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TAPHONOMY AND PALEOECOLOGICAL SIGNIFICANCE OF THE AILUROPODA-STEGODON COMPLEX OF BAN FA SUAI (NORTHERN THAILAND)

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Abstract: Since the description of the complex *Ailuropoda-Stegodon* as a faunistic association with chronological signification for South-East Asian area, no consideration was done to evaluate the melting of faunas pointed out by De Vos. The taphonomical study of the cave of the Monk (Ban Fa Suai, Northern Thailand) brings evidence of sequential deposits with ecological significance.

Keywords: Thailand, Fauna, Panda, Pongo, Stegodon, Paleoecology.

Introduction

A specific association of Mammals called the Sino-malayan fauna by Von Koenigswald (1938-1939) but more commonly termed the *Ailuropoda-Stegodon* fauna complex is described as an indicator of the Upper Middle Pleistocene in South-East Asia (Granger 1938; Bien, Chia 1938; Pei 1938; Kahlke 1961). This faunistic group includes Asian taxa endemic or strongly associated with tropical environments. This complex includes a Proboscidean fossil lineage: the Stegodon, Asian Elephant, different kinds of Rhinoceros, the large primates *Gigantopithecus* and *Pongo* and also numerous species of Suids, Cervids and Bovines. The most common Carnivora are Hyena, Tiger, Panther, Cuon and Tibetan Bear but also Giant Panda.

This particular faunistic complex was initially identified in South China (Matthew, Granger 1923) in connection with tropical taxa such as *Hylobates* and *Tapirus*. Then later the same complex was found in Vietnam (Patte 1928), Laos (Fromaget 1936), Burma (De Terra 1938), Cambodia (Beden, Guérin 1973) and Thailand (Pope *et al.* 1981; Ginsburg *et al.* 1982). It is associated with the so-called Indochinese biogeographic area that spreads from the Yangtse River (Pei 1957) to Isthmus of Kra (Tougard 2001). This association is mostly present at sites in karstic areas. Some sites were once swallow holes, like the Yenchingkuo site (Granger
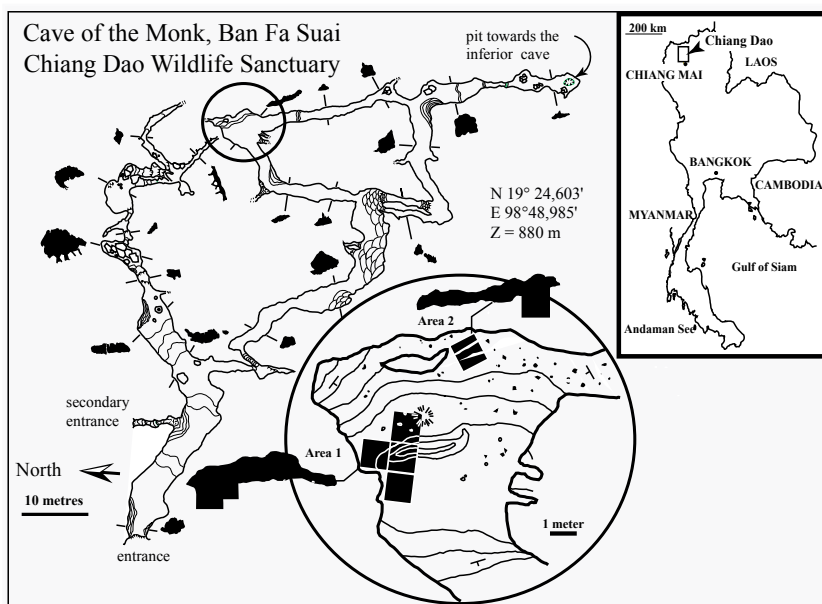

Figure 1: Location of the site of the Cave of the Monk (Ban Fa Suai I).

Cave of the Monk	Area 2	Area 1	surface	NtdR	Cave of the Monk	Area 2	Area 1	surface	NtdR
Primate indet.	1			1	Suids indet.	10		4	14
Macaca sp.	3	8		11	*Sus* sp.	119	150	21	290
Macaca cf *assamensis*		1		1	*Sus* cf *barbatus*	5	1		6
Macaca cf *nemestrina*		1		1	*Sus* cf *scrofa*	34	16	5	55
Macaca cf *andersoni*		1		1	**total of Suids**	168	167	30	365
Pygatrix cf *neamus*		1		1	Bovidae indet.	33	28	1	62
Hylobates sp.		1		1	*Bos* sp.	39	54	17	110
Pongo cf *pygmaeus*	1	3		4	*Bos* cf *gaurus*	9	3	4	16
total of Primates	1	16		21	*Bos* cf *javanicus*	8	6	2	16
Carnivora indet.	6	4		10	*Bos* cf *sauveli*	10	5	2	17
Cuon cf *alpinus*	1	1		2	*Bubalus* cf *arnee*	1		2	3
Cuon sp.	1	3		4	*Pseudoryx* sp.	4	1	2	7
Canidae indet.		4		4	**total of Bovins**	104	97	30	231
Ursidae indet.	3	5		8	Cervidae indet.	27	21	5	53
Ursus cf *thibetanus*	10	6		16	*Cervus* sp.	7	20	2	29
Ursus cf *malayanus*	3			3	*Cervus* cf *eldii*	3	5		8
Ailuropoda cf *melanoleuca*	3	4		7	*Cervus* cf *unicolor*	20	12	9	41
Arctyonyx cf *collaris*	1			1	*Cervus* cf *nippon*	1			1
Lutra sp.	1			1	total of big Cervids	58	58	16	132
Panthera cf *tigris*	1	1		2	*Axis* cf *porcinus*	2	4	2	8
Hyaenidae indet.	1			1	*Muntiacus* sp.	40	42	4	86
total of Carnivora	31	28		59	*Muntiacus* cf *muntjak*	26	10	6	42
Proboscidae indet.	2	19		21	*Muntiacus* cf *vuquangensis*	1			1
Stegodon sp.	6	6	2	14	total of small Cervids	69	56	12	137
Elephas sp.	6	14		20	**total of Cervids**	127	114	28	269
total of Proboscideans	14	39	2	55	Naemorhedae indet.	116	47	15	178
Perissodactyla indet.	10			10	*Naemorhedus* cf *caudatus*	2			2
Rhinocerotidae indet.	109	102	6	217	*Naemorhedus* cf *goral*	2			2
Rhinoceros cf *unicornis*	1	1		2	*Capricornis* cf *sumatraensis*	8	11	4	23
Rhinoceros cf *sondaicus*	1			1	*Capricornis sumatraensis* cf *kanjereus ?*	1			1
Rhinoceros cf *sinensis*	5	6	1	12	total of Naemorheds	129	58	19	206
Dicerorhinus cf *sumatrensis*		2		2	Artiodactyla indet.	535	659	57	1251
Tapirus sp.	4			4	**total of Artiodactyla**	1063	1095	164	2322
total of Perissodactyla	130	111	7	248	total number of tooth	1414	1462	191	3067
Rodent indet.	131	154	6	291	total number of tooth	1414	1462	191	3067
Hystrix sp.	20	8		28	bones	235	153	6	394
Hystrix cf *brachyura*	18	11	12	41	tympanic bones	30	23	3	56
Atherurus cf *macrorurus*	1			1	fragment of tooth indet.	56	112	14	182
Muridae indet.	1			1	fragment of dentine indet.	8	2		10
total of Rodents	171	173	18	362	Total	1743	1752	214	3709

Figure 2: Listing of the faunal remains of Ban Fa Suai I.

1938); others are sinkholes such as at Longuppo (Wanpo *et al*. 1995). Most of the sites, however, are caves (Liucheng, Hoschangtung, Maba, Zhoukoudian, etc.). The sites are highly important for an understanding of the Pleistocene in South-East Asia, and all the more so because human remains were found which could provide crucial information regarding the dynamics of peopling of this part of the World (Brown 2001). The faunistic series from these sites is being used to establish a regional biostratigraphy (Kahlke 1961; Han, Xu 1985; Tougard 1998) and is a useful tool for reconstructing evolutionary scenarios in these environments (Tougard, Montuire 2006). The Cave of the Monk (Ban Fa Suai I) site, discovered in northern Thailand, is a new paleontological site. The approach we developed for its excavation has led to interesting paleoecological data and our findings suggest that a reinterpretation of earlier paleontological sites in South-East Asia may be appropriate.

The characteristics and limitations of South-East Asian pleistocene paleontological sites

Despite being interesting for numerous reasons, a detailed examination shows that the paleontological series from different sites in South-East Asia are poorly documented. Generally, reports of excavations of this kind of site only include lists of fauna and data such as the position of all the remains in the site, the description of the stratigraphy of the deposits, or the documentation of other remains other than determinable bones and teeth (coproliths, surfacial state of bones, etc.) are lacking.

The first reason for this lack of data is historical. Indeed, in this region of the world excavations are either old or modern methods are still not used. One of the first excavations was at Yenchingkou (Granger 1938). Prior to this, Pleistocene fauna was only known from Chinese drugstores where remains of fossil hominids, *Pongo* or *Gigantopithecus* (Schlosser 1903) were discovered. Despite the momentum generated by the Zhoukoudian site in the 1920s, it was only at the end of the 1970s that a project was developed to fully document Asian sites and attempt to determine the origin of the bony assemblages (White 1975).

The second reason for the lack of complete data is because this goal is difficult to reach. As emphasized by Pope *et al*. (1981) numerous sites were already plundered by Dragon bone collectors. Therefore preserved sites where a detailed excavation can be undertaken are rare. Furthermore, new sites are hard to find due to their often hidden nature and difficult access.

A major limitation to the thorough exploitation of known sites is also the fact that there is little existing data on which to base criteria for the identification of the origin of the accumulated remains. Thus the mechanisms involved in human remain deposition, biases linked to the formation of the sites and the limitations of paleoenvironmental information are rarely discussed (Simons, Ettel 1970; White 1975). The issue of site deposition is central to the interpretation of the significance of the faunal assemblages. In most cases authors considered assemblages as homogeneous in terms of chronology and environmental origin.

Following Patte (1928), De Vos (1984) assessed that Indochinese paleontological assemblages are a faunal mixture from different periods and environments. This was also the case in the famous cave of the *Gigantopithecus* in Liucheng (Pei 1957; Kahlke 1961). At that site, remains of *Pongo pygmaeus*, a modern taxon adapted to forest environments, were found associated with bones of species typical of the Ancient Pleistocene such as the archaic *Stegodon praeorientalis*, and species from open environments such as the ancient horse *Equus yunnanensis* (De Vos 1984). In the case of the Hsinganshien cave, Pei (1935) associated faunal material collected with fossils bought in the drugstores because their provenance seemed to be the same « *Yellow Deposit* ». Young and Liu (1950) also lumped together the remains from several caves to make their series as long as they came from « *the brecciated yellow*
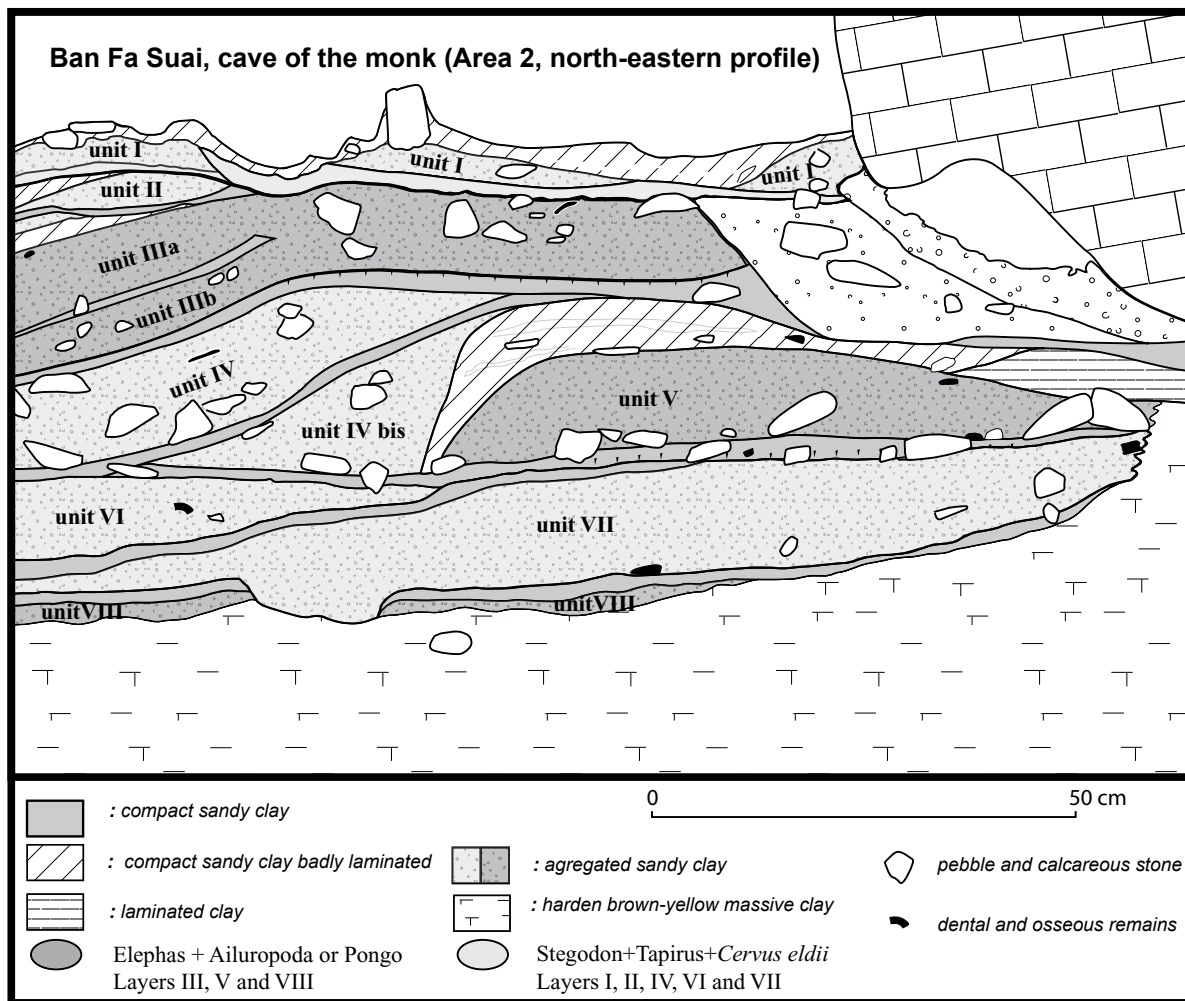

Figure 3: Biostratigraphic units of the Cave of the Monk (Ban Fa Suai I).

UNIT I	UNIT II	UNIT III	UNIT IV	UNIT V	UNIT VI	UNIT VII	UNIT VIII
Stegodon sp.	Stegodon sp.	Elephas sp.	Stegodon sp.	Elephas sp.	Stegodon sp.	Stegodon sp.	Elephas sp.
	Tapirus sp.	Ailuropoda sp.	-	Pongo sp.	Tapirus sp.	Tapirus sp.	Ailuropoda sp.
	Cervus eldii	-	Cervus eldii	Cervus eldii	Cervus eldii		
			Macaca sp.	-	Macaca sp.		
			Sus barbatus	Sus barbatus	Sus barbatus		
			Pseudoryx sp.	Pseudoryx sp.	Pseudoryx sp.	-	Pseudoryx sp.
		Capricornis sp.	Capricornis sp.	Capricornis sp.	Capricornis sp.	Capricornis sp.	Capricornis sp.
	Bos gaurus	-	Bos gaurus	Bos gaurus	Bos gaurus	Bos gaurus	
	Naemorhedus goral	Naemorhedus goral					

Figure 4: Faunistic assemblages of the Cave of the Monk (Ban Fa Suai I).

clay type » (*op. cit.* : 46). The site of Tham Khuyen contains deposits from several periods in the form of different breccia fragments scattered around the cave walls. However, in his published faunistic listing, Cuong (1992) does not relate remains to the specific breccia shreds in which they were found. Astonishingly the stratigraphy of this site published by Ciochon *et al.* (1996) does not refer to this complexity and only illustrated a unique fossiliferous deposit settled under a calcite floor. This may be a Vietnamese tradition since at Ma U'Oi, Bacon *et al.* (2004, 2006) did not hesitate to mix faunistic corpus found in different spots in the site. A mixture seems also to be the case in the Tham Winam Nakin cave where authors noted the association of ancient (Middle Pleistocene of Kahlke) and recent (Final and recent Middle Pleistocene of Kahlke) elements. The figures reached by direct dating (Esposito *et al.* 2002) which range from 8,000 to 350,000 years also point to mixed fauna which a taphonomic study by the initial instigator of the excavation of the site could have avoided.

Towards more reliable data

The absence of data on the mechanisms of deposition in existing sites, led us to the conclusion that important advances could be made by excavating and extensively studying new sites. A few projects have been undertaken with this aim in China (Bakken 1997; Schepartz *et al.* 2001, 2003). In Vietnam, sedimentological studies of the Tham Khuyen (Ciochon *et al.* 1996) and Ma U'Oi (Bacon *et al.* 2004) caves have been published. In Ma U'Oi, the authors concluded that a fluviatile accumulation of bones occurred in the endokarst. Nevertheless, biases in the composition of the assemblage related to this kind of deposition mechanism (Voorhies 1969) were not noted. Nor was the exclusive preservation of teeth *versus* bones in relation to this kind of deposition discussed. It seems unlikely that this differential preservation could be caused solely by a fluviatile phenomenon.

Bakken (1997) did carry out a compared taphonomic study on six Chinese sites among which two are found in the Indochinese area: Yenchingkou and Longuppo. The first site is a swallow hole and the second is a sinkhole among which « *the representation and condition of the Longuppo fossils also recall the assemblages from Yanjinggou [Yenchingkou], where carcasses accumulated in vertical passages, the result of predation and falls* » (Wanpo *et al.* 1995: p. 275). Nevertheless, the results obtained can not be extended to the whole of South China where the majority of sites are caves. Finally, taphonomic and geological approaches were not undertaken conjointly on any site.

Due to these limitations, the articles written remain anecdotal and no synthetic model or general rule can be derived from research into the formation of the paleontological sites in the karstic context of South-East Asia. The biases which influenced the accumulation of bones are unknown as are the limitations of the usefulness of the collected series for documenting the biostratigraphy, recontructing paleoenvironments, or providing evidence of human activity in the past. For these reasons, the mechanisms involved in the formation of these paleontological sites remain to be elucidated in spite of their importance for our understanding of the fauna and environment present in this part of the world during the Pleistocene.

In this paper, we present the results of a pluridisciplinary approach carried out in the Cave of the Monk in Ban Fa Suai, northern Thailand. We analysed both geological and taphonomic data to describe the deposition mechanisms in the cave and derive a reliable paleoecological scenario.

Materials and Methods

The Cave of the Monk was discovered near the village of Ban Fa Suai, 80 kilometres north of Chiang Mai at an altitude of 900 metres in one of the satellite calcareous massifs of the Doi Chiang Dao (Zeitoun *et al.* 2005) (Fig. 1). The Cave of the Monk is situated in the highest section of a karstic network of which only the lower section is active. The main entrance to the cave is in a sheer rocky wall on the side of the mountain. During excavations in two sections covering a total surface area of 5 m², we collected 3709 paleontological remains 100 metres from the entrance. The remains were discovered in the first 50 centimetres of relatively soft and well-stratified sediment (see Lenoble *et al.*: 46 for complete description of the sedimentology and taphonomy of the deposits and remains). The location of all remains was recorded and all remains were collected. We also sifted the deposits with water and a 1.3 mm wide-mesh sieve and after drying all artefacts held by the sieve were kept.

The fossil material is made of 12% of bone (most of them are pieces of 1.5 cm long) and only 11% of the dental remains are complete teeth. About 50% of the complete teeth are gnawed. Overall, **24** genera and **38** mammalian species including **3** rodent genera were identified. The determination rate at the genus level was high: 31.6 %. But it was only 9.1 % at the species level. In the faunistic listing (Fig. 2) the term « cf » specifies that the identification was made using the closest present-day taxon. The assemblage includes Stegodon: a species only found in the fossil record and Panda and Pongo: two species which have now vanished from this area. According to this data the fossil assemblage belongs to the *Ailuropoda-Stegodon* complex. The absence of archaic species at the site, suggests that the assemblage could be similar to the fauna found at Yenchingkou II, which pertains to the Upper Pleistocene of southern China according to Han and Xu (1985). Nevertheless it is not possible to fully assert this fact because the modern Hyena : *Crocuta crocuta ultima* that typically replaced *Hyena sinensis* (Kurten 1956; Ginsburg *et al.* 1982) during this period was not found in the Cave of the Monk.

Composition of the faunistic assemblages and their significance

The specific profile of faunistic assemblages, and specifically the assignment of Carnivores within the series, can be determined by examining the ratio of Carnivores to Ungulates. According to Cruz-Uribe (1991) the ratio of Carnivores/Carnivores+Ungulates is characteristic of a Carnivores lair. The value for a Hyena lair is above or equal to 20 %. In the Cave of the Monk this ratio is 2.3 % and does not significantly change from one area to an other in the chamber (Table 1). Usually this ratio is calculated using the minimum number of individuals (MNI). In this study, however, due to the very fragmentary state of the collected remains, we did not use the MNI which would have led to an underestimation of the ratio. Instead, we chose to use the number of taxonomically determined remains (Ntdr) at the genus level. This does not modify the number of Carnivores represented in the assemblage. Among Carnivores that can gather big mammal bones, we found only one piece of Hyena tooth, two Tiger dental fragments, and six Cuon dental fragments out of a total of several thousand remains. Among Carnivores, Bear were the most significant with 27 determined remains including 16 attributed to the Tibetan Bear.

Many agents can contribute to the accumulation or the alteration of remains and consequently disturb attempts to reconstruct the original environment (Monchot 2006). From the regional point of view it is interesting to observe the variability in finds of some remarkable species. Thus the absence of Hyenids is

noted in some sites, and suggests that the Hyena lair hypothesis, held by many authors, is weak. The sites in the neighbourhood of Koloshan in southern China are a good example even though this series is said to be one of the richest in Asia (Young, Liu 1950). Similarly, in the Tham Khuyen cave in Vietnam (Cuong 1992; Schwartz *et al.* 1994), and in all the sites of Lang Son, Tam Pa Loi and Houec Oi in Laos (Beden *et al.* 1972) or the Wuyun cave, Guangxi (Chen *et al.* 2002) no Hyena or Tiger were found. Among Carnivores, the Cuon is considered as the potential bone gatherer in the study of the Cave of the Gigantopithecus (White 1975). The Cuon was present at Ban Fa Suai but this Carnivora is not systematically identified in South-East Asian paleontological sites. For example it was absent at Tham Wiman Nakin (Tougard 1998). The Bear is omnipresent in the sites and could theoretically be a potential gatherer of *Ailuropoda-Stegodon* complex bones. Nevertheless, as with other Carnivores, this taxon is often represented by only a few remains which is too low compared to the amount usually found in a lair (Cruz-Uribe 1991).

Pei (1935) argued that the abundance of *Sus* remains implies human involvement in the constitution of assemblages. Von Koenigswald (1952: 299) also noted that numerous Suids dental remains characterised the material found in Chinese drugstores: « *There were no horse, but many of the porcupine and Sus* ». The prevalence of Boar was also observed at Lang Trang but the authors did not reach any firm conclusions regarding this discovery (Long *et al.* 1996).

In the Thai sites studied by Tougard (1998), the frequency of *Sus* was 13 % at Tham Phra Kai Phet and 8 % at Tham Wiman Nakin. In both cases Cervids and Bovines were more common which is different from our finding in the cave of the monk where Suids accounted for one third of all the Artiodactyls (the most common taxon found) collected. In an area at the back of the cave chamber, where the record is the most complete, the distribution of identified remains is the following: 0.5 % Primate, 1.4 % Carnivora, 1.3 % Proboscidean, 6% Perissodactyl, 56.1 % Artiodactyl (including 34,1 % Suidae, 21.5 % Bovinae, 25.1 % Cervinae and 19.2 % Caprinae) and 8.8% Rodents.

As previously reported (Lenoble *et al.* this volume: 46), at the Cave of the Monk the excavated remains were preferentially associated with layers of coarse aggregates and stones which indicates that they have filled in basins made by a burrowing animal.

	Area 2	Area 1	Total in the cave
Ungulates	1,193	1,206	2,570
Carnivores	31	28	59
Ratio Canivores / Ungulates + Carnivores	2.5 %	2.3 %	2.2 %

Table 1: Number of remains of Ungulates and Carnivores collected in the Cave of the Monk (NRDt) and ratio Carnivores / Ungulates + Carnivores. The total includes the remains collected at the entrance of the room.

Therefore, we can see that our geological and taphonomic studies of the Cave of the Monk converge to describe a porcupine lair.

Ethological studies made on material gathered by porcupines showed that it is reliably representative of the environment close to the porcupine's habitat (Brain 1981). The wide diversity of fauna found in the Cave of the Monk assemblage reflects this characteristic. The quality of porcupine accumulations, judged in terms of its environmental representativeness, can be briefly compared to accumulations made by other animals. The environmental representativeness expected in a Hyena lair is low because Hyena do not bring the biggest taxa (Proboscideans or Rhinoceros)(Tong 2001) or even small mammals back to their lair. This means that quantitative methods, such as cenograms (Legendre 1989), which aim to determine the ecology of the ancient environment (open *versus* forested, arid *versus* humid) by examining the distribution range of animal weight found in lairs, are of minimal interest especially if applied on Hyena lair remains.

Several aspects of the paleontological material collected at Tham Wiman Nakin are comparable with our discovery, thus we would like to suggest that the origin of the assemblage is probably similar to that of the Cave of the Monk and is probably not due to Hyena as proposed by Tougard (1998). This conclusion actually gives more legitimacy to the recent palecological study carried out by Tougard and Montuire (2006) on Tham Wiman Nakin.

Other limitations of cenograms are related to both the period of time represented in the fossil record and the spatial organisation of the fossil remains. If neither of these aspects, that is the temporal or spatial characteristics of the remains, are precisely determined and taken into account then the result is a tenuous ecological picture and a landscape mosaic**.**

Depending on the precautions taken during the excavation to appreciate the different steps during the deposition of the material and the possibilities of direct dating this material, the ecological conclusions will be more or less vague.

Apart from the artificial mixtures of fauna by researchers, already criticised by Patte (1928) and De Vos (1984), which have led to erroneous paleoecological and biostratigraphic findings, there is also a real problem related to the chronology of paleontological sites in South-East Asia. Direct radiophysical dating on fauna samples has been rarely done. Most of the time dating was done on speleothems and extrapolated to the fauna without any evidence of the relationship existing between the remains and the speleothem (Esposito *et al.* 1998 ; Bacon *et al.* 2006). Indeed, no taphonomic work has been undertaken.

The Cave of the Monk material was collected following an appropriate procedure for identifying sedimentary structures and a joint geological and taphonomical approach provided evidence of the dynamics of the deposition process which followed a sequence of ten distinct phases (Fig. 3).

Elephant and Stegodon remains have not been found together in some sites (Young, Liu 1950). This was also the case in the Cave of the Monk where the presence of these taxa appears to be mutually exclusive. The described faunistic series of each stratigraphic unit can be interpreted to produce a presence/absence "binary" signature, where for example, two different faunal assemblages will record individual signatures that have a good chance of having an ecological value. Thus the genus *Ailuropoda* and *Pongo* are only present with *Elephas*. On the other hand, Eld's Deer, Tapir and Macaques are preferentially associated with *Stegodon* (Fig. 4). It was necessary to go back to the primary taphonomic data (Lenoble *et al.* this volume: 46) to note that among the material gathered by porcupine, there is older and newer material mixed in during the burrowing of the lair. This phenomenon disrupts the homogeneity of each stratigraphic unit. The work made by Stockton (1973) described the implications of such alterations. The material is spread from lower layers to upper layers which masks the original recording and especially the sharp shifts in the faunal series composition found in each stratigraphic layer. Nevertheless, despite the potential mixture of the material, in the Cave of the Monk the recorded signature in two different assemblages suggested that a reliable, high resolution recording of paleoecological signification was still possible, indeed we could decipher clear cut signatures for a sequence of ten distinct layers.

Conclusion

Although the pluridisciplinary approach we carried out in the cave of the monk did not lead to sensational results and the work was heavy going, we believe that it exemplifies the rigour needed to analyse the paleontological sites of South-East Asia for ecological purposes. The nature of the *Ailuropoda-Stegodon* complex collected at Ban Fa Suai I could be specified and by direct dating on teeth enamel we could describe the timing of the site deposition. A paleoecological interpretation was possible and we could identify the deposition mechanism even though the number of remains was statistically weak. Indeed, data from the excavation of the Cave of the Monk are the most precise among the sites known in South-East Asian, which are mostly fossiliferous breccia. In the past, information from these sites was taken into consideration as if the breccia was well dated and the range of the dating known, this led to paleoecological scenarios that were peremptory and over-generalised. We hope that our meticulous excavation at Ban Fa Suai, which integrated taphonomy and geology, will provide impetus for significant progress in the excavation and in-depth study of new paleontological cave sites in South-East Asia.

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