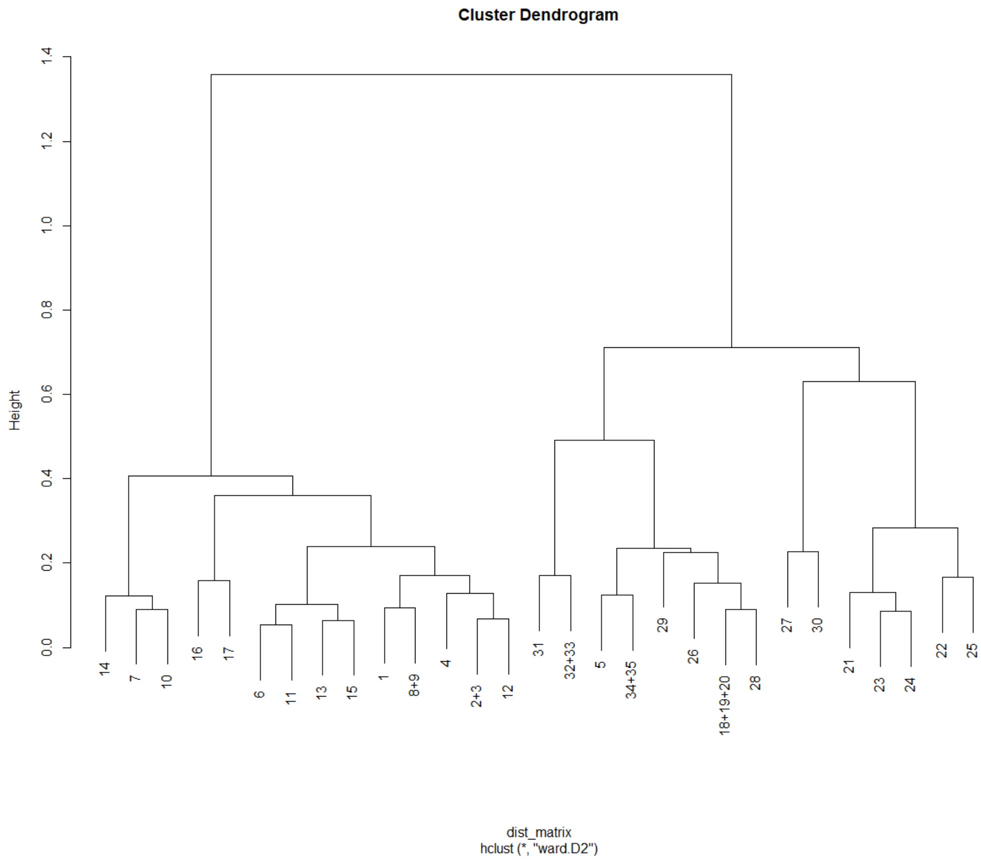


Figure 38 Cluster Dendrogram of Spits Based on Archaeological Remains

To establish analytical groupings for the absence of reliable stratigraphy of this site due to bioturbation, we worked by using a combination of archaeological and statistical approaches. The classification of spits into four chronological layers based on typological markers was supported by Chi² tests, Correspondence Analysis, and Hellinger-transformed Euclidean distance analysis. The Results revealed two main faunal groupings, divided into post-Neolithic (spits 1–17) and pre-Neolithic (spits 18–35) based on their significant differences in taxonomic composition. While spits 21–25 were identified as a sub-group, due to limited sample size, it was not further separated. These two broader groupings will thus form the basis for the forthcoming taphonomic and zooarchaeological analyses.

3.3 Taphonomy of Bone assemblages

3.3.1 Fragmentation of the remains

This study applies the percentage of fragmentation ranging from 100% (complete bones) to less than 5% to assess the preservation state of faunal remains at the site. Overall, bone remains of this site show high degree of fragmentation. The results of the Chi^2 tests indicate statistically significant ($P\text{-value} < 0.001$). Layers 1/2 and 4 show strongly different patterns of bone completeness, especially for both complete bones (100%) and heavily fragmented bones (<10%), while Layer 3 tends to have more mixed distributions, though some categories (like 30–40% and 20–30%) remain significantly different.

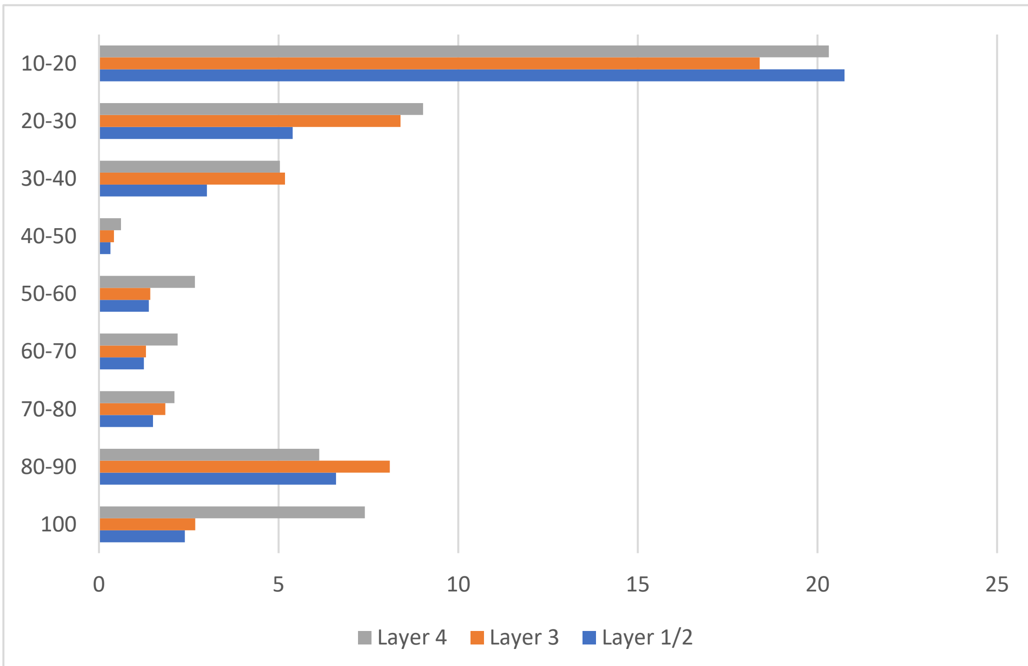


Figure 39 Distribution of bones with evidence of fragmentation across layers

Additionally, a few bones also show the preservation of anatomical connections; these assemblages were uncovered in spits at depths below 200 cm. This evidence suggests that there remain some areas without the disturbances.

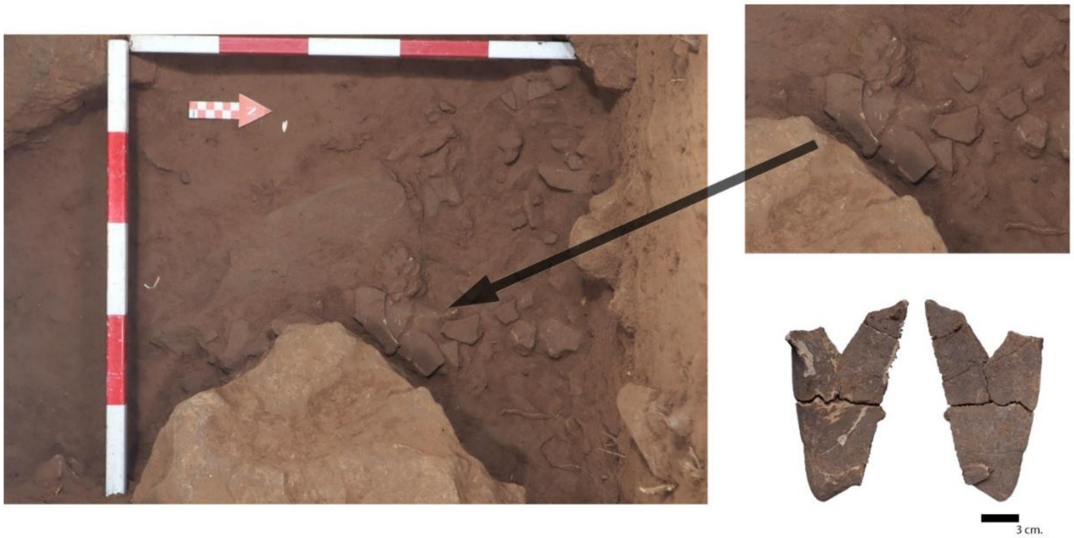


Figure 40 An example of a Hyoplastron and Xiphiplastron in anatomical connection was found in square N3W4, spit 33 (at a depth of 225 cm).

3.3.2 Bone surface alterations

A total of 4,202 bone remains were recorded with identifiable taphonomic modifications, weighing 8,836 grams. Most of the assemblages (45% of the NISP) were covered by a veil of calcite, which made it difficult to observe surface alterations on the bones. The second most representative taphonomy is burning (25%), and it is also represented by carbonization, indicated by grey and white colors (12%). Among these bones, only a small portion of the assemblages (1%) shows direct evidence of anthropogenic modification, such as cut-mark and percussion.

Moreover, they are bones with dissolution and surface abrasion consistent with water flow, 14% of NISP, particularly from layers above spit 17. An additional 2% of the bones exhibit post-depositional fragmentation and were later covered with calcite, likely caused by water flowing. Some bioturbation is also present in the form of gnaw marks attributed to porcupines and murinae (0.4%), including root etching that was found down to a depth of 245 cm.

The results of the Chi^2 tests indicate that these taphonomies represent a significant difference among layers; anthropogenic is significantly different in layer 1/2 and layer 4. While burning is significant in all layers, especially extreme in layers 1/2 and layer 4, as well as the water effect. Roots and Bioturbation show no difference in layer 1/2, while others do. Concretions are strongly significant in all layers. In contrast, crashed and concretion bones show no significant change in layer 3, but others do.

Table 14 Number of Identified Specimens (NISP)and Weight of the remains (WR), identified in the taphonomic alteration of the different layers of the second excavation of Khao Ta Plai.

	Layer 1/2		**Layer 3**		**Layer 4**		**Total**	
	NISP	**WR**	**NISP**	**WR**	**NISP**	**WR**	**NISP**	**WR**
Anthropogenic	31	246.7	8	52.9	1	0.4	**40**	**300**
Burning	1046	2,214.60	306	885.5	168	1207.3	**1520**	**4307.4**
water-effected	481	1250.7	82	236.5	19	66.7	**582**	**1553.9**
Roots/Bioturbation	21	142	5	21.6	38	13.4	**64**	**177**
Concretion	319	791.1	812	1712.1	1948	6333	**3079**	**8836.2**
Crashed and Concretion	0	0	15	77.7	66	497.7	**81**	**575.4**
Total	**1898**	**4645.1**	**1228**	**2986**	**2240**	**8119**	**5366**	**15750**

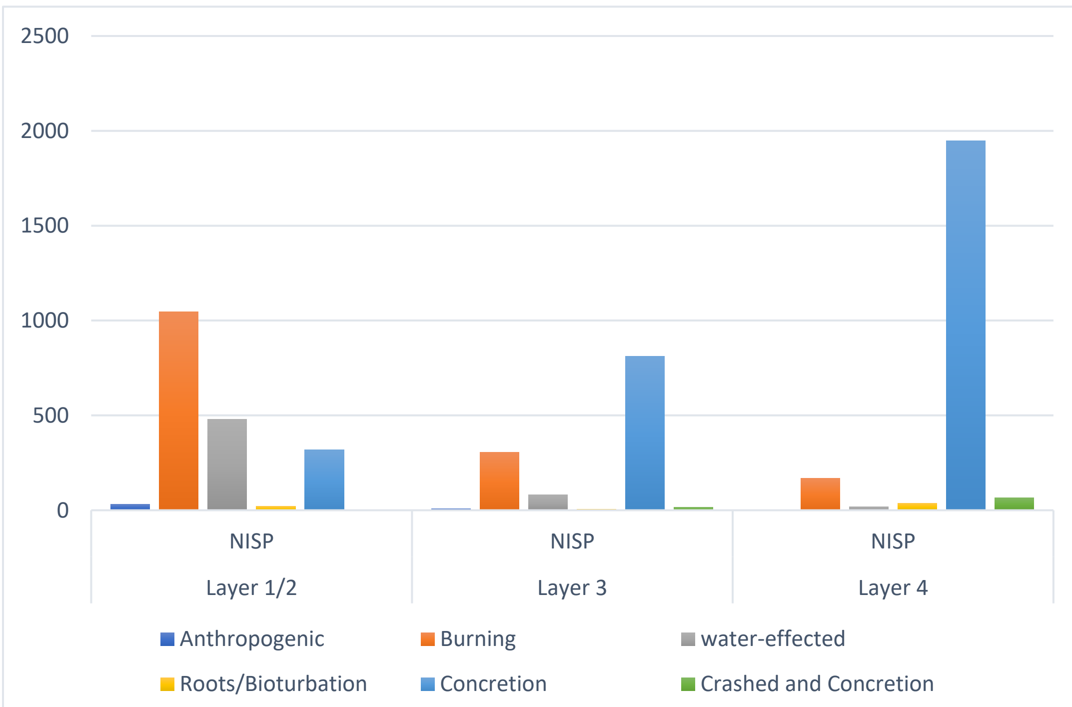


Figure 41 Distribution of bones with traces of Taphonomy across layers

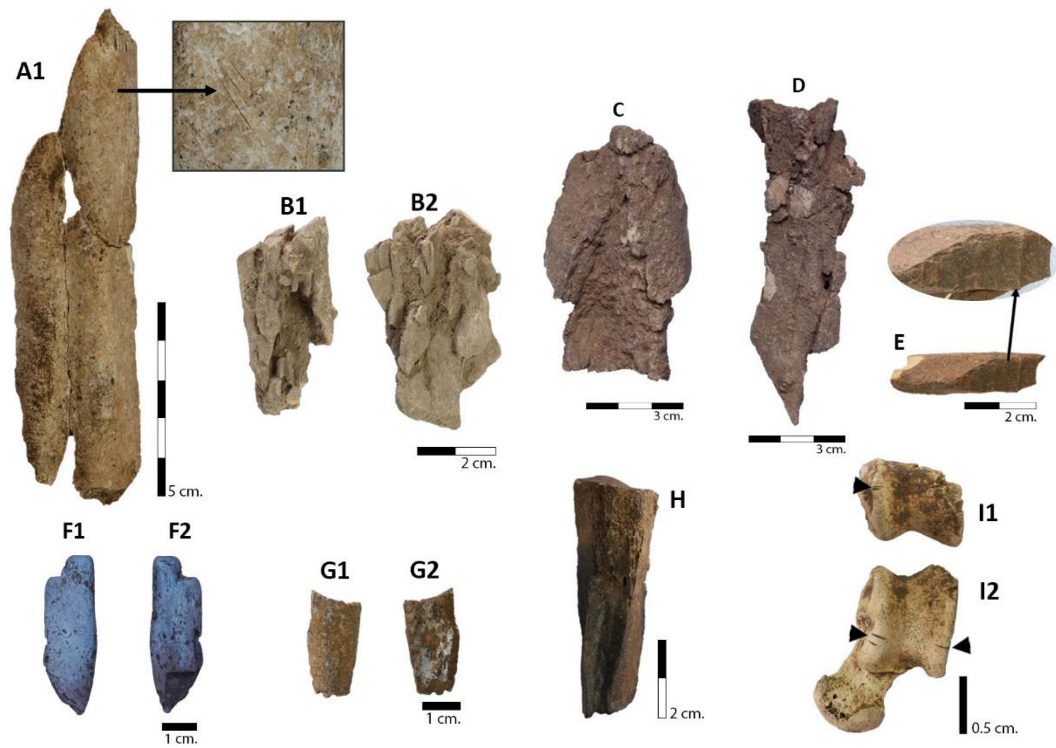


Figure 42 Examples of the studied bone remains with trace of Taphonomy of Khao Ta Plai: **A)** Metatarsus of Large Bovidae with cut marks (anterior view); **(B-D)** Unidentified long bone of large-sized mammals with trace of crashed and concretion; **E)** Unidentified long bone of medium-sized mammal with porcupine's gnawing marks; **F)** Unidentified long bone of medium-sized mammal with trace of carbonization (white); F1) posterior view; F2) anterior view **G)** Unidentified long bone of medium-sized mammal with trace of carbonization (black and white) and concretion; G1) anterior view; G2) posterior view; **H)** Left metacarpal of large-sized Bovidae with burning trace (black) (anterior view); **I)** Left talus of Ratufa indica with traces of cut mark.

3.3.3 Analysis of bone fragmentation and bone surface alteration in each taxon

<u>Bovidae</u>

Among 294 bone fragments attributed to Bovidae, 33 are complete elements (11.4%), and 42 are nearly complete (at least 90% of the bone is preserved), while 71 (24%) are small fragments representing less than 10% of the complete anatomical part. The horn, humerus, tibia, and metacarpus are also more heavily fragmented (completion mean 20% - 38%) compared to others that have completions mean of more than 80%. Traces of burning (black) and carbonization (grey/white) were observed on 54 bones (18% of the NISP). These traces were present indiscriminately on every anatomical element of the skeleton. Water effect and cut marks were observed on only eight and four bones, and ten bones with concretion. Three bones consist of the humerus, astragalus, and phalanx, show traces of porcupine gnawing.

Cervidae

Among the 373 bone fragments attributed to Cervidae, 54 bones are complete elements (14.5% of the NISP), and 59 are nearly complete (at least 90% of the bone is preserved), while 121 (32%) are small fragments representing less than 10% of the complete anatomical part. Antlers are the most heavily fragmented (completion mean 17%), followed by metapodial, femur, and ulna (completion mean 33% - 78%), compared to others that have a completion mean of more than 89%. Traces of burning (black) and carbonization (grey/white) were observed on 77 bones (21% of the NISP). These traces were present indiscriminately on every anatomical element of the skeleton, while the majority of traces on bones were observed on 145 bones (39% of the NISP). The cut mark is only observed on one humerus. Water effects were observed on 18 bones.

Sus scrofa

Among the 85 bone fragments attributed to *Sus scrofa*, 19 bones are complete elements (22.4% of the NISP), 16 are nearly complete (at least 90% of the bone is preserved), while 17 (20% of the NISP) are small fragments representing less than 10% of the complete anatomical part. Overall, of bone elements of this taxon are not heavily fragmented (completion mean more than 90%). Traces of burning (black) and carbonization (grey and white) were observed on 18 bones (21.2% of the NISP). These traces were present indiscriminately on leg bones, while 19 bones (22% of the NISP) were observed with concretion. Cut marks were only observed on three bones: the zeugopods (ulna and radius) and the phalanx. Additionally, 9 bones were observed with traces of water affected.

Monkeys

Among the 52 bone fragments attributed to the monkey, only eight bone elements of teeth and tarsals are complete (15.4% of the NISP), and seven bones are nearly complete (at least 90% of the bone is preserved), while eight (15%of the NISP) are small fragments representing less than 10% of the complete anatomical part. Overall, of bone elements of this taxon are not heavily fragmented (completion mean more than 75%). Concretion is the majority trace on 23 bones, while traces of burning (black) and carbonization (grey and white) were only observed on five humerus, ulna, and talus bone elements.

Carnivores

Among the 28 bone fragments attributed to carnivores, only two metacarpals are complete elements (7% of the NISP), two calcanea are nearly complete (at least 90% of the bone is preserved), while five bones (18% of the NISP) are small fragments representing less than 10%of the complete anatomical part. Overall, of bone elements of this taxon are not heavily fragmented, except for the ulna, for the completion mean is below 70%. Concretion is the majority trace on 17 bones, and traces of burning (black) and carbonization (grey and white) were only observed on eight bones of the scapula, humerus, ulna, and metatarsus.

Rodent

Among the 76 bone fragments attributed to rodents, only five bones are complete elements (7% of the NISP), 17 bones are nearly complete (at least 90% of the bone is preserved), while eight bones (11% of the NISP) are small fragments representing less than 10%of the complete anatomical part. Concretion is the majority trace on 31 bones (41% of the NISP), and traces of burning (black) and carbonization (grey and white) were only observed on six bones. These traces appeared indiscriminately on every anatomical element of the skeleton, while the cut mark and water effect were observed on only one bone on each of them.

Turtle

Among the 1604 bone fragments attributed to turtles, 109 are complete elements (6.8%), 142 are nearly complete (at least 90% of the bone is preserved), while 239 (15%) are small fragments representing less than 5%of the complete anatomical part. Humeri are more heavily fragmented (completion mean 36%) compared to those that are identifiable as stylopods (femur), zeugopods (radius), and girdle elements (completion mean 47% - 50%). For the plates, Xiphiplastron and Hyoplastron have high fragmentation (completion mean 71% - 77%). Traces of concretion were observed on 239 bones (15% of the NISP). These traces appeared indiscriminately on every anatomical element of the skeleton, while burning (black) and carbonization (grey/white) were observed on only 19 bones (1.2% of the NISP). Additionally, 15 bones show signs of water effect, and some of them are in the anatomical connection.

Monitor Lizards

Among the 436 bone fragments attributed to monitor lizards, 40 are complete elements (9.2% of the NISP), and 180 are nearly complete (at least 90% of the bone is preserved), while 37 (9%) are small fragments representing less than 10% of the complete anatomical part. The average percentage of completion of the bones is 95%. The cervical vertebrae are more heavily fragmented (completion mean 10%) compared to those that are identifiable as stylopods (femur), zeugopods (tibia), and post-orbital (completion mean 57% - 67%).

Snake

Among the 88 bone fragments attributed to the snake, 23 are complete elements (26% of the NISP), and 57 are nearly complete (at least 90% of the bone is preserved), while only one trunk vertebra is a small fragment representing less than 10% of the complete anatomical part. Traces of concretion were observed on 217 bones (50% of the

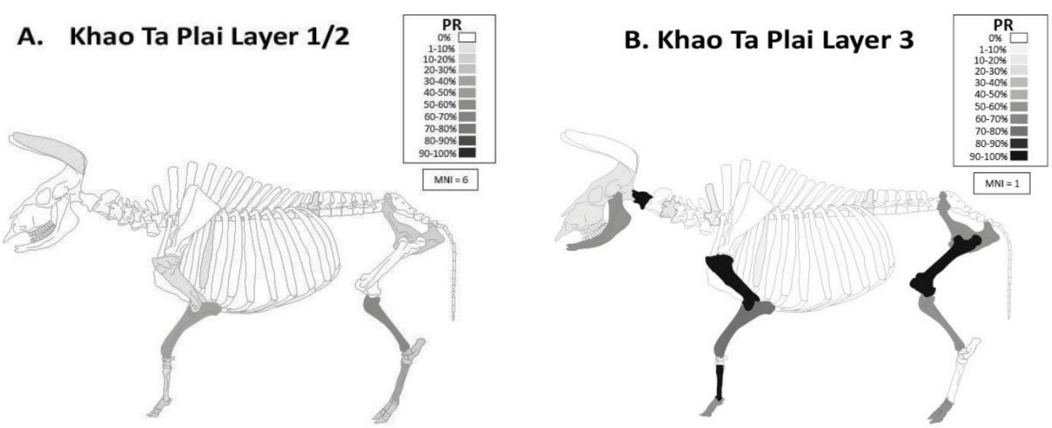
NISP). These traces were present indiscriminately on every anatomical element of the skeleton, while burning (black) and carbonization (grey/white) were observed on 31 bones (7% of the NISP). Only two bones have with water effect.

3.4 Anatomical Representations and Distributions

Anatomical Representations and Distributions of the Bovidae, Cervidae, *Sus scrofa*, turtle/tortoises, and monitor lizards are given in the table below to show the differences in preservation across layers.

Bovidae

The overall Percentage of Representation (PR) is 17%. The anatomical distributions are fairly homogeneous across layers, with a high representation of stylopods and zeugopods. In the first layer, there is a general underrepresentation of all anatomical parts except for the skull (mean PR = 12%). The most anatomically representative parts with fats are the best represented (hind zeugopods (tibia) and metapods -PR>43%-). These are followed by the radius and sesamoidians (tibia, metatarsus, and tarsals -PR>20%-). The least represented (girdle elements, and most vertebrae and ribs are poorly defined -PR<2%-). In layer 3, they represent more forelimb stylopods and fore metapod (humerus, radius, femur, and metacarpus -PR = 50%), followed by zeugopods, girdle elements, and some pieces of the skull, with PR values of 32%. Meanwhile, only 3% belong to the vertebrae and ribs. In the last layer, the hind zeugopod (tibia) remains well represented, with the vertebrae and ribs being the least represented (mean PR-25 %). Overall distribution of Bovidae, zeugopods (radius, ulna, tibia, fibula), metapods (metacarpals and metatarsals), stylopods (humerus, femur) -PR=41%-, followed by acropods (phalanges, carpals, tarsals, sesamoids) -PR 12%-, is the most representative bone element. These bones are known to contain high concentrations of marrow and fats. Meanwhile, the least represented bones are ribs and vertebrae PR<1%.



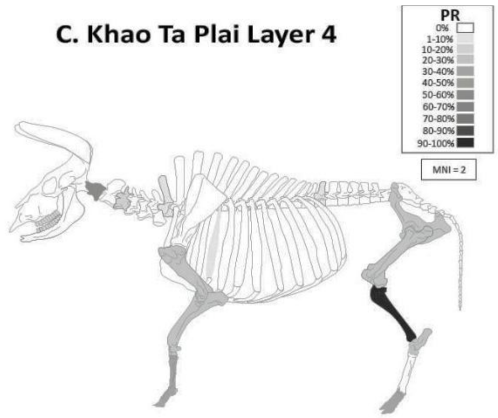
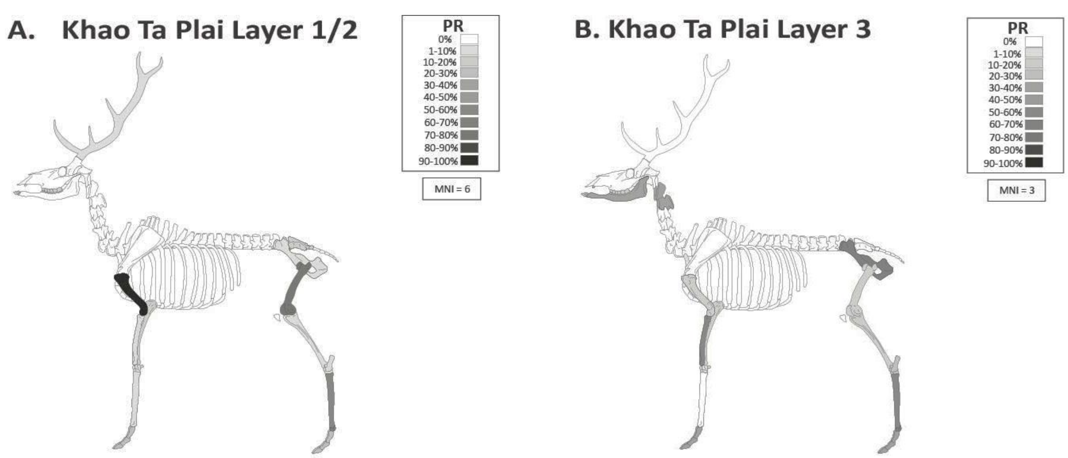


Figure 43 Anatomical distributions of the Bovidae remains collected in the different layers of the site of Khao Ta Plai. The percentage of representation (PR) is considered here to provide a graphical visualization of the different values observed for the different anatomical elements.

Cervidae

The overall Percentage of Representation (PR) is 17%. The anatomical distribution of Cervidae bone elements shows consistent patterns across different layers (mean PR = 47%), with representation of all anatomical parts, except the skull. The most representative bones (are the fore stylopods (humerus), zeugopods (radius and tibia), metapods (metacarpals and metatarsals), and basipods (tarsals) -PR=55%-) with high concentrations of marrow and fats. These are followed by hind stylopod (femur), zeugopods (ulna), basipods (phalanges), and acropods (carpals). The least represented (metacarpus, with a fragile element as sternum -PR<1%-). It should be noted that the innominate bones are increased in layers 3 and 4, as well as the radius, carpals, and tarsal bones.



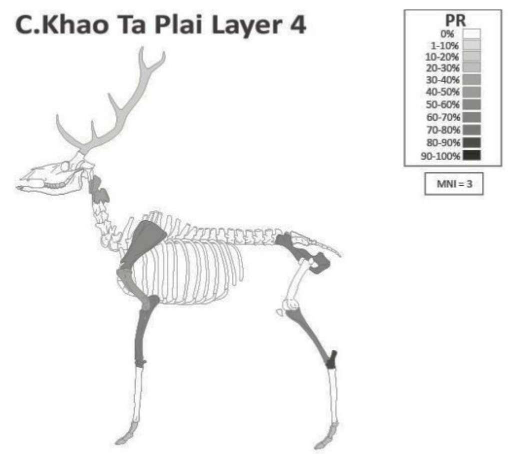
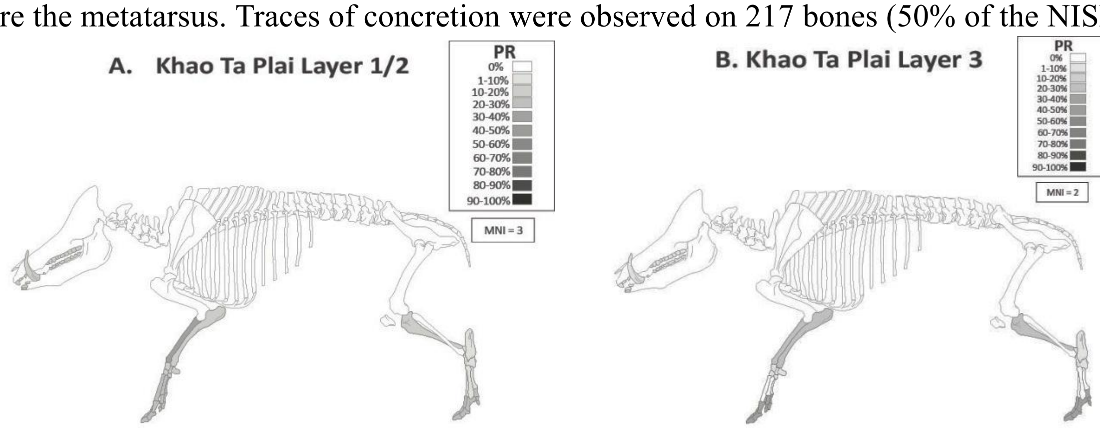


Figure 44 Anatomical distributions of the Cervidae remains collected in the different layers of the site of Khao Ta Plai. The percentage of representation (PR) is considered here to provide a graphical visualization of the different values observed for the different anatomical elements.

Sus scrofa

The anatomical distribution of Suidae bone elements shows consistent patterns across different layers (mean PR = 42%). Among these bone elements, they represent all anatomical parts, except the skull. The most representative bones are basipods (phalanges -PR=24%), followed by zeugopods (ulna, radius, and tibia), and fore metapods (metacarpus) (PR=57%). Otherwise, the least representative bone elements (PR only 2%) are the metatarsus. Traces of concretion were observed on 217 bones (50% of the NISP).



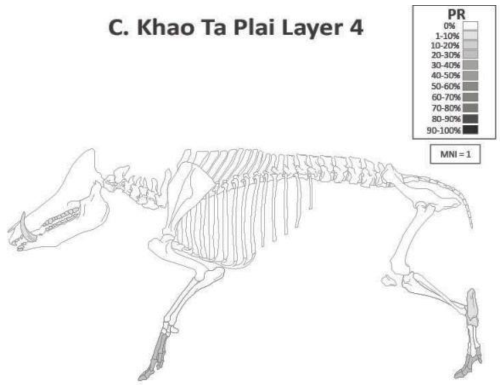
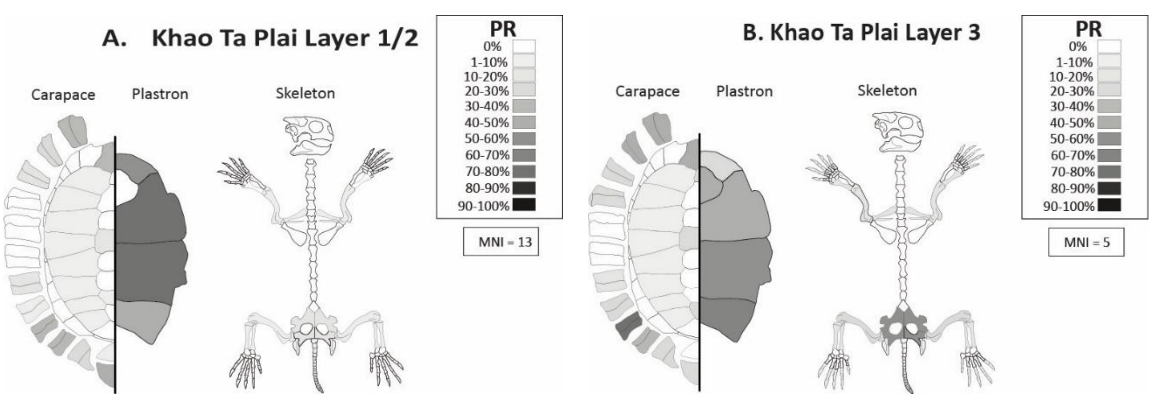


Figure 45 Anatomical distributions of the Sus scrofa remains collected in the different layers of the site of Khao Ta Plai. The percentage of representation (PR) is considered here to provide a graphical visualization of the different values observed for the different anatomical elements.

Turtle

The overall Percentage of Representation (PR) is 28%. The anatomical distributions of the turtle bone elements show consistent patterns across different layers. The distribution is fairly homogeneous with representation of all the anatomical parts except for the smallest elements (carpal and tarsal articulations, and vertebrae), and the skull. The most robust anatomical parts are the best represented (Peripheral plates, Epiplastron, Entoplastron, and Nuchal plate -PR>65%-), while the most fragile elements are the least represented (zeugopods, and most girdle elements -PR 10%-). An exception to this pattern is observed for the peripheral plates of the bridge (PR <1%), which are less represented than the other elements of the carapace and other peripherals (mean PR=59%).



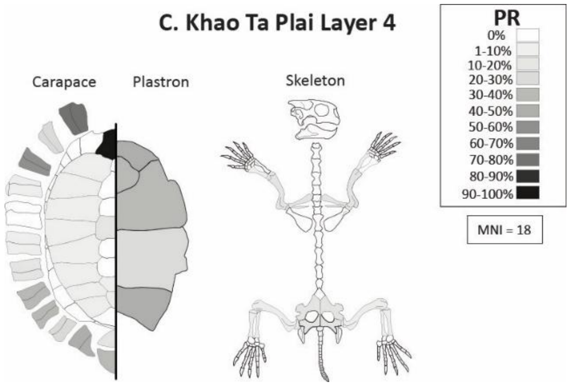


Figure 46 Anatomical distributions of the turtle remains collected in the different layers of the site of Khao Ta Plai. The percentage of representation (PR) is considered here to provide a graphical visualization of the different values observed for the different anatomical elements.

Monitor lizards

The overall Percentage of Representation (PR) is 14%. The anatomical distributions of the *Varanus* bone elements show consistent patterns across different layers. The distribution is fairly homogeneous (mean PR=25%), with representation of all the anatomical parts except for the smallest elements (carpal and tarsal articulations). The most robust anatomical parts are the best represented stylopods (humerus, femur, and girdle elements -PR=43%-). These are followed by vertebrae (PR=21%).

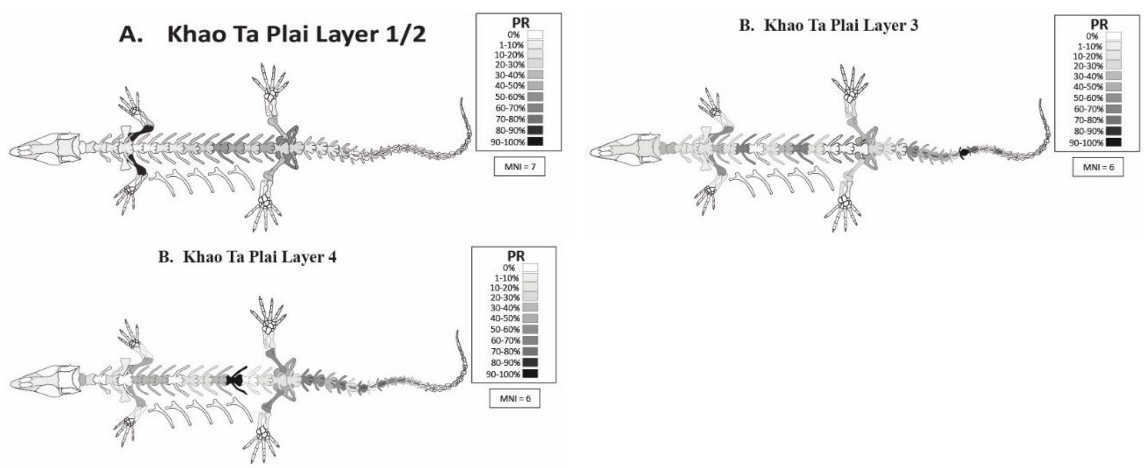


Figure 47 Anatomical distributions of the Varanidae remains collected in the different layers of the site of Khao Ta Plai. The percentage of representation (PR) is considered here to provide a graphical visualization of the different values observed for the different anatomical elements.

3.4 Age at Death of Large Mammals

Age estimation based on the epiphyseal fusions indicates that a total of 29 Large-sized (i.e., Rhinocerotidae, *Bos* sp., *Bubalus* sp., *Cervus* sp., and *Sus scrofa*) and medium-sized (i.e., *Axis* sp., *Rucervus* sp.) animal specimens were juvenile individuals. Among these, medium-sized Cervidae are the most represented juveniles (39% of the NISP), followed by large-sized Bovidae and Cervidae (19% of the NISP) (Table 15). The majority of juvenile elements found are metapodials and phalanges, which indicates these juveniles are under 3 years old. Based on the percentage of fused versus unfused bones following Chaplin (1971:129). indicates that juvenile specimens represent a significant part of the assemblage while adult specimens remain the most numerous (Table 16).

Table 15 Number of Identified Specimens (NISP) attributed to fully mature (FM) or not fully mature (NFM) individuals in the different layers of the second excavation of Khao Ta Plai.

	Layer 1/2				Layer 3				Layer 4			
	NFM	**%**	**FM**	**%**	**NFM**	**%**	**FM**	**%**	**NFM**	**%**	**FM**	**%**
Large Cervidae	2	22	17	57	0	0	0	0	4	33	22	69
Large Bovidae	2	22	4	13	1	13	8	50	3	25	5	16
Large Mammal	1	11	7	23	0	0	0	0	0	0	0	0
Sus scrofa	1	11	1	3	0	0	0	0	1	8	2	6
Medium Cervidae	2	22	0	0	7	88	8	50	3	25	3	9
Medium Mammal	1	11	1	3	0	0	0	0	0	0	0	0
Rhinocerotidae	0	0	0	0	0	0	0	0	1	8	0	0
Total	**9**	**100**	**30**	**100**	**8**	**100**	**16**	**100**	**12**	**100**	**32**	**100**

Table 16 The percentage of fused versus unfused bones following Chaplin (1971:129) attributed to fully mature (FM) or not fully mature (NFM) individuals in the different layers of the second excavation of Khao Ta Plai.

	Layer 1/2		Layer 3		Layer 4	
	NFM	**FM**	**NFM**	**FM**	**NFM**	**FM**
Large Cervidae	11	89	0	0	15	85
Large Bovidae	33	80	100	80	38	62.5
Large Mammal	13	88	0	0	0	0
Sus scrofa	50	50	0	0	33	67
Medium Cervidae	100	0	47	53	50	50
Medium Mammal	50	50	0	0	0	0
Rhinocerotidae	0	0	0	0	100	0
Total	**257**	**357**	**147**	**133**	**236**	**264**

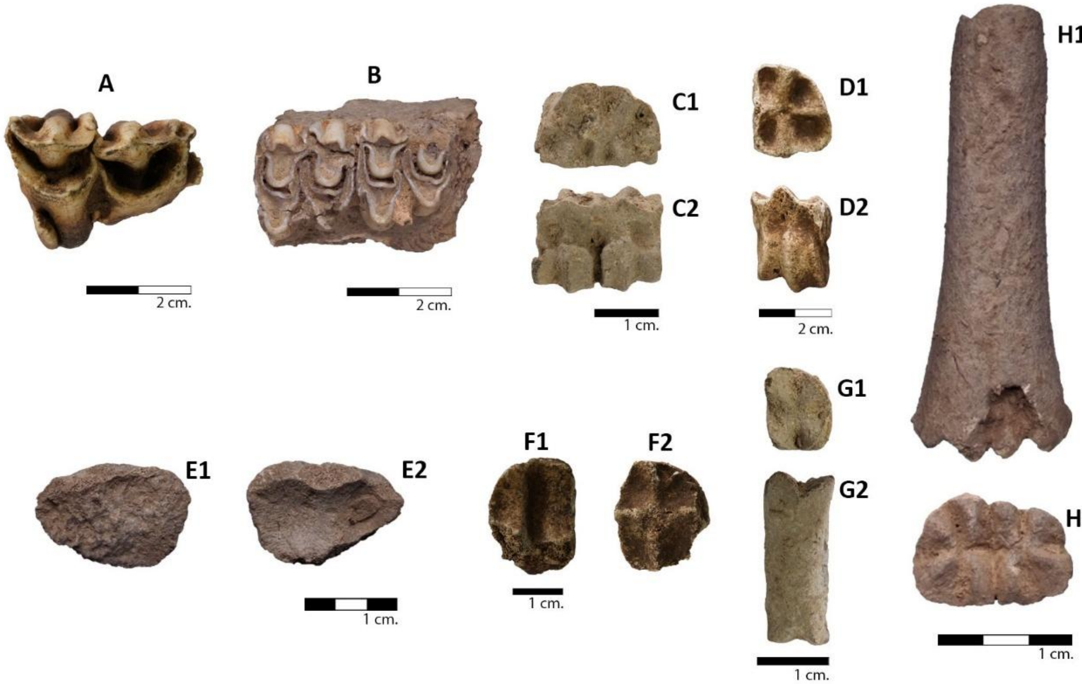


Figure 48 Examples of the studied juvenile individuals of Khao Ta Plai: **A)** Right upper 3rd premolar of Bos javanicus; **B)** Left upper deciduous 3rd and 4th premolar of Cervus unicolor; **(C-D; H)** Distal metapodial of Cervidae; **E)** Proximal radius of Rhinocerotidae; **F-G)** 1st Phalange of Cervidae.

4

Discussion

A. Taphonomy and formation process of the assemblages

The site exhibits a high level of bone fragmentation across all stratigraphic layers; most fragments correspond to less than 10% of the complete element. The evidence of layer 3 appears to represent a transitional phase between Layers 1/2 and 4, with very shallow in depth. This layer shows similarity with Layers 1/2 and 4 in terms of chronology and preservation. While Layers 1/2 contain only rare occurrences of calcite on bones, but more traces of human activities. Layer 4 shows heavy concretion and extensive bone breakage.

The majority of bone surface alterations are traces of concretion, which are especially prevalent in layer 4. This may be related to post-depositional processes, such as the collapse of the cave ceiling, which caused bone breakage or trampling. Due to the veil of calcite present on the surface of many bones it is difficult to observe surface modifications clearly. In contrast, bones from Layer 1/2 show fewer calcite deposits but more evidence of water effects (i.e., polished and rounded surfaces). This evidence of water movement is supported by the presence of limestone flakes in the sediments in this layer. Layer 3 shows evidence of human activity, including burning, carbonization, cut marks, and percussion traces, along with a higher proportion of concreted bones compared to Layer 1/2. Some evidences of bioturbation (i.e., root etching and porcupine gnawing marks) are represented across the stratigraphy, indicating post-positional disturbances that may have affected the stratigraphic integrity and the accuracy of sediment dating. However, the presence of some bones below 200 centimeters of depth indicates that at least the basal part of the stratigraphy is still in primary position and did not suffer much perturbation. Human activity is characterized by a strong fragmentation of fresh bones, and the occurrence of numerous fire traces (i.e., burning (black) and carbonization (grey and white)). These traces demonstrated that the carcasses were processed and consumed onsite and that the bones may have been later used as combustible. However, as Layer 1/2 exhibits fewer traces of calcite compared to Layer 4, where deposits are dense to the extent that other surface modifications on the bones cannot be observed, this makes the interpretation limited.

The bone assemblages provided no elements attributed to cave-dwelling species, with the exception of a few porcupine bones. However, taphonomic observations of the samples did not reveal significant evidence of porcupine impact on the assemblage (notably, the near absence of gnawing marks and the absence of bone dice), and no digestion traces were observed in the sample. Conversely, most of the elements correspond to large herbivores, many of which presented burning traces. These elements suggest that humans are responsible for the accumulation of at least most of the bone elements at the site. Large taxa, such as rhinoceros and large bovids, are mainly represented by juvenile individuals, which may indicate that hunters avoided dangerous adults and instead focused on easier prey, such as juveniles, medium-sized mammals, and small reptiles. The high frequency of turtles bones in every layers also supports this pattern of targeting species that are easier to capture. In addition, the presence of juvenile tortoises (*Indotestudo elongata*) could also indicate seasonal hunting patterns. During the dry season, tortoises are less active and harder to find, which could lead the hunters to be less selective and collect smaller specimens, especially in the case of the use of non-selective hunting methods that allow them to find these animals. In contrast, smaller tortoises are more active in the rainy season, making it easier to track, especially with the assistance of dogs (Blythe 1854; Theobald 1868). Ultimately, both hypotheses (hunting method and activity season) could explain the occurrence of small tortoise individuals in the bone assemblages.

B. Evolution of subsistence strategies along the stratigraphy

The taxonomic composition of the faunal assemblages from Layers 1/2, 3, and 4 shows significant variations. Turtles, large mammals, and *Varanus* dominate the assemblages, the relative proportions of taxa vary significantly by layer. While small and medium-sized mammals, snakes, and few taxa such as birds, fish, and frogs are comparatively less abundant.

- In layer 1/2, Turtles, large mammals, and Varanus are abundant. Turtles dominated with a percentage of NISP is 44% and 31% of the MNI. These make them the most represented taxon in both categories. Followed by large mammals accounting for 24% of the NISP and 22% of MNI. *Varanus* also shows a strong presence with 41% of NISP and 14% of MNI. Small mammals appear in lower NISP **7%** but show higher representation in MNI (13%), indicating more individuals were identified. Medium mammals are present with 5% NISP and 9% MNI. While snakes account for 4% NISP and 6% MNI. Ultimately, birds, fish, and frogs are the least represented, with < 1% of NISP and <2% of MNI for each of them.

- Layer 3, turtles remain dominant in both categories, with 32% of the NISP and 29% of the MNI, while large mammals slightly increase in NISP (31%) and are stable in MNI (22%). Monitor lizards increase in NISP to 22% and MNI to 15%, continuing to be a major component. Meanwhile, both MNI and NISP (5% and 7%, respectively) of small mammals slightly decrease. Medium mammals become more abundant in this layer, increasing to 7% of the NISP and 12% of the MNI, becoming more significant in this layer. Snakes decline in NISP (2%) but remain high in MNI (**7%**). Ultimately, birds, fish, and frogs remain the least represented, with < 1% of NISP and <2% of MNI for each of them.

- Layer 4 is overly dominated by turtle remains in term of NISP (69%) and MNI (42%). Small mammals are much more present in this layer by increasing in MNI (16%) while remaining at 5% of the NISP. In contrast, large mammals decrease sharply to 13% NISP and 14% MNI. Meanwhile, *Varanus* also declines in NISP (8%) and MNI (12%). Snakes remain stable with 2% of the NISP and 5% of the MNI. While Medium mammals decrease to 1% NISP and 4% MNI. Ultimately, birds, fish, and frogs remain the least represented, with < 1% of NISP and <2% of MNI for each of them.

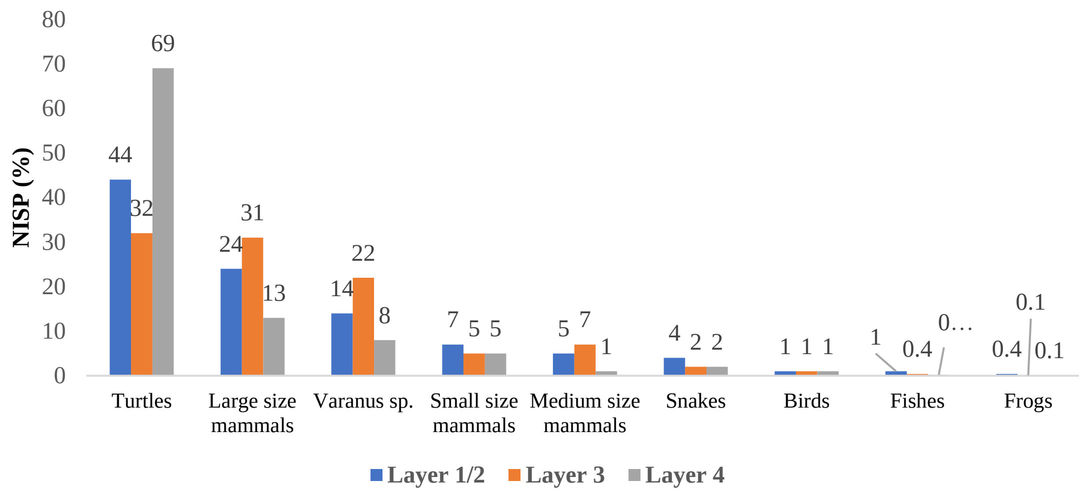


Figure 49 Faunal composition of the Khao Ta Plai layers in terms of percentage of NISP

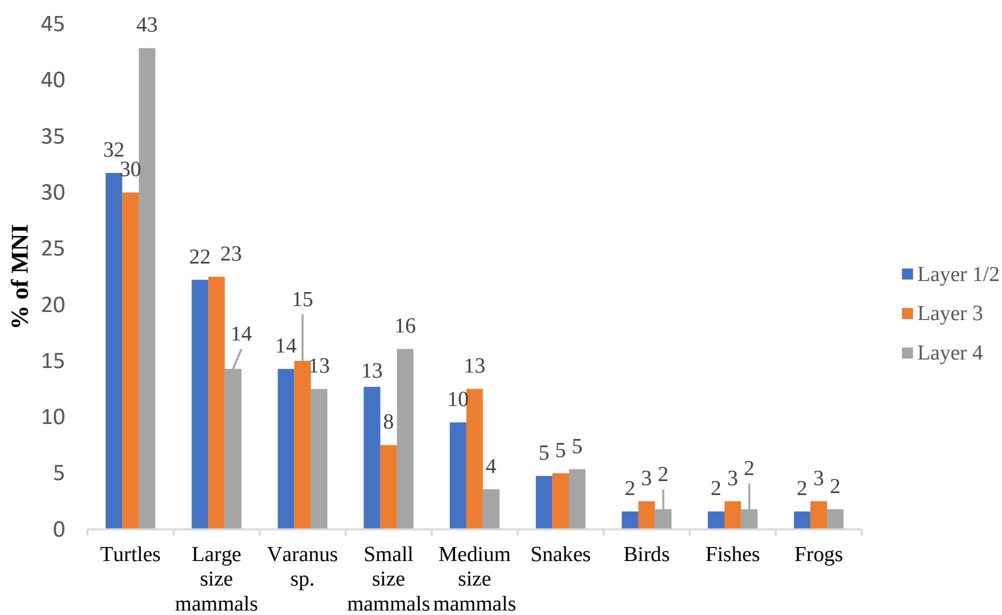


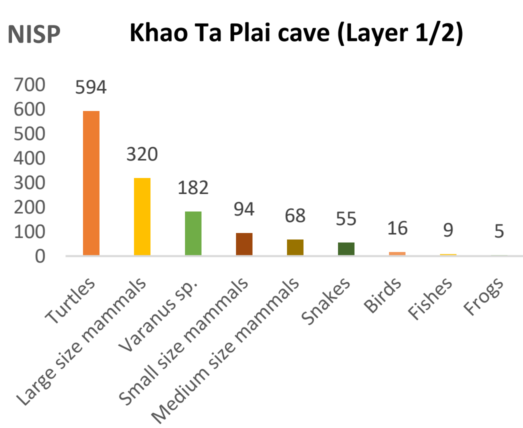
Figure 50 Faunal composition of the Khao Ta Plai layers in terms of the percentage of MNI.

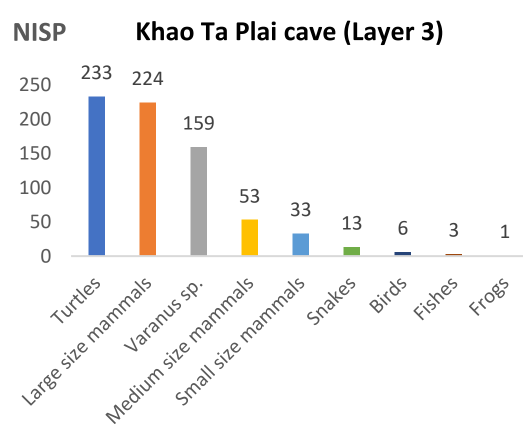
The results suggest notable changes in taxonomic composition. In Layer 4, turtles dominate overwhelmingly in both NISP (69%) and MNI (42%), indicating a clear focus on turtles as the main preys. In contrast, Layers 1/2 and 3 show more varied exploitation, with higher proportions of medium and large-sized mammals, particularly bovids, cervids, aquatic turtles, and *Sus scrofa*, along with a higher presence of *Varanus*. This diversification may reflect broader hunting strategies, focusing on both terrestrial mammals and reptiles. Overall, these differences in taxonomic representation between layers highlight changes in hunting practices and resource use through time, explaining why the statistical analyses identify Layer 4 as distinct from the other layers (see chapter 3).

C. Comparison with other regional assemblages

The site of Khao Ta Plai cave presents occupation layers contemporaneous (Late Pleistocene and Holocene) with other well-known prehistoric sites in Mainland Southeast Asia, including Doi Pha Kan (Frère *et al.* 2018; Bochaton *et al.* 2019) in Northern Thailand, Moh Khiew in Southern Thailand (Auetrakulvit 2004; Mithong 2014), and Laang Spean in Cambodia (Bochaton *et al.* 2023; Zeitoun *et al.* 2024). To contextualize human activity at Khao Ta Plai, we here compare faunal data from these sites. Due to the absence of Minimum Number of Individuals (MNI) data in some cases, the comparison relies on the Number of Identified Specimens (NISP).

The result of the faunal remains analysis reveals notable patterns in subsistence strategies. At Laang Spean cave and Doi Pha Kan (Figure 48), the animal assemblages are dominated by large-sized mammals, followed by turtles. For Doi Pha Kan cave, they particularly present a relatively balanced appearance of large-sized mammals, turtles, and varanids. These suggest a broad spectrum of hunting strategies. In contrast, Moh Khiew cave (Figure 49) shows a faunal profile more similar to Khao Ta Plai. Both sites exhibit large amounts of turtle remains, followed by varanids (with higher amounts in the Holocene period). However, a key difference lies in the mammalian component as Moh Khiew contains a higher proportion of medium-sized mammals, while Khao Ta Plai is richer in large-sized mammal remains. These differences indicate a strong variability in the subsistence behaviors of the populations having occupied the different sites (Auetrakulvit 2004; Piper & Rabett 2014; Conrad *et al.* 2016; Frère *et al.* 2018; Bochaton *et al.* 2019).





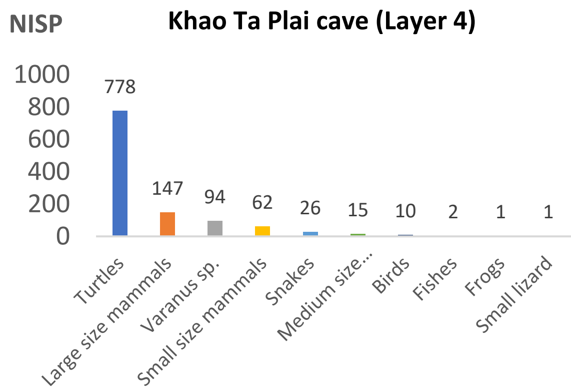


Figure 51 Faunal composition of the Khao Ta Plai assemblage in terms of Number of Identified Specimens (NISP) across layers.

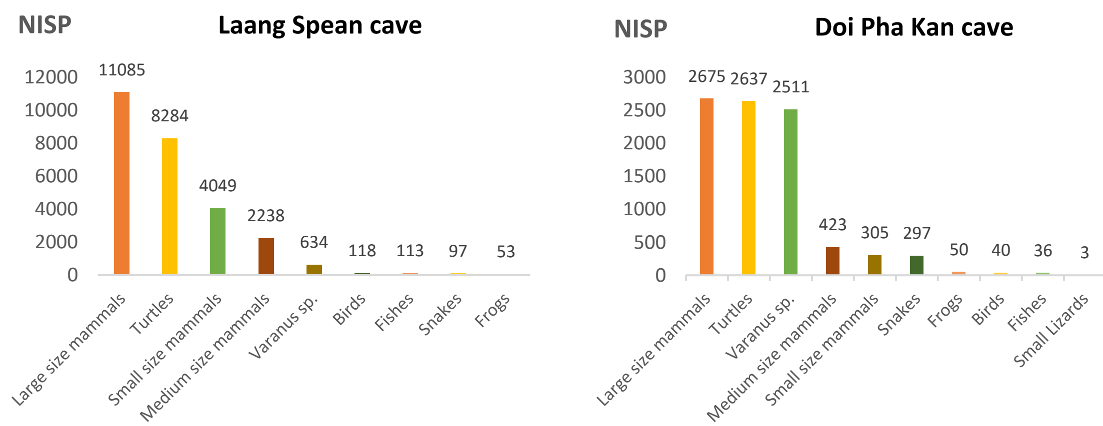


Figure 52 Faunal composition of the Laang Spean cave and Doi Pha Kan cave assemblage in terms of Number of Identified Specimens (NISP).

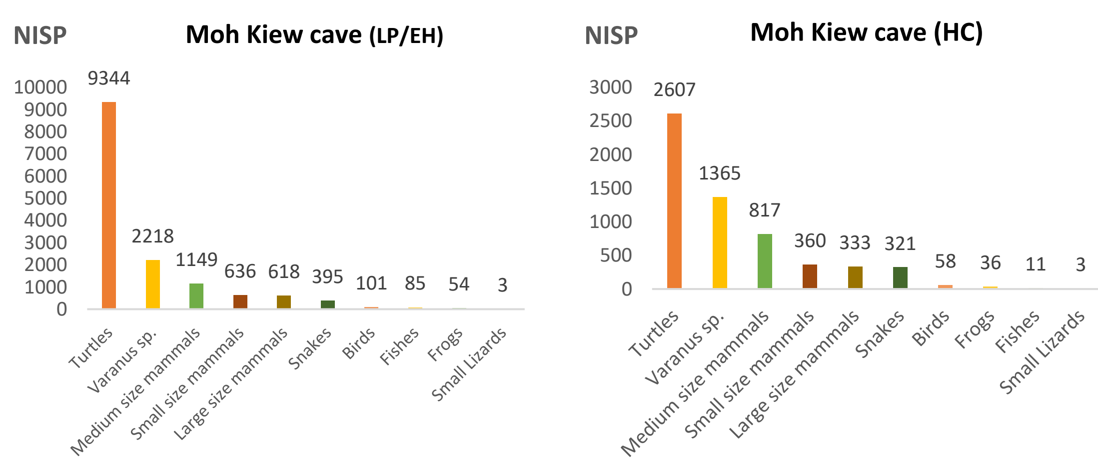


Figure 53 Faunal composition of the Moh Kiew cave assemblage in terms of Number of Identified Specimens (NISP) across layers of the late Pleistocene/early Holocene (LP/EH) and Holocene (HC).

D. Synthesis

The analysis of the faunal remains from Khao Ta Plai reveals complex interactions between taphonomic processes and human subsistence behavior. The bone accumulation was formed by both natural and cultural forces, as seen by the considerable fragmentation and surface changes across all levels. Traces caused by water flow on bone surfaces are abundant in Layer 1/2, whereas in Layer 4, the bones are covered with a veil of calcite that obscures other surface modifications. In contrast, Layer 3 presents traces commonly found in both Layer 1/2 and Layer 4. This suggests that this layer represents a transitional phase between these two layers. At the same time, the presence of some bones, at least in the basal part of the stratigraphy, in anatomical connection indicates that they remained in their primary position and were not suffer much perturbation.

Changes in prey hunting across time can be seen in the faunal composition. The dominance of turtles in Layer 4 indicates that they are the main source of supply at the moment. This could be due to the simplicity of capture, or possibly seasonal availability, or the fact that they are not dangerous to hunt compared to hunting large mammals. On the other hand, Layers 1/2 and 3 show a wider collection of reptiles, including Varanus, as well as medium and large animals like pigs, bovids, and cervids. While the presence of juvenile tortoises *(Indotestudo elongata*) may indicate seasonal hunting or non-selective gathering methods, the targeted hunting of juvenile rhinoceroses and bovids displays selective strategies to avoid dangerous adults. These findings suggest that subsistence strategies were flexible and may have adapted to both prey availability and risk management. These two layers provide a more balanced representation of mammals and reptiles, indicating a broader range of hunting strategies. The study of the assemblage shows that subsistence strategies have evolved across the stratigraphy. In layer 4 (the deepest layer), turtles were abundant while the diversity of other fauna was low. This suggests that the hunters mostly relies on easily accessible species. In the upper layers (3 and 1/2), a broader diversity of animals is shown, which may reflect the higher biological diversity. This may reflect the development of hunting techniques, according to the presence of metal tools that are commonly found in Layer 1/2, while only stone tools were used in Layer 3 and 4, suggesting the advancement and development of hunting tools, along with the knowledge of metalworking, which may have been introduced through exchanges with outside groups. Moreover, the evidence of hunting small terrestrial or arboreal animals, such as monkeys, in Layers 1/2 and 3 suggests the necessity for specialized implements. These may have included poisoned darts comparable to those employed by the Mani or Sakai groups (see Pookajorn 1994), or traps and spears, as implied by the presence of elongated and sharply pointed metal tools. Such findings further demonstrate the advancement of hunting strategies and technological refinement during this period.

Comparison with other regional assemblages highlights both similarities and local specificities. At Doi Pha Kan and Laang Spean, large mammals dominate, with turtles forming an important but secondary component, suggesting a broad hunting focus. Moh Khiew, however, is closer to Khao Ta Plai in its emphasis on reptiles, particularly turtles and varanids, although Moh Khiew contains more medium-sized mammals. Khao Ta Plai is unique in showing a relatively high proportion of large mammals alongside substantial turtle exploitation. This indicates that local ecological conditions and cultural preferences influenced the balance between mammal and reptile exploitation, though regional populations shared an emphasis on reptiles as dependable resources. These could be a result of both cultural preferences for food selection and local biological options, including the presence of large animals near the cave. To conclude, the paleoenvironmental evidence from Layers 4 to 1/2 suggests that the area was initially characterized by a moist evergreen forest with high humidity, where humans primarily exploited the yellow-headed tortoise, an easily available food resource in such habitats. With the onset of the Holocene, rising temperatures facilitated the expansion of tropical vegetation, transforming the landscape into more open grasslands, as indicated by the presence of artiodactyl remains, along with semi-open forests, inferred from arboreal species. Furthermore, the appearance of nearby water sources is reflected in the increasing frequency of freshwater turtle and fish remains from Layers 3 and 1/2 onward.

In Layer 4, only stone tools were recovered, whereas Layer 3 yielded red-slipped pottery, polished axes, and bifacial tools, reflecting both continuity of earlier traditions and the adoption of new technologies, indicating their exchange with neighboring groups. By Layer 1/2, long-distance interaction is evident through finds such as glass and stone beads, metal objects, and Sa Huynh–Kalanay pottery, comparable to materials from coastal port sites like Khao Sam Kaeo, Khao Sek (Chumphon), and Pak Jan (Ranong). These assemblages highlight Khao Ta Plai's role in regional networks shaped by coastal change around the Thai–Malay Peninsula. One of particular importance is the Sa Huynh–Kalanay-related pottery, linked to ceramic traditions across the South China Sea, alongside glass and stone bead ornaments such as carnelian and agate, consistent with Maritime Silk Road traditions. XRF analysis shows the glass beads align with alumina-rich groups also found at Khao Sam Kaeo, Khao Sek, and Pak Jan, supporting the major maritime route of the Kraburi–Chumphon, as well as the presence of metal artifacts that further confirms Khao Ta Plai's participation in long-distance exchange, paralleling finds from Khao Sam Kaeo, Khao Sek, and Phu Khao Thong (Ranong).

5. Conclusion and perspectives

The faunal evidence from Khao Ta Plai Cave demonstrates that prehistoric groups in Mainland Southeast Asia employed varied and adaptive subsistence strategies. Although taphonomic processes such as concretion, water action, and bioturbation shaped the assemblages, clear signatures of human activity remain visible. Layer 4 reflects a strong focus on turtle exploitation, while Layers 1/2 and 3 show broader hunting practices that included large and medium-sized mammals as well as varanids. The selective targeting of juvenile individuals and the presence of small tortoises further indicate nuanced hunting strategies shaped by both ecological and seasonal factors. According to the evidence of faunal and artifact finds from Khao Ta Plai suggests a gradual refinement of hunting technology. In the earliest phase (Layer 4), stone tools were general tool used for hunting. By Layer 3, the exploitation of arboreal animals implies more specialized weapons (i.e., spears or possibly poisoned darts).

In a regional perspective, Khao Ta Plai shares patterns with Moh Khiew in its strong reliance on reptiles, while also maintaining a distinctive component of large mammal hunting. These results emphasize the variability and adaptability of prehistoric subsistence strategies in Mainland Southeast Asia, with hunters responding flexibly to environmental opportunities and constraints. Ultimately, the assemblage from Khao Ta Plai contributes valuable insight into the mosaic of prehistoric lifeways in the region, highlighting the importance of both turtles and mammals in the subsistence economy during the Late Pleistocene and Holocene.

Avenues for Future Research

The site of Khao Ta Plai has yielded various types of archaeological evidence, and many aspects remain underexplored. The complex and unclear stratigraphy makes it challenging for interpretation. Therefore, a comprehensive study of the remaining faunal assemblages from both excavation seasons, followed by a comparative analysis, may provide further insights into spatial use patterns and diachronic changes across the site. Additional dating is underway using compact bone samples from large-sized mammals at the LSCE laboratory (France). In addition, lithic material analysis, including technical and traceological approaches, still must be done to identify material culture differences between layers. Also, further study of the Sa-Huynh Kalanay pottery shards is necessary for contextualize analysis through thin section petrography or typological analysis, which may provide broader insights into regional interaction networks. Additionally, most of the animal assemblages in this study are mainly identified only to the family level due to the limited availability of comparative anatomical reference collections of continental Southeast Asia. Consequently, the development of broader taxonomical criteria will be essential for future research to improve the resolution of species-level identification in future studies.

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