Archaeozoological contribution to the characterization of the stratigraphy of the Upper Pleistocene in Tabuhan layers (Song Terus Cave, Eastern Java, Indonesia)

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Abstract

Song Terus cave is one of the important prehistoric sites in Southeast Asia that presents a long archaeostratigraphic sequence, since the Middle Pleistocene period up to the Holocene. The Tabuhan layers, as an intermediate layer, dated to around Upper Pleistocene period, have an important meaning regarding the problems of faunal composition, human subsistence behavior, and also the problem of *Homo erectus*-sapiens replacement. The appearance of faunal assemblages in a cave associated with some other archaeological remains raises a question relating to human activities. But, the cave activities are more often disturbing the depositional process which can be lead to misinterpretation of the archaeological remains. The aim of this study is to characterize the Tabuhan layers from its faunal remains through archaeozoology and taphonomy approaches, with focus mainly on the large mammals’ remains. The analyses focus on faunal composition, skeletal elements representation, mode of accumulation, and surface modifications (fissures, concretions, and manganese). The results suggest that based on distribution of the archaeological remains the Tabuhan layers can be divided into three levels. Human played a role in the accumulation of faunal remains, but other agents probably take part also for the faunal accumulation. There are still some questions that cannot be answered from this study, such as the butchering techniques and economic strategies of the human groups involved, or when were the human inhabited the cave, and also the question about the boundary between Pleistocene-Holocene period in this site.

Ikhtisar

Résumé
**Introduction**

Regarding human history in Southeast Asia during the Upper Pleistocene, one of the most important phenomena which happened was the replacement of *Homo erectus* by anatomically modern humans (*Homo sapiens*). The appearance of *Homo sapiens* resulted into several cultural phenomena, such as: (1) more extensive settlement all over the archipelagos, even to the most remote parts of Southeast Asia, Western Melanesia, and Australia; (2) intensive occupation changed in the mode of habitation: from life on the open air to activities in the natural niches like caves and rock shelters; and (3) technological development, particularly in lithic and bone technology and subsistence (Simanjuntak, 2006:372).

The Upper Pleistocene period (i.e., the period spanning ca. 130,000 to 10,000 years ago) has come under increasing scrutiny for identifying the origin and spread of modern humans. The origin of the *Homo sapiens* is indicated in Africa from 130,000 years ago and perhaps as early as 190,000 years ago (McBrearty & Brooks, 2000:455).

Excavations in Sri Lanka, South Asia, led to the discovery of remains of *Homo sapiens* at Fa Hien Cave and Batadomba-lena. Through radiocarbon dating it is known that the remains from Fa Hien Cave date ca. 31,000 years ago, and the remains from Batadomba date ca. 28,500 years ago (Kennedy & Deraniyagala, 1989:394). The remains from Batadomba were discovered in the lowermost level and associated with microlithic industries. Moreover, the dating from charcoal remains provides the earliest conclusive evidence for the humans remains that were both anatomically and behaviourally modern within the Indian subcontinent (James & Petraglia, 2005:86).

In Southeast Asia, the evidences of human fossils have been discovered in several sites. In Tabon cave, Philippines, one of the important sites in Southeast Asia, the discoveries of human occupation layers, lithic industries, and human remains have been dated between about 30,500 and 9000 years BP based on $^{14}$C dating on charcoals (Fox, 1970; Détroit et al., 2004:706). Over two hundred burials have been excavated at Niah Cave, Borneo, and the oldest ages for these burials are 42,600±670 BP (Niah 310) (Barker et al., 2007). *Homo sapiens* colonized Australia at least 45,000-42,000 years ago (Bowler & Price, 1998; O’Connell & Allen, 2004:835) and possibly earlier (Thorne et al., 1999:605). Kow Swamp, a site in Australia, has been dated by OSL (optically stimulated luminescence) method and suggests that people lived on the Kow Lake shore between 22,000 and 19,000 years ago around the time of the Last Glacial Maximum (LGM) (Stone & Cupper, 2003:109). There are two dates of Australia’s earliest colonization from a site in Lake Mungo (LM3 skeletal remains), 40-45,000 years ago from $^{14}$C, thermoluminescence (TL) and optically stimulated luminescence (OSL) dating methods (Allen & O’Connel, 2003:8-13) and ≥62,000 ± 6000 years by combination between ESR and U-series dating methods (Thorne et al.,
The latter result remains a disputed issue until now, especially for the older dates because of taphonomic reasons (O’Connel & Allen, 2004:835). The oldest age implies that the people colonized Australia continent during or before marine isotopic stage 4 (57,000-71,000 years).

In Indonesia, there are several sites dated to around 40,000-30,000 BP ($^{14}$C dating) such as Leang Burung 2 (South Sulawesi), Leang Sarru (Talaud Island), Golo cave (Maluku), and a number of caves at Gunung Sewu (Java) (Simanjuntak, 2006:375).

Gunung Sewu area has become known to the prehistorians by the discovery of stone artefacts (called “Patjitanian industry”) in the terraces of Baksoko River by von Koenigswald in 1930s (van heekeren, 1972). Movius (1948) attributed this industry to the Middle Pleistocene period, while Bartstra (1984) consider it as Upper Pleistocene period. Punung, as an area in Gunung Sewu, has several archaeological and paleontological sites dated around the Upper Pleistocene. The Punung Fissure is famous for its Punung Fauna, discovered in fissures which represent a significant faunal change in Java because of the appearance of several extant Southeast Asian species (Elephas maximus, Hyllobates syndactylus, Helarctos malayanus, Pongo) and a single tooth attributed to Homo sapiens determined on the basis of its size (Badoux, 1959; Storm et al., 2005; de Vos, 2007; Westaway et al., 2007). An attempt to know the age of the Punung Fauna has been done by take direct dating from a similar fossiliferous breccias at Gunung Dawung near Tabuhan Cave, called Punung III. The result is the Punung Fauna was deposited no earlier than 128±15 ka and no later than 118±3 ka from thermoluminescence, optically stimulated luminescence, and thermal ionization mass spectrometry methods (Westaway et al., 714-715). The Homo sapiens tooth, found in the Punung Fauna, would imply that Homo sapiens present as early as the last interglacial of MIS 5e (Westaway et al., 2007:715).

Tabuhan cave, also located in Punung, has been identified as a human occupation site of the Upper Pleistocene period as it is demonstrated by the presence of several artefacts and anthropic animal remains ca. 45,000 years ago (Sémah, et al., 2004:60).

There is other site near Tabuhan cave, called the Song Terus cave. This site has a long time span sequence, since the Middle Pleistocene period up to the Holocene, comprise of three archaeological layers; Terus layers, Tabuhan layers, and Keplek layers. The Tabuhan layers, referred to Tabuhan cave because it has the same characteristic of archaeological remains and comparable dating, is an intermediate layer dated back to 30,000 to 80,000 (Hameau, 2004:177; Sémah et al., 2004). Many remains have been discovered from archaeological excavation in this layer (±2 meters thickness) such as faunal remains, fire places, and few artefacts, but only one small bones attributed to homo.

Faunal remains significantly dominated the excavation remains, along with stone remains, in the Tabuhan layers mostly represented by Cervidae and Bovidae. The preservation of these faunal remains is various (from clean surface until fully covered by concretions), but most of the bones conditions are fragmented. This layers documented human activity within the cave by the presence of faunal remains itself, fresh bone fracture, fire places, burnt stones,
and several lithic artefacts (chert flakes and one big andesitic hammer-stone (Sémah et al., 2004:57-58), as well as other traces from other taphonomical agents.

The present study is a contribution to the characterization of the Tabuhan layers, which seem to cover an important part of the Upper Pleistocene. Besides the oldest floors discovered at the top of the Terus layers, the Tabuhan layers represent the thickest Upper Pleistocene archaeological record we have in Song Terus cave. Though characterization of these layers is difficult, stones, especially limestone blocks are very common in the Tabuhan layers and make their stratigraphy somewhat complex for archaeological interpretation of the distribution of the numerous faunal remains, burnt stones and fire places, and of the few artefacts.

This study is a contribution to the archaeozoological study of the Tabuhan layers, and its objective is to try to propose and interpret the archaeostratigraphy of the layers, grounding on the archaeozoological approach of large mammals (taxonomy, fragmentation, and taphonomy).

This study is divided into fourth parts: the first part provides the presentation of Song Terus Site. The second part presents the methodology and proposition of archaeostratigraphy in the Tabuhan layers. The third part presents the analysis of the faunal remains, anatomy and taxonomy composition, taphonomical alteration, and spatial distribution; and the fourth part presents the synthesis of data and comparative study with other results along with the conclusion and perspectives.
Chapter I

Song Terus Site Presentation

1.1 Gunung Sewu

1.1.1 Geographic characteristics

The Gunung Sewu region is located in the eastern part of the Southern Mountains (van Bemmelen, 1949) (figure 1). It is characterized by numerous isolated small hills, as a result of the erosion of Miocene limestone formations (Sartono, 1964; Gallet, 2004:42). Gunung Sewu lies around 80 km, from Pacitan gulf in the east to Oyo River in the west, with 20-25 km wide along the Indian Ocean to the north. Gunung Sewu is a privileged region for prehistoric research because it preserves numerous sites dating from Paleolithic (Pleistocene period) until the Paleometallic period (Holocene period), in open air, fluvialite, cave or rock shelter sites (Simanjuntak, 2002).

![Figure 1. Location of Gunung Sewu and several prehistoric sites (after Waltham et al., 1983; Sémah et al., 2004 and Hameau, 2004).](image)

1.1.2 Research in Gunung Sewu

In the beginning, research was conducted in open air sites. In 1927 van Stein Callenfels reported that there are more than 100 open air sites (Neolithic workshops) in the Punung area, East Java. Then in 1935, Ralph von Koenigswald and MWF. Tweedie conducted a research in Baksoko river terrace and found a Paleolithic assemblage known as
“Patjitanian” (Bartstra, 1976: 75), named from Pacitan town. After them, several researchers continued to study this, de Terra (in 1943 and 1953), Movius (in 1944 and 1953) who establish typology of Pacitanian, van Heekeren (in 1972), Bastra (in 1976), and Soejono (1982).

Von Koenigswald started to study the Song Agung cave in 1936, a rockshelter on the slope of Cantelan Mountain, Punung, and found cultural elements related to the “Sampungian bone industry” (1972:92) During the 1990s, Simanjuntak conducted excavations in the Punung area (Keplek and Braholo caves). In Song Keplek, a cultural stratigraphy was encountered extending from 24,000 to 800 BP with three stages of human occupation. In Braholo cave (near Pracimantoro) the ages range from 33,000 to 3000 BP (Simanjuntak, 2004:18). Furthermore, in Tabuhan cave, an 11 meter deep test pit was excavated and anthropic layers with faunal and artefactual content were discovered, dated by combined ESR/U-series method to around 45,000 BP (Hameau, 2004; Semah et al., 2004:49-60). There is also an underground river that is accessible through a collapse of the roof of the karst near the Tabuhan cave. This river passes under the caves of Tabuhan and Song Terus caves, and contains many Paleolithic tools, which were probably washed out from older cave fillings.

But the Punung area is not only famous for its archaeological sites but also paleontological sites. In 1959, Badoux studied and described the fossil material from two fissures in Punung, from von Koenigswald excavations. Punung I is located near the Song Agung cave, and Punung II, located near the Tabuhan cave (de Vos, 1983; Westaway et al., 2007:710). The age for Punung Fauna is considered no earlier than 128±15 ka (Thermoluminescence and OSL ages, Westaway et al., 2007: 714). The Punung fauna is unique for Java because, first, it represents an actual tropical rain forest environment, contrary to several older faunas from Java, for instance the Trinil fauna (de Vos, 1983; Storm et al., 2005:540), which reflects drier environmental conditions (de Vos, 1983).

The Song Terus site presents an important sedimentary filling consisting of archaeological and paleontological remains. There are three archaeological layers described in this site (from the oldest to the youngest); Terus layers, Tabuhan layers, and Keplek layers. The Terus layers contain lithic industry on big flakes and some from pebbles that deposited since the Middle Pleistocene (±300 ka) (Hameau, 2004:181). But until now, the oldest occupation layer was found in the upper part of the Terus layer and contain burnt stones, fresh broken bones and fresh artifacts, fresh micro-mammals remains and stalagmites. The occurrence of in situ speleothem allowed to undertake accurate U/Th analysis that give an age of ca. 115,000 years ago, which is known as the oldest occupation recorded in Southeast Asia (Semah et al., 2007). The Tabuhan layers lay in the middle of the sedimentary filling and contain numerous faunal remains, several lithic tools, and evidence of fire places dated around 30,000 to 80,000 years ago (Hameau, 2004:181). The Keplek layers, contain a human sepulture, faunal remains, and stone and bone tools attributed to the Holocene period (figure 2).

With the age ranging from Middle Pleistocene up to the first occurrence of Neolithic traditions during the second part of the Holocene along with numerous archaeological and
paleontological remains, it seems that Song Terus site is considered as important site, especially to study about the replacement of *Homo erectus* by *Homo sapiens*.

![Figure 2. stratigraphy section from KI and KII test pits (MQPI)](image)

1.2 Song Terus site

1.2.1 Geography and site description

Song Terus Site is located in Punung, Pacitan, in the East Java Province, Indonesia. Song Terus is one of the caves in Gunung Sewu (Thousand mountains) area. It has an orientation west-east and is 20 m wide, 100 m long, with an altitude of ±330 m at the entrance of the cave (Sémah *et al*., 2004:52) (figure 3).
1.2.2 Research history

R.P. Soejono and Basoeki excavated this cave for the first time in 1953. From this research they found Neolithic artifacts and animal bones, belonging to *Elephas maximus* and primates (Soejono, 1993:93). In 1992, the Centre of Archaeological research, Jakarta, and the *Museum National d’Histoire Naturelle*, Paris, began a collaborative research in Gunung Sewu. Research in Song Terus site itself is conducted since 1994 and still continues today. The purpose of this research is to better understand the Upper Pleistocene settlements in the cave from their material remains.

A complete stratigraphy can be seen from the two test pits: KI, which reached more than 15 meters, located near the entrance of the cave and KII, which is located inside the cave and had to be stopped at ±b 8 meters depth because of the thickness of the encountered block fall (Sémah *et al.*, 2004:52).

1.2.3 Stratigraphy and sedimentology

The stratigraphy of the KI pit begins near the basis by a level of clay more than 5 meters thick, indicating an environment with low energy. Then we find fluvial sediments between 10-4 meters depth, composed of sands, gravels and pebbles, characterized by the presence of ferruginous concretion which give a red color to the deposit. Above 4 meters depth, we find silts and sands marked by the presence of volcanic ashes layer. Two volcanic ashes layer are well marked: the lower one is called layer «J» with black and grey color and 30 to 40 cm thickness and, the in the upper we find layer «G» with grey color and which is
consistently powdery (Galet, 2004:71-72; Hameau, 2004:34-37; Sémah et al, 2004:54) (figure 4). The thick and dense dark grey layer of ashes «J» represents the last fluviatile flood in the cave and is considered as the boundary between the Terus and Tabuhan layers.

1.2.4 Chronology

The lower part of the filling (Terus level) was dated by electron spin resonance (ESR)/U-series dating with two fauna teeth samples, a rhinoceros tooth at 448 cm depth and a tapir tooth at 820 cm depth from KI pit (Hameau, 2007:319). The results from ESR dating provide an age of 254±38 and 341±51 ka for the two teeth that associated with lithic artifacts (Hameau et al., 2007:402).

The Tabuhan level was dated by the same methods and gives an age related to the second half of Upper Plesitocene, between 30 to 80 ka (Hameau, 2004:181).

The Keplek level was dated by \(^{14}\)C from a shell remain found around the burial, above the human skeleton, and on charcoal lenses in the excavation between 5700 and 9400 BP and by U-\(\text{Th}\) methods gives an age between 11,2±0,6 ka (Hameau, 2004:181) (figure 5).

1.2.5 Paleoenvironment

Based on the pollen analysis, the paleoenvironment of the Tabuhan layers was dominated by *Poaceae, Arrecaceae, Casuarina*, and *Moraceae/Urticaceae*. It means that the environment was an open land with dry climate. This environment then changed, as can be clearly seen from the pollen spectra from Holocene Keplek layers with the presence of *Quercus, Podocarpus, Dipterocarpaceae, Castanopsis* and ferns which belong to a rain forest environment (Sémah et al., 2004:58).
Figure 4. Stratigraphy section of KI test pit (Gallet, 2004:73)
1.2.6 Industry

The Terus layers are characterized by a high concentration in lithic artefacts, mostly flakes, retouched or not, patinated or fresh. Flint material dominates over limestone, silicified wood, and andesite.

The Tabuhan layers are poor in lithic industry. Primary materials are flint, limestone and andesite. Some animal bones bear evidence of anthropic activity, and might have been worked to make tools.

The Keplek layers are very rich in lithic and bone industry, and also tools and jewelry from mollusk material. Lithic tools have various types and forms, such as scraper, denticulate, couteau à dos, perçoir and end-scaper (Forestier, 1998). The bone tools of the Keplek layers are points, pins, spatulas, and small adzes (Fadjar, 2006).
1.2.7 Faunal List

a) Carnivores

The carnivores are more represented in the Keplek layers than on the other levels in Song Terus. The *Viverridae* are represented by the palm civet (*Paradoxorus hermaphroditus*). This species was identified from its maxilla and mandibula remains (figure 7) that show similar characteristics with the recent species. Besides cranial remains, we also found post-cranial elements (tibia, humerus, and radius), costae, and isolated teeth.

The *Mustelidae* are identified from mandible remains (figure 7) attributed to *Martes*, and for the post cranial elements by humerus remains which correspond to this species. The *Canidae* are represented by one humerus attributed to wild red dog (*Cuon*). The *Felidae* family is represented by the small-sized of *Panthera pardus*. This species is recognized from maxilla remains (figure 8). There are some isolated teeth identified as cats, but further taxonomical identification still needs to be done.
Figure 7. Mandibula of *Paradoxorus hermaphrodites* (left) and *Martes* (right) from the Keplek layers (MQPI).

Figure 8. Maxilla of *Felidae* from the Keplek layers (MQPI).

In the Tabuhan layers, the carnivores are represented by a complete cranium and mandibula of *Paradoxorus* (figure9), and one phalange determined as a tiger (*Panthera*). The others remains cannot be identified further.

Figure 9. Cranium of *Paradoxorus* found in the Tabuhan layers (MQPI).
b) *Suidae*

The determination of suid species can be only be done from teeth remains. In the Keplek layers, from the characteristic of the last accessory cusp of the talonid, the fossils correspond to the *Sus vittatus – scrofa* (figure 10) morphology. Suids also present in the Tabuhan layers, but are quantitatively less significant. In general, suid remains show similarity in both layers based on the morphology of dental remains and post-cranial bones.

![Figure 10. Canine (a. Keplek, b. Tabuhan) and distal humerus (a. Keplek, B. Tabuhan) from *Suidae* (MQPI).](image)

c) *Bovidae*

This family is well represented for all skeletal elements, except for horncore. There are two genus in Song Terus, *Bos* and *Bubalus*. In the Keplek layers, *Bubalus* is more represented than *Bos*. In K9 square, near the human burial, *Bubalus* is found in quite complete skeletal elements, especially the vertebrae bones found as an almost complete vertebrae column (figure 11). The bovids in the Tabuhan layers are more abundant than in the Keplek ones (figure 12).
Figure 11. An almost complete Vertebrae column found in the Keplek layer (top) and teeth (bottom) from *Bovidae* found in the Keplek layers (Lebon, 2008:82, MQPI).

Figure 12. Vertebrae and teeth remains of *Bovidae* from Tabuhan layers (MQPI).

d) **Cervidae**

The *Cervidae* are represented by three species; Rusa (*Cervus timorensis*), *Axis kuhli*, and *Muntiacus muntjak*. *Cervus timorensis* is the biggest sized *Cervidae* in Song Terus site, but unfortunately no antlers have been found attributed to this species. Meanwhile, *Axis* is determined from a quite complete antler which shows a first tine (characteristic of this animal) (figure 13) with a well developed tubercle, a murrain cylinder, and with thin ornamentation. *Muntjak*, a very small sized cervid, was also determined from some fragments of antler (Figure 13). The three species are presents in the Tabuhan layers (figure 14).
Figure 13. Antler *Axis* (left) and *Muntiacus* (right) from the Keplek layers

Figure 14. Metacarpal of *Cervidae* from the Tabuhan layers

e) **Rhinoceritidae**

Rhinos are only present in the Keplek layers. They are represented by some deciduous teeth, upper incisor, lower molar, and phalanges in the Keplek level. The teeth are characteristic of *Rhinoceros sondaicus* (figure15 and 16).
f) *Elephantidae*

Fragments of cranium, costae, and complete lower deciduous tooth (d4) (figure 17), other fragmental or complete teeth and an adze made on a tusk fragment were discovered in the Keplek layers and determined as an *Elephas maximus* species. The elephant is absent in the Tabuhan layers, but some fragments of cranium and ribs were found in the upper part of the Terus layers.
g) Primates

*Cercopithecidae* family is very abundant in the Keplek layers and represented by two genus, *Macaca* and *Trachypithecus* (figure 18)

Figure 18. Cranium from *Trachypithecus* (bottom) and maxilla and mandibula of *Macaca* (top)

1.2.8 Human remains

Until now, there are no human remains found in Terus and Tabuhan levels (except for the small facial fragment mentioned above). The only human remains are found in the Keplek layers, either isolated scattered remains or the complete skeleton found in the burial. This sepulture is associated with animal remains, lithic industry and also bone industry (figure 19).
Figure 19. Human burial in K9 square from the Keplek layers (MQPI).
Chapter 2

The Tabuhan layers and their Archaeozoological approach

2.1 Methods of Study

2.1.1 Taxonomical and anatomical determinations

Faunal determinations of the Song Terus faunal remains are still under process. This work has been carried out by Anne-Marie Moigne, Rokhus Due Awe, Kasman Setiagama, Mirza Ansyori, and the author of the present thesis. For the purpose of this study, we collected and controlled the previous determinations on faunal remains from the Tabuhan layers and made as new determinations on unstudied remains. This work involving anatomical comparison was done by the help of several anatomical and bibliographical references such as R. Barone (1976), L. Pales and M. A. Gracia (1981), Schmidt (1972), and Hilson (2005).

The determinations are recorded following the database codification established in the Lexique du laboratoire du Muséum National d’Histoire Naturelle, Paris. The faunal remains were identified until various taxonomical levels, depending on the features and possibilities offered by each fossil, such as the fragmentation (proximal epiphysis, diaphysis, and distal epiphysis), portion, zone or face (cranial, lateral, medial, etc), and laterality (left or right).

2.1.2 Age

Age determination aims is to estimate the age of death of the animal. We can estimate the age by observing the teeth wear stage or eruption stage, and the long bones fusion. For estimating the ages, in this study we used the work of A. Forsten and A. M. Moigne (1998) about the degree of eruption and use stage for each tooth. The abrasion can be divided into 7 stages (Forsten & Moigne, 1998):

Stage 1 : corresponds to an indifferentiate dental gum.

Stage 2 : corresponds to a bud including the tooth that is new, with intact occlusal surface for whatever type of tooth. The roots are not formed.

Stage 3 : the tooth wear is just at the beginning stage. The roots are formed but not yet closed. At this stage the tooth reaches its maximum height.

Stage 4 : the tooth is significantly worn but still sharp. The roots are formed but still very thin.

Stage 5 : the height of the crown is reduced by half. The wear surface of the jaw has led to an almost total flattening that affects almost in all types of tooth. The roots are well formed and thickened.
Stage 6: the tooth height falls below one third or even a quarter of the maximum height of the crown. The teeth are very worn and the roots are very damaged and becoming thicker.

Stage 7: the tooth is completely worn out, and virtually only the roots remain. All teeth show full alterations of the roots shape with spongy appearance.

Seven classes of age are identified, which correspond to the degree of tooth wear:

Infantile: corresponds to very young individuals with only deciduous teeth that begin to wear out.

Juvenile: corresponds to young individuals whose teeth are worn; the M1 is begin to erupt.

Sub-adult: the M1 and M2 are worn, the deciduous teeth begin to replaced by the premolars, the second deciduous incisor and canine teeth are about to fall.

Adult 1: the M3 shows the stage of wear 3.

Adult 2: the M3 correspond to the stage of wear 4.

Adult 3: the M3 correspond to the stage of wear 5, the M1 is very worn-out.

Aged Adult: the M1 inferior is worn out, and is represented only by its roots and significantly reduced crown.

2.1.3 Quantification

Quantitative methods can be used to identify and count the material in order to make an interpretation. Different methods have been developed by some authors (Poplin, 1976; Klein & Cruz-UrIBE, 1984; Grayson, 1979; Lyman, 1994 & 2008). Each one is characterized its own set type of data and analysis.

A. Number of Identified Specimens (NISP)

Specimen count is the primary data in analyzing fauna remains. NISP is related to the number of identified specimens which correspond to specific elements of anatomical part (Reitz & Wing, 2008:203). NISP can be used as one category or combined with other methods (e.g. MNE). NISP cannot be used to infer the number of animal individuals in a site because of the fragmentation condition of the remains. Fragmentation makes bias because some elements are more likely than others to be fossilized. The fragmentation of bones can be caused either by natural or anthropic processes and practices, or even both. Human intervention in bone fragmentation is related to the transportation, butchering, distribution of meat, cooking, disposal, and also non subsistence uses (e.g. technological).
B. **Minimum Number of Elements (MNE)**

MNE is derived by determining how many elements are represented by the fragmentary remains, based on the presence of overlapping landmarks features, and hence is not the same as NISP (Reitz & Wing, 2008:226). The elements can be represented for each skeletal element, for example by separating the proximal and distal part of the long bones. The MNE result may be in absolute value or standardized in percentage with respect to the highest MNE.

Different authors have developed their own way to measure MNE (Klein & Cru-Uribe 1984; Bunn, 1986; Marean & Spencer, 1991; Lyman, 1994; Stiner, 1994; Bartram & Marean, 1999). In this work, we calculated the MNE by taking account a more detailed approach of the fragmentation, such as the fragmented parts or faces of the bones, e.g. dorsal, ventral, or lateral side of the fragment.

C. **Minimum Number of Animal Units (MAU)**

Binford proposed this quantitative unit based on his experience with the Nunamiut that suggest that hunters make no discrimination between the laterality of the carcasses. The MAU is defined as the minimum number of animal units necessary to account for the specimens observed, and it is calculate as:

\[ \text{MNEe / number of times e occurs in one skeleton} \]  
(Lyman, 1994)

While the %MAU is the MAU per skeletal portion calculate by dividing all MAU values by the greatest value in the assemblage (Binford, 1978; Lyman, 1994:106).

D. **Minimum Number of Individuals (MNI)**

MNI is defined as the minimum number of individuals which account for all of the skeletal elements (specimens) within a particular species found in a site. High MNI estimates are related to the number of identifiable symmetrical or singular axial elements (Reitz & Wing, 2008:207). To estimate the MNI, it is necessary to consider not only identifications and represented elements, but also age, sex, size, and the archaeological context (Reitz & Wing, 2008:206).

There are several ways to count MNI: 1) from teeth, by taking into account the teeth specificities, their position (superior/inferior), laterality (left/right), and age (based on the eruption and use wear stage); 2)with bones, by taking into account the fragmentation, portion, face, age (ossification), and the number of specific bones in one complete skeleton.

E. **Survival Index/ Percent Survivorship**

Percentage of survival is the proportion of originally present skeletal parts that survived the attritional processes (Lyman, 1994:61). In an archaeological context, the survivorship of skeletal elements is a result of humans’ activity, and the different patterns become important (Daly, 1969:149). Perkins and Daly (1968) called this
phenomena the “schlep effect”: the larger the animal and the farther from the point of consumption it is killed, the fewer of its bones will get “schlepped” back to the camp, village, or other area (Daly, 1969: 149). This quantitative unit is used when one seeks to explain the skeletal parts frequencies as resulting from differential transport or differential destruction, as it has been demonstrated by Kehoe (1967) and Perkins & Daly (1968).

In this study, I used the index of survival from Brain (1969) calculated in an assemblage as:

\[
\frac{(\text{MNE}_e)100}{\text{MNI} \times 100}
\]

For example, in case of ribs, 26 of which are found in a single goat skeleton, the original number contributed by 64 [=MNI] goats must have been 1,664 [=64 x 26], and only 170 [=MNE] have been found, that indicating a 10.2 percent of survival (Brain, 1969:18).

F. **Skeletal representation**

Measuring the abundance of skeletal elements in archaeological assemblages is important for zooarchaeological studies. This measurement not only aims to distinguish natural accumulation from the anthropic one, but is also often used to investigate hominin butchery practices, bone transport decisions, hominin nutritional needs, activity specialization, etc. (Marean & Spencer, 1991:645). In the accumulation caused by natural traps, the bones should be abundant for axial skeletons and the bones should probably be anatomically connected to one another. That is why it is also necessary to observe the pattern of accumulation caused by carnivores and hominids based on the representation and percentage of survival index of the skeletal elements.

Skeletal elements abundances in the context of foraging theory have been studied by Binford, grounding on the ethnoarchaeological approach of Nunamiut hunting strategy (Binford, 1978). He grounds on the fact that the nutritional value of different body parts plays a critical role in determining Nunamiut butchery and transport decisions (Faith *et al.*, 2009:247). Taphonomic processes can destruct bones before and after burial (with the involvement of hominids, carnivores, and other agents). But one needs also to take into account that each agent leaves different traces which result from its own strategy to fulfill its nutritive needs, such as skeletal proportion abundance.

The skeletal proportions in archaeological sites depend on the bias caused by the agents involved in the formation of the deposit (Lyman, 1984). Klein and Cruz-Uribe (1984) assume that the relation between cranial/post-cranial elements and the size of the animal can allow to determine the agent responsible of the accumulation of the faunal remains. According to Binford (1981) and Lyman (1994), the skeletal
representation in archaeological sites helps not only to identify the involved agent but also the timing access to the carcasses. Blumenschine (1986) suggests that the abundance of hind limbs bones indicates a carnivore consumption activity, because carnivores tend to consume hind limbs first. When the ratio between hind limbs and fore limbs is close to 1, or in other words there is no selection for hind or fore limbs, she suggests that hominids are responsible of the accumulation of the assemblage.

The percentage of skeletal representation is calculated for all the bones in one skeleton and by type of fragments, especially for long bones (diaphysis, distal and proximal epiphyses). In this study we used the percentage of MNE frequency of each anatomic element.

2.1.4 Surface modifications

In this study, we observed three types of surface modifications on bones in the Tabuhan layers, particularly in the M10 square: fissures, manganese oxydes, and concretions. After observing the bones, we quantified them following the depth of their find (here we used intervals of 20 cm starting from 220 cm (below the laminations which mark the boundary with the Holocene layers) until the ash layer (layer J) at ±400 cm (ZDu reference).

Fissures are caused by the process by which the original microscopic organic and inorganic components of a bone are separated from each other and destroyed by physical and chemical agents operating on bone in situ (called weathering process), either in surface or within the soil zone (Behrensmeyer, 1978:153). Behrensmeyer (1978) distinguished six stages of weathering by observing the modification on the surface of large mammal bones due to exposure to weathering in African environments. The stages range from 0 (absent), slightly cracking, to splitting (stage 5), because bones become extremely fragile in the later stages of weathering, and may be completely destroyed when the bone structure and consistency is lost (Fernandez-Jalvo et al., 2002:357). In applying weathering stages to fossils, Behrensmeyer made three broad categories: 1) fresh (stage 0), 2) slightly weathered (stage 1-2), 3) weathered (stage 3-5) (Behrensmeyer, 1978:159). In this study we four stages of fissure on bone surface (Lexique du Laboratoire de Prehistoire du Museum National d’Histoire Naturelle, France) to distinguish the weathering modification in the Tabuhan layers. The stages are:

- F0 : no fissure on the bone.
- F1 : fissure presence in thin and discrete line.
- F2 : long and well marked fissure without bone’s deformation.
- F3 : fissure is wide (cracking) and with one longitudinal fragment.

After bones are buried, physico-chemical agents produce important changes in their mineral and organic structure, and in their chemical composition (Denys, 2002:479). The presence of black-colored bones in caves is often associated with human activities, such as the use of fire. Nevertheless, there are many agents apart from fire that can cause the
presence of the black-colored bones, such as the presence of carbonaceous material (soot from torches, lanterns and guano fires; humate; tar; coal-derived organic material and surface vegetation-derived material). But undoubtedly, manganese oxides are the most common coloring agents in caves (Hill, 1982:15-19). By studying manganese we can obtain valuable information about the origin and the sequence of formation of paleontological or archaeological deposits (Lopez-Gonzales et al., 2006:707).

Concretion is also one of the surface modifications that must be considered. This cemented sediment that is heavily attached to the faunal remains usually appears in the karstic fillings. The concretions are caused by deposition of calcite and iron-oxide cements from solutions running through the more or less sandy and permeable filling. The rain water dissolves the carbonates which tend to accumulate around the germs that are constituted by the fossils. In this study, we distinguish three stages of concretion: concretion stage 0 (C0), bones without concretion; C1, bones slightly concretionated, and C2, when the bone surface is covered by concretions.

2.1.5 Mode of Accumulation

The comparison between cranial and post-cranial skeletal remains in an assemblage can be used to determine the agent responsible of the accumulation. This method was introduced by R.G. Klein and K. Cruz-Uribe (1984). Lyman (1984 and 1985) used this method by taking into account the correlation coefficients between the abundance of skeletal parts (MAU) and the bone density, and also the nutritive value (FUI: Food Utility Index of Metcalfe & Jones, 1988). We tried to apply both methods on two main families in Tabuhan layers (Bovidae and Cervidae) in each level of the proposed archaeostratigraphy. But, this is just estimation because of the lack of FUI data that correlated to the Tabuhan species.

2.2 Preliminary Archaeostratigraphical Model of Study

Individualization of levels in the excavated zones is done by computer, and is based on the density of objects. The beds that are relatively dense with objects may indicate occupation levels in the archaeostratigraphy (Sam, 2009:64). This method is particularly useful in the case of uniform filling deposits and has already been used on numerous sites (e.g. Lazaret, le Vallonet, la Caune de l’Arago, Boquete de Zafaraya cave; Canals & Salomo, 1993; Pois, 1998; Valensi, 1994, in Sam, 2009:64).

The first phase of this work was the preparation of the excavation databases (validated database and uniform the depth reference, in this case we used the ZDu depth reference). After, preparation of profiles in the computer, i.e. vertical cross-sections that cut the deposits following longitudinal and transversal directions according to the X and Y excavation grid axis. Simple profiles can be obtained using Excel software.

Grounding on those profiles, we generally can individualize the archaeological levels, as was carried out in the Tabuhan layers. The aim of that observation is to clarify the
distribution pattern of each species, to trace the origin agents of accumulation and therefore the human activities within these levels. In the case of the M10 square, in which we studied all the faunal remains (including smaller sherds), we observed and quantified the surface modifications such as concretions, fissures, and presence of manganese.

2.2.1 Proposition of Tabuhan Archaeostratigraphy

Using the tridimensional position and distribution of the objects (bones, teeth, stones, charcoal, burnt bones and stones, etc) in the excavation area, we can observe the objects associations and propose a sequence of the occupation levels in the Tabuhan layers, beginning with the youngest ones.

**Level A**

The presence of blockfalls and medium-sized blocks make us difficult in defining the upper part level of Tabuhan layers. These blockfalls and also some lenses made the remains scattered and cannot be trace exactly the range depth of this depositional sequence. Based on these phenomenons we defined that the deposition below the lamination carbonates until the abundance of large stones (or in some squares until the presence of the blockfalls) as the uppermost part of the Tabuhan layers and the Level A lay below this level.

This level contains bone remains along with teeth and burnt stones, but less abundant compared to other levels. Besides the presences of bones, teeth, and stones, individualization of this level is also based on the presence of several teeth which can be associated to the same individuals. Individualization of that upper part called Level A is more visible in the L squares (figure 20). It reaches upwards a depth of 200 cm where we find only few scattered remains, especially in L8 square, and cannot be traced in L9 square which is practically sterile. Archaeological remains become more abundant and concentrated at 270 cm. This phenomenon is also visible in M8, M9 and M11 squares (figure 21), but hardly visible in M10 square because of the generally and exceptionally high density of the remains throughout that square. Individualization in M10 square is more visible if we focus on the presence of burnt stones. There is a concentration of burnt stones at 270 cm associated with bone and teeth remains. This individualization is also clearly visible from the L/M 8 and L/M 9 profiles (figure 22 and 23).

The remains become more scarce and scattered from 300 cm until 315 cm. We can see that clearly in L and M squares profiles, and it is even more obvious in the L/M 8 and L/M 9 transversal profile sections.

Based on the features above, we determined that Level A ranges in average from 270 cm until 320 cm at the base. Level A in L squares is at 270 cm until 315-320 cm. The range is the same for the M squares, the only difference being noticed in the M11 square where the Level A upper part is at 280 cm. The presence of faunal remains is very low, especially in the lower part between 309 and 320 cm. There are a
lot of large stones and blocks found in the lower part of Level A. The presence of these blocks makes the archaeostratigraphical interpretation difficult, and also accounts for the relative scarcity of archaeological remains found at this depth. The faunal and other remains probably deposited in the lower part of Level A due to post-depositional influence. The remains were falling down and filled in the spaces between these large stones and blocks.

**Level B**

The upper part of Level B is marked by the increasing number of archaeological remains at 320 cm. This contrast is clearly visible in all squares. In M squares, the upper part of Level B is also marked by the presence of burnt stones and teeth remains, while in L squares, although burnt stones are also present (especially in L9 square), teeth remains are the most visible parameter marking the boundary between Levels A and B.

The density of remains in Level B is clearly visible in all squares and we used this as a reference to determine the beginning of this level. The remains begin to be dense at 350-360 cm. In L squares, Level B begins at 360 cm marked by the density of remains and also the abundance of teeth. In M squares, we also determined by the same features the base of Level B in M8 and M9 at 360 cm, while in M10 and M11 Level B begins at 350 cm.

Based on the features above, the Level B begins at 350-360 cm, before the presence of large stones and blocks, until 320 cm. This Level is characterized by the density and abundance of faunal remains, burnt stones, and small stones.

**Level C**

The boundary between Levels B and C can be seen from the contrast between the abundance of teeth remains at the base of Level B with the sparseness of remains at 350-360 cm. In L squares, the upper part of Level C is at 360 cm, while in M squares it is between 360 cm (M8 and M9) and 350 cm (M10 and M11). The basis of Level C is located between 390 and 400 cm, at the top of the thick dark grey ashy layer J.

Based on the features above, Level C begins at 390-400 cm until 350-360 cm. It contains much less archaeological remains compared to Level B, but more than Level A. The lower density compared to Level B, especially in L8 and M8 squares, is probably due to the presence of big blocks in these two squares.
Figure 20. Longitudinal L8 and L9 squares (axis x=0-25)
Figure 21. Longitudinal M profile (axis x=0-25)
Figure 22. Transversal profile from L/M8 square (axis Y=175-200 cm).
Figure 23. Transversal profile from L/M 9 square (axis Y=0-25 cm).
Figure 24. Level A, B, C in L8 and L9 squares correlate with the stratigraphic profile (after MQPI)
Figure 25. Level A, B, and C in M squares correlate with the stratigraphic profile (after MQPI).
This part presents the archaeozoological study of the Tabuhan layers, including for the M10 square fragmentation analysis, index of survival, and surface modifications, which will be divided in each level from the proposed archaeostratigraphy.

3.1 Representation of Anatomy and Taxonomy

The faunal collection analyzed for this work comes from the excavation of the Tabuhan layers, from six squares (L8, L9, M8, M9, M10, and M11) of ±200 meter depth and 4 m² wide each. In total, 10220 specimens were collected for this analysis, consisting of those which have been well recorded contextually (meaning that each specimen has its own coordinates x,y,z), and the specimens collected from the sieving with only information of depth range and zone. 2440 of large mammal bones have been identified, both taxonomically and anatomically.

3.1.1 Taxonomy

Basically, as highlighted in the previous chapter, the present work consists into both control and new analysis regarding the determination and the identification of the remains under the paleontological and archaeozoological aspects.

The uppermost part of the Tabuhan layers are dominated by the Cervidae (74%), followed by the Bovidae (19%), Suidae (3%), and Viverridae (1,3%).

In the defined Levels, Artiodactyls are represented by three family; Cervidae, Bovidae, and Suidae. Cervidae are dominant in all levels: 69% in Level A, 73% in Level B, and 80% in Level C for the percentage of NISP. The cervids consist of three genus; (1) Cervus, the biggest Cervidae, probably Cervus (Rusa) timorensis, (2) Axis, medium-sized Cervidae, and (3) the smallest, Muntiacus, probably the Muntiacus muntjak.

The Bovidae are represented by two genus, Bubalus and Bos. NISP percentages show 26% in Level A, 25% in Level B, and 18% in Level C. Suidae and carnivores are very less represented in the Tabuhan layers. Suidae are more represented in Level A by 4% and less than 2% in Level B and C., while the carnivores are; (1) the Viverridae, (0,2% in Level A and B, and absent in Level C), and (2) the Felidae, represented only in Level A by one remain (0,11%).

For conclusion of faunal representation; the Bovidae are less represented at the base of Tabuhan (Level C) and are equally more numerous in Levels A and B, while the Cervidae are more represented at the base of the Tabuhan layers, in Level C and slightly decrease towards
the upper part of the Tabuhan layers. The *Suidae* are less represented in Levels B and C and much more represented in the upper part of the Tabuhan layers, in Level A. The carnivores only appear in Levels A and B. These faunal distributions characterize open woodland.

<table>
<thead>
<tr>
<th>Level A</th>
<th>Fauna</th>
<th>NISP</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovidae</td>
<td>236</td>
<td>26,19</td>
<td></td>
</tr>
<tr>
<td>Cervidae</td>
<td>622</td>
<td>69,03</td>
<td></td>
</tr>
<tr>
<td>Suidae</td>
<td>40</td>
<td>4,44</td>
<td></td>
</tr>
<tr>
<td>Viverridae</td>
<td>2</td>
<td>0,22</td>
<td></td>
</tr>
<tr>
<td>Felidae</td>
<td>1</td>
<td>0,11</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>901</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 and Figure 26. Taxonomy representation based on %NISP in Level A

<table>
<thead>
<tr>
<th>Level B</th>
<th>Fauna</th>
<th>NISP</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovidae</td>
<td>245</td>
<td>25,13</td>
<td></td>
</tr>
<tr>
<td>Cervidae</td>
<td>712</td>
<td>73,03</td>
<td></td>
</tr>
<tr>
<td>Suidae</td>
<td>16</td>
<td>1,64</td>
<td></td>
</tr>
<tr>
<td>Viverridae</td>
<td>2</td>
<td>0,21</td>
<td></td>
</tr>
<tr>
<td>Felidae</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>975</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 and Figure 27. Taxonomy representation based on %NISP in Level B

<table>
<thead>
<tr>
<th>Level C</th>
<th>Fauna</th>
<th>NISP</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovidae</td>
<td>104</td>
<td>18,21</td>
<td></td>
</tr>
<tr>
<td>Cervidae</td>
<td>458</td>
<td>80,21</td>
<td></td>
</tr>
<tr>
<td>Suidae</td>
<td>9</td>
<td>1,58</td>
<td></td>
</tr>
<tr>
<td>Viverridae</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Felidae</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>571</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 and Figure 28. Taxonomy representation based on %NISP in Level C
3.1.2 Anatomy

The percentage representation of each anatomical element is calculated based on the MAU. We calculate it by dividing the MAU of each element with the highest MAU and multiply it by 100. For example, the mandibula MAU of Cervidae in Level A is 0.5 and the highest MAU of Cervidae in Level A is 6.63, so the representation is \((0.5/6.63) \times 100 = 33.3\%\).

**Bovidae**

The Bovidae are represented by all elements of their skeletal anatomy. The cranial elements are very poorly represented and highly fragmented, except for the isolated teeth. The vertebral columns are also very poorly represented, as only several vertebrae could be determined in detail. Member anterior elements are long bones, well-represented by their diaphysis, while the scapula is well-represented by its cavity glenoid and spinal scapula, and the carpal elements are often found complete. The member posterior elements are long bones, also well-represented by their diaphysis, the pelvis represented by its acetabulum and ilium fragments, the tarsal elements are found as complete bones, except the calcaneus which is sometimes fragmented.

The graph of anatomical representation shows that Bovidae are well-represented in Levels A and B (Figure?). The cranial elements are well-represented by isolated teeth, while the fragile elements, such as costae, vertebrae, and scapula are very rare in all levels. Member posterior elements are better represented than the member anterior elements, especially by the diaphysis elements. The presence of the phalanges is more significant in Level A than in the others levels.
Cervidae

The Cervidae are also present with all skeletal elements. Cranial skeletal elements are dominated by isolated teeth remains. The cranium is represented by small fragment of antlers, ear bone, and occipital fragments. Three maxillas are represented with teeth still attached, one of them belonging to a young individual. Several elements of mandibula are present with teeth still attached, and we found also processus coronoid fragments and ramus mandibular fragments.

The vertebrae and ribs are very rare and difficult to identify. Ribs are mostly represented by their corpus parts, and few articulation parts have been found.

The member anterior elements are the scapula, represented by its articulation part and some specimens found complete. The long bones are mostly represented by the diaphyses, except for the radio-ulna which is more represented by the proximal part. There is a complete bone belonging to a young individual identified from its unfused epiphysis. The carpals are represented by all elements, the scaphoid and capitatum-trapezoid are the most represented.

The member posterior is represented by all elements. The pelvis is mostly represented by the acetabulum. The long bones are well-represented by diaphysis elements, and only few proximal and distal part are present. The epiphysis parts are more abundant for the tibia than for other long bones. Two patella elements were found complete. The tarsals were found complete with all their elements. The phalanges (anterior/posterior) are found with all elements and often complete.

The graph of anatomical representation shows the comparison of the skeletal elements in each level. The cranial elements are well represented by isolated teeth, especially in Levels B and C which are more abundant than in Level A. The ribs and vertebrae elements are less-represented in all levels. The comparison between anterior and posterior elements cannot be
seen clearly, except for the metapodials where the metatarsals are more represented than the metacarpals. The phalanges show similar representation as for the *Bovidae*, more numerous in Level A.

![Graph showing anatomical representation of cervids based on %MAU](image1)

**Suidae**

Only 70 specimens can be determined as *Suidae*, two cranium fragments, one maxilla, one mandibula with teeth still attached, three vertebrae elements and several ribs, nine teeth, and several post-cranial elements. This family is more represented in Level A by bone remains, while in Level B teeth remains are dominant.

![Graph showing anatomical representation of Suidae based on %MAU](image2)
**Carnivores**

The *Viverridae*, determined as *Paradoxorus hermaphroditus*, are only represented in the Level A by post-cranial elements, and in Level B by one humerus and one canine tooth. The only *Felidae* remain is a canine tooth found in Level A.

### 3.1.3 Number of Complete Long Bones

The number of complete long bones is very small in the Tabuhan layers. In Level A, *Cervidae* present two metapodial, one radio-ulna, and 108 phalanges; *Bovidae* show only 23 phalanges and 6 phalanges of *Suidae* are found complete. In Level B, there are 14 phalanges of *Cervidae* and 4 phalanges of *Bovidae* found complete, and only one complete humerus of *Paradoxorus*. In Level C, there are only 5 phalanges of *Cervidae* and 2 phalanges of *Bovidae* found complete, together with one femur and one complete tibia belonging to carnivores.

### 3.2. Age

Numerous isolated teeth and some series of teeth which are still attached to the jaw fragments allow us estimate the age of the animals. The *Bovidae* are present in all ages, except aged-adults, while adults are dominant (especially the sub-adults). Young individuals are present in Levels A and B, with one individual each, and one infantile was found in Level C.

The *Cervidae* are more represented in Level B, with 11 individuals, and 13 individuals in Level C. In general, adult individuals dominate in the repartition of cervids in all levels (22 individuals). The aged-adults are only present in Levels A and B, while young individuals are represented by 5 individuals in total. No infantile specimen was found.

<table>
<thead>
<tr>
<th>Level</th>
<th>Infantil</th>
<th>Juvenil</th>
<th>Sub-adults</th>
<th>Adults 1</th>
<th>Adults 2</th>
<th>Adults 3</th>
<th>Aged-adults</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
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<td>2</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>17</td>
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**Table 4. Repartition age of *Bovidae***

<table>
<thead>
<tr>
<th>Level</th>
<th>Infantil</th>
<th>Juvenil</th>
<th>Sub-adults</th>
<th>Adults 1</th>
<th>Adults 2</th>
<th>Adults 3</th>
<th>Aged-adults</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
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<td>1</td>
<td>6</td>
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<td>B</td>
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<td>C</td>
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</table>

**Table 5. Repartition age of *Cervidae***
3.3 Index of Survival

Index of survival or percentage of survival is calculated by counting the frequencies of bones that have survived some destructive or attritional processes (Brain, 1969; Lyman, 1994:62). The purpose is to explain the skeletal parts frequencies as results from differential transport or differential destruction (Lyman, 1994:62). Here, to calculate the % of survival, we used the equation introduced by Brain (1969):

$$\frac{MNEe}{MNI \times 100}$$

First, the percentage of survival is quantified for each skeletal elements, before we globalize the approach into different anatomical categories: cranial skeleton (skull and mandible), axial skeleton (vertebrae and ribs), stylopods (humeri and femora), zygopods (radii, ulnae, tibiae), basipods (carpals and tarsals), metapods (metacarpals and metatarsals), and acropods (phalanges).

**Bovidae**

The survival index of the *Bovidae* is higher for the post-cranial elements in all levels. The stylopods elements are the most represented, especially in Level A humerus (75%) and femur (37.5%); for zygopods elements we find radio-ulna (25%) and tibia (50%). The axial skeletal elements have the lowest survival index in all levels, below 8% for the vertebrae elements, and only less than 1% for costae.

The difference between cranial/post-cranial elements is more significant in level A, while in Levels B and C the results are more similar. Among the long bone elements, the stylopods and zygopods show significant differences with the metapods in Level A (more similar in Levels B and C). But in Level B metapods are the most highly represented elements.

<table>
<thead>
<tr>
<th>Anatomy</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
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<td>10</td>
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<td>AXIAL</td>
<td>2,88</td>
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<td>5,56</td>
<td>6,25</td>
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<td>12,5</td>
</tr>
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<td>ZYGOPODS</td>
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<td>25</td>
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<td>2,27</td>
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<td>18,75</td>
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<tr>
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<td>4,63</td>
<td>3,125</td>
</tr>
</tbody>
</table>

Table 6. Survival index of *Bovidae*
**Cervidae**

The cranial elements are well represented in Level A, especially by the mandibles. The axial elements, like for the *Bovidae*, have the lowest survival index with less than 4% for each skeletal element. The girdles (scapula and pelvis) are more represented by the scapula in all levels. The long bone elements (stylopods, zygopods, and metapods) show a significantly different representation between levels, these elements being highly more important in level A. In Level C, long bones are very poorly represented. The acropod elements are more likely to be found in Level A than in Levels B and C.

The comparison between cranial and post-cranial elements shows significant differences in Levels A and B (more significant in Level A). But in Level C, there is no significant difference between cranial and post-cranial elements. For example, between cranial and stylopods/metapods (which have the same index) the discrepancy is 7.69/9.62. With reference to the zygopod elements (which have the highest survival index in Level C), the difference is more significant (7.69/17.31).

<table>
<thead>
<tr>
<th>Anatomy</th>
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<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
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Table 7. Index survival of *Cervidae*

We may compare the survival index for anatomic segments of *Bovidae* and *Cervidae* in each level. In Level A, the index of survival between cranial and post-cranial is comparable in both families. The axial elements represent the lowest value for all elements. The girdle elements are more represented for the *Cervidae*, although the value is still low. The long bones show a big difference for the zygopods and metapods elements, which are more represented for the *Cervidae*. The articulation bones (basipods) are very rare in both families. The acropod elements are more represented for the *Cervidae*, even though they still show a quite high value for the *Bovidae*. 

45
Table 8. Index survival of *Bovidae* and *Cervidae* in Level A

In Level B, the comparison between cranial and post-cranial elements shows a dominance of post cranial elements for the *Cervidae*, but almost similar frequencies for the *Bovidae*. The long bones are more represented for the *Cervidae* regarding all elements. The metapods are the most represented elements in both families. The basipods are poorly represented, and the acropods are also very rare, a difference with Level A where those elements are more significant.

Table 9. Index survival of *Bovidae* and *Cervidae* in Level B

In Level C, the comparison between cranial and post-cranial is not very noticeable. The differences can only be seen between cranial and zygopod elements in both families. The axial elements are very poorly represented, and the girdles are more represented for the *Cervidae* than for the *Bovidae*. In general, the long bones are very poorly represented in both families.
Table 10. Index survival of *Bovidae* and *Cervidae* in Level C

In conclusion, the indexes vary between Level C and A, indicating a differential preservation of bones in the related layers. The low indexes for girdles and long bones elements show that the condition of the remains is highly fragmented in the lower part of the Tabuhan layers, and becomes less and less fragmented when reaching the upper part.
<table>
<thead>
<tr>
<th></th>
<th>Bovidae</th>
<th>Cervidae</th>
<th>Suidae</th>
<th>Viverridae</th>
</tr>
</thead>
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Table 11. Index of survival in the Level A
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Table 12. Index of survival in the Level B.

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</tr>
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<td></td>
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</table>

Table 13. Index of survival in the Level C.

3.4 Surface Modifications

The bone remains in the Tabuhan layers have recorded several important modifications on the surface, such as fissure/cracking, mineralization (concretion), and manganese. These modifications could be caused when the bones were exposed (before burial), or in the soil (post-depositional alterations). The samples used to observe these
surface modifications are the bone remains from the M10 square, because (1) M10 has the most abundant archaeological remains, and (2) the square is located in the middle of the excavation area. M10 was also the most carefully excavated square as humid sieving began quite late during the several yearlong excavation program.

A. Fissures

We distinguished four stages of fissure on bone surface (*Lexique du Laboratoire de Prehistoire du Museum National d’Histoire Naturelle*, France). The stages are:

F0 : no fissure on the bone.
F1 : fissure presence in thin and discrete line.
F2 : long and well marked fissure without bone’s deformation.
F3 : fissure is wide (cracking) and with one longitudinal fragment.

Based on the chart and cluster analysis we can group the various chosen depth ranges according to the pattern of fissuration for the different stages F0 to F3. Similarities are noticed between depth ranges 260-279 cm and 340-379 cm, and also between 280-319 cm and the lowermost part of the Tabuhan layers (380-399 cm). 320-339 cm and 240-259 cm show more specific fissuration patterns.

In the lowest part (380-400 cm) of the Tabuhan layers, none of the bones shows the F3 stage, and only several present fissures on the surface. Between 340 and 379 cm, the appearance of fissures on bones is similar between the F0, F1 and F2 stages and only slightly different for F3 stage (more bones with F3 stage in 360-379 cm). Between 300 and 340 cm the presence of bones with fissures increases. Between 280 and 299 cm the presence of fissures decreases in a more or less similar way with the appearance of fissures at 340-359 cm. Between 240 and 279 cm there are more fissured bones, especially bones with F3 stage (8%), the highest percentage for F3 stage throughout the sequence.

<table>
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<th>ZDu (cm)</th>
<th>F0</th>
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<th>F2</th>
<th>F3</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NR</td>
<td>%</td>
<td>NR</td>
<td>%</td>
<td>NR</td>
</tr>
<tr>
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<td>300-319</td>
<td>87</td>
<td>71,31</td>
<td>12</td>
<td>9,84</td>
<td>17</td>
</tr>
<tr>
<td>320-339</td>
<td>179</td>
<td>70,47</td>
<td>51</td>
<td>20,08</td>
<td>18</td>
</tr>
<tr>
<td>340-359</td>
<td>372</td>
<td>80,87</td>
<td>48</td>
<td>10,43</td>
<td>30</td>
</tr>
<tr>
<td>360-379</td>
<td>227</td>
<td>79,37</td>
<td>27</td>
<td>9,44</td>
<td>17</td>
</tr>
<tr>
<td>380-399</td>
<td>46</td>
<td>76,67</td>
<td>6</td>
<td>10,00</td>
<td>8</td>
</tr>
<tr>
<td>1082</td>
<td>186</td>
<td>110</td>
<td>54</td>
<td>1432</td>
<td></td>
</tr>
</tbody>
</table>

Table 14. Frequencies of bone with fissures in M10 square
Figure 1. Cluster analysis from fissures data

Figure 2. Proportion from different stage of fissures in the Tabuhan layers.

A. Concretions

The concretions can be classified into three stages; C0, bone without concretion, C1 with slight concretion, and C2 when the surface is covered by concretions. Based on the simple chart and cluster analysis we can see that there is a correlation between the depth and the appearance of concretions in the Tabuhan layers. From the base until 300 cm, most of the bones surfaces are not covered with concretions. The percentage of bones with concretions (C1 and C2) is less than 30%. Only at 360-379 cm we find a slight
increase to 40%. In the upper part, the number of bones with concretions significantly increases and continue until 240 cm.

If we consider concretion stage 2 as an important criteria, because it means that the circulation of water in the site is important, we can see that the C2 stage is present with 6,7 to 11,9 %, then slightly decreases at 360 cm and gradually increases to the top.

<table>
<thead>
<tr>
<th>ZDù (cm)</th>
<th>C0 NR</th>
<th>C0 %</th>
<th>C1 NR</th>
<th>C1 %</th>
<th>C2 NR</th>
<th>C2 %</th>
<th>TOTAL NR</th>
</tr>
</thead>
<tbody>
<tr>
<td>240-259</td>
<td>19</td>
<td>25,3</td>
<td>11</td>
<td>14,7</td>
<td>45</td>
<td>60,0</td>
<td>75</td>
</tr>
<tr>
<td>260-279</td>
<td>34</td>
<td>37,4</td>
<td>31</td>
<td>34,1</td>
<td>26</td>
<td>28,6</td>
<td>91</td>
</tr>
<tr>
<td>280-299</td>
<td>23</td>
<td>27,4</td>
<td>47</td>
<td>56,0</td>
<td>14</td>
<td>16,7</td>
<td>84</td>
</tr>
<tr>
<td>300-319</td>
<td>94</td>
<td>77,0</td>
<td>21</td>
<td>17,2</td>
<td>7</td>
<td>5,7</td>
<td>122</td>
</tr>
<tr>
<td>320-339</td>
<td>189</td>
<td>74,4</td>
<td>52</td>
<td>20,5</td>
<td>13</td>
<td>5,1</td>
<td>254</td>
</tr>
<tr>
<td>340-359</td>
<td>386</td>
<td>83,9</td>
<td>59</td>
<td>12,8</td>
<td>15</td>
<td>3,3</td>
<td>460</td>
</tr>
<tr>
<td>360-379</td>
<td>173</td>
<td>60,5</td>
<td>79</td>
<td>27,6</td>
<td>34</td>
<td>11,9</td>
<td>286</td>
</tr>
<tr>
<td>380-399</td>
<td>42</td>
<td>70,0</td>
<td>14</td>
<td>23,3</td>
<td>4</td>
<td>6,7</td>
<td>60</td>
</tr>
<tr>
<td>960</td>
<td>314</td>
<td></td>
<td>158</td>
<td></td>
<td></td>
<td></td>
<td>1432</td>
</tr>
</tbody>
</table>

Tableau 15. Frequencies of bone with concretions in M10 square.

Figure 35. Proportion of concretion in M10 square.
C. Manganese

Based on the chart and cluster analysis of the presence of manganese, we can see that at the base of the Tabuhan layers until 340 cm manganese presence is between 20-30%, then increases to almost 49% at 320-340 cm. At depths between 280 and 320 cm, the presence of manganese is not significant (<18%). It significantly increases at 300 cm until the top, especially at 240-259 cm where 72% of the bones surfaces show traces of manganese.

<table>
<thead>
<tr>
<th>ZDu (cm)</th>
<th>Manganese</th>
<th>Non-manganese</th>
<th>TOTAL NR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NR</td>
<td>%</td>
<td>NR</td>
</tr>
<tr>
<td>240-259</td>
<td>54</td>
<td>72</td>
<td>21</td>
</tr>
<tr>
<td>260-279</td>
<td>39</td>
<td>42,86</td>
<td>52</td>
</tr>
<tr>
<td>280-299</td>
<td>12</td>
<td>14,46</td>
<td>71</td>
</tr>
<tr>
<td>300-319</td>
<td>21</td>
<td>17,21</td>
<td>101</td>
</tr>
<tr>
<td>320-339</td>
<td>124</td>
<td>48,82</td>
<td>130</td>
</tr>
<tr>
<td>340-359</td>
<td>129</td>
<td>28,04</td>
<td>331</td>
</tr>
<tr>
<td>360-379</td>
<td>91</td>
<td>31,47</td>
<td>196</td>
</tr>
<tr>
<td>380-399</td>
<td>12</td>
<td>20</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td>482</td>
<td>950</td>
<td>1432</td>
</tr>
</tbody>
</table>

Table 16. Frequencies of manganese in M10 square
3.5 Mode of accumulation

According to Klein and Cruz-Uribe (1984), who compared hyena and anthropic sites of the Pleistocene in South Africa, the relation between cranial and post-cranial elements and the size of the animal let us determine if the agent responsible of the accumulation of the faunal remains were humans or carnivores in the Tabuhan layers.

There are two causes which may account for the fact that the skeletal parts of a species can diverge: first, the agent may selectively destroy certain parts in dismembering or consuming a carcass, and second, it may carry the most portable or desirable parts to another locality, leaving the less portable or less desirable parts at the carcass site (Crus-Uribe &
Klein, 1984:64). Human decisions in transporting the carcass are different with the behavior of the carnivores. Humans can transport one carcass, or the cranial part of large mammals, while carnivores can only transport cranial parts of small or young animals.

Many authors developed other methods to explain the difference in abundance of skeletal elements, whether in relation with the decision of transporting or with the nutritive value of the anatomical part (Binford, 1984; Metcalfe & Jones, 1988). Lyman (1984) claims that the bone density is one of the factors responsible for the imbalance of skeletal representation. He documents an inverse correlation between the density of the elements and their nutritive value. The elements with high utility have a low density and are therefore destroyed faster.

To estimate the importance of these factors, we propose to calculate the correlation between the abundance of skeletal elements (%MAU) with the density of bone, and also with its nutritive value (Food Utility Index). We used the density of caribou for Cervidae, and the density of bison for Bovidae (Lyman, 1984, 1994). Regarding FUI, we used the FUI of caribou for Cervidae (Metcalfe & Jones, 1988) and utility indices of bison (by Emerson, 1990 in Lyman, 1994).

**Cervidae**

In all Levels, the correlation between the faunal abundances (%MAU) and the density is constantly correlated, between 0,38 and 0,50. But, on the contrary, there is no correlation between the faunal abundances and the utility indices (FUI).

Regarding the utility indices, the abundance of remains is very poor for the bones that have a high nutritive value. This is probably caused by the intensive fracturation to extract marrow from the bones (Figure 38).

**Bovidae**

In all Levels, the correlation between the faunal abundance and the density is poorly correlated, between 0,05 and 0,2, and there is no correlation between the abundance of fauna and the utility indices (-0,06 and -0,33). The negative relation between the skeletal elements and the nutritive value is probably cause by an intensive fracturation (more intensive than in the case of the Cervidae) by humans (figure 38).
Figure 39. Skeletal element abundance against bone density and utility values for *Cervidae* and *Bovidae*. 
Based on Klein and Cruz-Uribe (1984), the presence of different skeletal elements representation in the Tabuhan layers can be interpreted as follows:

The low ranked utility parts (cranial, axial, basipods, and acropods) are very poor represented, while the high ranked utility parts (stylopods and zygapods) are well represented for the Bovidae and especially for the Cervidae. The significance of the high index of survival of metapod elements has to be considered with caution: it can be linked to a better preservation, but the easy determination of such fragments (especially due to the presence of a dorsal median line) might significantly increase the number of such bones in NISP. The presence of all skeletal elements of these large mammals (cervids and bovids) in all levels, according to Klein and Cruz-Uribe, can be accounted for human activity, and the differences in survival index for each skeletal part is probably due to human decisions in transporting the carcass based on the size of the animal.

It seems that for the Cervidae, high representation of girdles (higher than for Bovidae) and long bones in Levels B and C is linked to human activity in the Tabuhan layers: they transported the long bones with the girdles still attached. But this is not the case for the Bovidae, where the girdle elements are poorly represented. This is probably because it is more easy to transport the long bones with girdles in the case of a medium-sized herbivore (in this case the Cervidae), than for large-sized ones (Bovidae).

![Figure 40. Representation of Index survival in Level A](image1)

![Figure 41. Representation of Index survival in Level B](image2)
3.6 Time Access

As already mentioned, according to Binford (1981) and Lyman (1994) the skeletal representation in archaeological sites is not only used to identify the involved agent but also the timing of access to the carcasses. The human selective transport of anatomical parts is the result of primary and immediate access, and there are no differences between hind and fore limbs (Binford, 1981; Blumenschine, 1986; Bunn, 1993; Rosell, 2001: 174).

Hominids tend to remove the bones from the extremities when the access to the animal body was primary and immediate, and leave the axial skeletons and the skull behind (Behrensmeyer and Boaz, 1977; Binford, 1978; Bunn, 1981). When the time access is secondary or late, then the skeleton parts in the camp site often contain of a great amount of axial skeleton and skull, and we notice a significant lack of stylopod and zygopod elements. Carnivores also tend to carry axial skeleton more than hominids (Kruuk, 1972; Brain, 1981; Hill, 1989; Blumenschine, 1991; Blumenschine and Marean, 1993).

In the Tabuhan layers, the ratios between fore limbs/hind limbs is close to 1 (1,35 in cervids and 0,92 in bovids) (table 17). This ratio fits enough with Blumenschine’s suggestion and we can infer that hominids were the agents of accumulation in the studied layers and that the access to the bodies were not delayed (primary access). The pattern fits both with the skeletal representation and the ratio of fore-limb hinds of the Tabuhan layers, leading to a model of differential transport by hominids.
Table 17. Ratio between fore/ hind limbs

<table>
<thead>
<tr>
<th>MNE CERVIDS</th>
<th>MNE BOVIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fore limbs</td>
<td></td>
</tr>
<tr>
<td>SCAPULA</td>
<td>19</td>
</tr>
<tr>
<td>HUMERUS</td>
<td>21</td>
</tr>
<tr>
<td>RADIUS</td>
<td>28</td>
</tr>
<tr>
<td>ULNA</td>
<td>8</td>
</tr>
<tr>
<td>METACARPAL</td>
<td>28</td>
</tr>
<tr>
<td>Hind limbs</td>
<td></td>
</tr>
<tr>
<td>PELVIS</td>
<td>4</td>
</tr>
<tr>
<td>FEMUR</td>
<td>16</td>
</tr>
<tr>
<td>TIBIA</td>
<td>21</td>
</tr>
<tr>
<td>METATARSAL</td>
<td>32</td>
</tr>
</tbody>
</table>

3.7 Conclusion

The abundance of faunal remains in the Tabuhan layers, which mainly consist of *Cervidae* and *Bovidae*, were accumulated by humans. The age of death from these large herbivores dominated by adult individuals indicates a selection by human in hunting activity. Humans transported parts of the carcasses and in the case of *Cervidae* probably brought back the limbs with the girdles still attached.

The long bones representation, which counts more diaphysis than epiphysis parts (in NISP) does not indicate carnivore activities in the assemblages. The low representation of long bones epiphysis was probably causes by humans while extracting the marrow from the bones. This explains why the representations of elements with high nutritive value are very poor in the assemblages.

From the surface modifications we can assume that the bones in the Tabuhan layers show a better conservation in the lower part, where the bones have less fissures, less concretion, and show less oxidization by manganese.
Conclusion and Perspective

In this chapter we shall attempt to correlate all the results that we have already obtained in various levels and contexts, and also compare them with other studies.

1. Level C

This level lays between 360 and 400 cm (ZDu reference) with 6203 archaeological objects found (excluding those recovered in sieving). From the horizontal longitudinal profiles, the objects are more concentrated in L9, M9, and M10 squares. In M8 square, whose excavation is not complete, the presence of big blocks disturbed the deposition of the remains, which are concentrated between Y=100-200 cm and X=200-250 cm.

Limestone artifacts, pebble, and chert are more present in this level than in others. Burnt stones also present even though not very significant as in Level B.

Large mammals in this level are dominated by Cervidae (80% NISP), followed by Bovidae (18%) and Suidae (<2%). There were no carnivores found in this level. The present high representation of Cervidae and the low representation of Bovidae help to infer an open forest environment.

The ages of the animals show a high representation of adults, 3 individuals of Bovidae and 11 individuals of Cervidae; while the young-aged fauna is composed of 1 infantile Bovidae and 2 juvenile Cervidae. The dominance of adult individuals is considered as evidence that humans were responsible of their presence in this level.

The human activity also accounted for the differences in the representation of skeletal elements, where long bones are more numerous than other elements, both for the Cervidae and the Bovidae. The skeletal elements are not well preserved; even though all skeletal elements are present, their representation highly depends on their fragility. Bones that are more fragile, like the scapula, pelvis, vertebrae and costae are very less represented.

Regarding bone abundance, there does not seem to show any relation between the abundance of a specific bone and the nutritive value of the concerned anatomical part of the body. Bones with high density are more likely found, and their high fragmentation level can be accounted for either human activity (e.g. marrow consumption, an assumption supported by the presence of several clear impacts) or mechanical fragmentation just after the deposition.

The fissures are very less frequent on the bones at the base of this level, but several bones show a high stage of fissuration in the upper part. We can assume that
the depositional process at the beginning of Level C was fast, and underwent a change around the upper part of that level.

The concretion stage is not significant in this level. Many bones do not show any concretion on their surface (60-70%), meaning that the circulation of water was not significant. This observation is supported by the scarcity of manganese traces.

2. LEVEL B

This is the richest and dense level that lays between 315 and 350 cm (ZDu) in average and consists of 11,287 archaeological objects. The objects are more concentrated in L9, M9 and M10 squares. This level is characterized by the abundance of burnt stones, especially in L9 and M9 squares. 1.9% supposed artifacts were found and other remains (charcoals, chert, pebble, and speleothem) only represent less than 0.04%.

5063 faunal remains were recorded from this level, dominated by Cervidae (73% of NISP), followed by Bovidae (25%), Suidae (1.6%), and Viverridae (0.21%). The ages of the animals are also dominated by the adults, 8 individuals of Bovidae and 7 individuals of Cervidae. The young-aged fauna is represented by 3 individuals, 2 Cervidae and 1 Bovidae, while the aged-adults are represented by two Cervidae. The abundance of the Bovidae may correlate with the increase of the dryness in climate.

The representation of skeletal elements does not show any significant difference among the Bovidae, whose metapodial elements only are highly represented. Regarding the Cervidae, the representation of post-cranial elements is significantly different between the cranial and axial elements. That differential representation supports the assumption of human presence in Level B. In the case of Cervidae, the high representation of associations girdle indicates that humans probably brought back whole legs (the girdle still attached with the zygopod).

As for Level C, there is no relation between the abundance of a specific bone and the nutritive value. In the case of Bovidae, the negative relation between the abundance and nutritive value indicates that long bones fracturation was more intensively practiced by human to extract marrow.

The deposition of Level B probably happened fast, because there almost 80% of the bones do not show fissures. The bones covered with concretions are even fewer than in Level C, indicating a much reduced water circulation.

3. LEVEL A

This level lays between 270 and 320 cm (ZDu), and contains 5204 archaeological objects. The objects are more concentrated in L8, L9 and M10 squares. Besides bones and stones, several artifacts and burnt stones are also found in this level.
In the faunal remains, less isolated teeth were found in this level compared to the lower ones, but more jaws were found. The fauna is dominated by *Cervidae* (69% of NISP), followed by *Bovidae* (25%). More *Suidae* were found (4%), and carnivores are still scarce: *Viverridae* (0.2%), and *Felidae* (0.1%).

Fewer individuals were found in this level, 4 *Bovidae* and 6 *Cervidae*. The *Bovidae* consist of 1 juvenile, 2 sub-adults, and 1 adult; the *Cervidae* consist of 1 juvenile, 4 adults, and 1 aged-adult.

The representation of skeletal elements is different in this level. Cranial and acropod elements are frequent, especially for the *Cervidae* (88%). The taphonomical observations account for both human and carnivore activity: human activity might be reflected by the presence of all skeletal elements of *Cervidae* and *Bovidae*, while the high representation of phalanges and different representation of fore limb and hind limb indicate the presence of carnivores.

The fissures are important in this level: more than 40% of the bones show fissures on their surface (12% with stage 2 and 8% with stage 3), suggesting that the depositional process was probably slower than for other levels. The concretions significantly increase in this level, on more than 70% of the bones, indicating important water circulation in the upper part of the Tabuhan layers, and supported by the higher presence of manganese oxides.

As already mention before, we defined Level A until 270 cm marked by the last presence of large stones and the collapsed-blocks (clearly visible in L8 and L9 squares). The diversity in the distribution of remains in each squares and the presence of lenses make the Level A end at the 270 cm depth does not continue to the entire sequence. On top of this Level A until the laminated carbonate layer, lays another deposit which could be attributed as the uppermost part of the Tabuhan layers. This level contains several archaeological remains, with various distributions in each square. The presence of these collapse-blocks makes some difficulties to make interpretation of this deposit.

**Conclusion**

The Tabuhan layers consist of three levels of archaeological deposit. The lower part begins at 390-400 cm depth, mixed with the upper part of black-ash layer (layer J). There are two big block of limestones, one is located in the front entrance (L8 and M8 square), and another one in M11 square. Several medium-sized blocks also fill in the surface, especially in L9, M9, and M10. This lower part ended at 350-360 cm and replaced by new level. The middle part contained more medium-size blocks than the lower level. Some of the limestones show some burning traces and composed a structure like a fireplaces. The medium-sized blocks were scattered and gradually decrease from the base to the top in the middle level.
which ended until 320 cm depth. Above the middle level the sediments deposited until 270 cm where a very big blocks lies in this upper level.

The depositional processes begin fast in the lower part and increasing in the middle part, but then become slower in the upper part. This phenomenon showed by the presence of the fissures on the surface of the specimens. The sediment filled in the surface of the cave soon before the specimens lost their moisture, and the humidity from the sediment preserves the specimens from the dryness. In the upper part when the depositional process becomes slower, and the humidity was increasing, make very bad preservation for the specimens. The bones were highly affected by the taphonomical modifications in the upper part, while in the lower part of the Tabuhan layers is not too significant.

Regarding the deposition process of the Tabuhan layers, we can easily assume that the layers containing many blocks were influences either by collapses induced by earthquakes, which are quite frequent in the area, belonging to the inner volcanic Sunda arc, a region of high seismicity. On the other hand, it seems difficult to discard any palaeoclimatic interpretation of the blockfalls, as the desquamation of the cave walls is very important, and any karstic activity increase during a humid period may also result into blockfalls. Whatever the case, it seems that the actual entrance of the cave was located several meters in front of the extant one before the blockfalls, i.e. during early Tabuhan phase. There is a high probability that the remains found in the lower layers, i.e. Levels B and C, underwent some reworking from their original place situated near the entrance of the cave. Then they were transported following a solifluxion process to their present place. A comparable phenomenon was observed (Sémah, 2003) for the Keplek horizons in the cave, in the KII pit.

During the depositional processes of the three levels, the fauna composed by the domination of Cervidae and Bovidae, with only small quantities of Suidae and Carnivores (Felidae and Viverridae). We believe that the presence of the different species from cervids and bovids may mark the type of the local environment. The cervids show balanced frequencies in the whole levels, while the bovids has a tendency to increase. The increasing of suids specimens arise a question from both environmental and cultural point of view. This very adaptive and most reproductive animal was underrepresented at the lower and middle levels, and slightly increase compare with the two dominated family. Some species from Cervidae and Bovidae have a similar biotope with the suids, which probably belong to the Sus vittatus. Their low representation in the Tabuhan levels arise a question about their preferable biotope or human decisions to acquire and transported the body part of this animal to the cave.

There are several bones show a carnivores marks on their surface such as one long bone from Cervidae in Level C, 3 long bones from Level B (two Bovidae and one Suidae), and 3 long bones and 1 vertebrae from Cervidae in Level A. we could assume that the carnivores, probably as well as rodents, play a small role in the accumulation of the assemblage. The unbalanced proportions of the animal skeleton parts from the cranial, axial, and appendicular, as well as no complete body of animal found in the Tabuhan layers, are two supporting facts the evidence of human activities related to the animal. The lack of complete body of animals also supports the assumption that the bodies were transported partially to the
cave. The correlation between the density and %MAU from the dominant animals suggest a high degree of fragmentation of the skeletal elements. Even though the post-depositional can give affect also to the fragmentation of the skeletal elements, but the presence of the intentional fracture as well as the striation supported the assumption of the human activities to the elements.

We believe that the anthropisation during the Tabuhan layers can be used as a remark of the Upper Pleistocene record in Song Terus cave. Human transported the part of the animal bodies to the cave and exploited them. This also supported by the presence of some pieces of elements that used as tools. Some specimens with sharp edge as well as other specimens with pointed and wedge tips show as a utilization marks, i.e. crushing of the tip, polished, and lost of the angularity. During the Tabuhan layers, the underrepresented of silicified limestone-based artifact and the presence of limestone supposed-artifact were associated with the presence of the bone-based tools.

**Perspective**

After this present work, we could see better the Tabuhan layers in Song Terus. This Upper Pleistocene record present us three main different depositions based on the faunal assemblages with the contribution from the others archaeological remains. Their poor represented taxa are correlated with the Punung Fauna, but these animals were lies on the archaeological context with human intervention. Three levels have been determined in the Tabuhan layers, and characterize an anthropic layer of occupation with different representation of animals and their skeletal elements. The faunal assemblage also lies on the local climatic changes from a dry phase to drier phase, but entered to the wet phase in the upper part. The limit of Pleistocene-Holocene is still under question that cannot be observed through the archaeological record in this present work, which has a depth range between the beginning of the Tabuhan layers until 270 cm just before the occurrence of the lamination carbonate layers. We also need to carry on the research to reconstruct the mode of human activities during the occupation on the three subsequent levels. It is necessary to observe the human traces in the specimens to identify the human action to the animal parts. For example, how they butchered the animals, is there any differences among groups of animals (their taxa and size), and when were they inhabited the cave (a question of seasonal activity).


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