B) Paleogeographic and biostratigraphic contributions

The Quaternary biostratigraphy of Peninsular Malaysia is still poorly known in detail but faunal lists are available in the literature: Bukit Chuping, in Perils (Collings, 1937), Tambun, near Ipoh (Hooijer, 1962a), Gua Madu, Gua Cha, and Gua Peraling in Kelantan (Tweedie, 1940; Groves, 1985; Adi Haji Taha, 1985; Davison *et al.,* 1987), Gua Kechil in Pahang (Medway, 1969), and Gua Gunung Runtuh, in Perak (Davison, 1994), and in most of these sites the focus is on the prehistoric artifacts and stone tools found with associated mammalian fauna briefly mentioned or listed compared with well documented fauna presented in mainland Asia sites such as: Liucheng, Tashin, Changyang, Yenchingkuo, Hoshantung, Koloshan, Hsingan, Wuyun, Daxin, and Wuming in South China (Colbert and Hooijer, 1953; Kahlke, 1961; Rink *et al.*, 2008), Irrawady and Mogok in Myanmar (Colbert,1943), Tham Kuyen, Tham Hai, Tham Om, Hang Hum, Keo Leng Lang Trang, Ma U'Oi, and Duoi U'Oi in Vietnam (Olsen & Ciochon, 1990; de Vos & Long, 1993; Long *et al.,* 1996; Bacon *et al.*, 2004,2006, and 2008b), Tam Hang in Laos (Arambourg & Fromaget, 1938; Bacon *et al.*, 2008a and 2011), Phnom Loang in Cambodia (Beden & Guérin, 1973), ThumWiman Nakin and Thum Phra Khai Phet in Thailand (Tougard *et al.*,1996; Tougard, 1998 and 2001), Ngandong and Punung in Java (Badoux, 1959; van den Bergh *et al.*, 1996 & 2001), Lida Ajer and Sibrambang in Sumatra (de Vos, 1983), Madai and Niah in Borneo (Cranbrook,1988a; Harrison,1996).

The new data from Peninsular Malaysia links and fills a gap in the biostratigraphy of the region and allow for new correlations with other Southeast Asia Pleistocene sites.

Among the fauna in Batu Caves and Lenggong Valley, some previously unreported species add significantly to help revise and extend their paleogeographical distribution significantly.

Among the carnivores, the Asiatic Black Bear, *Ursus thibetanus*, ranges from Afghanistan, Pakistan, and the Indochinese region and extending into the Himalayas but never reached the Sundaic region except for indeterminate specimens from Java (Erdbrink (1953). This fauna has been described from the Late Middle Pleistocene and Late Pleistocene of the mainland in south China at Wuyun and Daxin (Rink *et al*., 2008), in Thailand at Thum Wiman Nakin (Tougard, 1998, 2001), in Vietnam at Lang Trang (de Vos & Long, 1993; Long *et al.*, 1966), and at Duoi U'Oi (Bacon *et al.*, 2008b). The present occurrence in Peninsular Malaysia confirms that this species was also present in the Sundaic region at 66 ka in Cistern Cave and around 500 ka in Badak Cave C and was not exclusively an Indochinese fossil fauna occurring only in south China, Vietnam, and Thailand and are now listed as the first records within the Late Middle and Late Pleistocene Sundaic fauna from Peninsular Malaysia.

The analysis of the Late Middle and Late Pleistocene faunas which contain northern taxa that were already present in the mainland of the Late Middle Pleistocene of the Indochinese region has modified the geographical distribution of the Southeast Asia fauna by extending the range of northern faunas further southwards. This hypothesis is supported by faunas found in this study only reported previously from north and south Southeast Asia countries such as *Helarctos malayanus*, *Tapirus indicus*, *Capricornis sumatraensis*, *Sus barbatus*, and *Pongo*. These taxa where first found in Indochinese region in the continental Late Middle Pleistocene localities and later in the Late Pleistocene Sundaic sites and currently inhabiting Sumatra and Java in Indonesia and Borneo.

Tougard (1998) concluded that strong climatic cooling that occurred during the Late Middle Pleistocene could have influenced the southward extension of the northern fauna. This extension may supported by the occurrence of *Elephas namadicus* exclusively a northern element was found in south China and Vietnam (Kahlke, 1961; Olsen & Ciochon,

1990) and not found in Java, though there are many Proboscidean fossils from sites in Java and on the Lesser Sunda Islands, as well as from Southwest Sulawesi.

Some species like the Orangutan are extinct in Peninsular Malaysia while others are in decline and heading for extinction such as the Bearded Pig as indicated in this study. These taxa are known members of the Middle or the Late Pleistocene faunas of other mainland Southeast Asian cave sites.

The fossil record of the Orangutan shows that the genus *Pongo* was formerly widespread in the Early to Late Pleistocene sites in Southeast Asia, in south China, Vietnam, Laos, Cambodia, Thailand, Indonesia (Sumatra and Java), and Borneo (all the details in chapter 3). No *Pongo* remains had been discovered in previous excavations from the Early Holocene (Tjia, 1993; Zuraina Majied, 1994; Mokhtar Saidin, 1997, 2005, 2006) in Peninsular Malaysia. Local extinction of the species must have occurred at some time during this long interval. The new discoveries in Batu Caves and Badak Cave C represent significant southward extensions of the ancient Southeast Asian continental range of fossil *Pongo* during the two key periods of the Quaternary.

Environmental conditions in the Peninsula during the Last Glacial Maximum (around 20,000 years ago) evidently became inhospitable for *Pongo* causing local extinction. Following post-glacial climatic amelioration and reforestation, a renewed sea barrier prevented recolonisation from the rainforest refugium in Sumatra accounting for the present day absence of *Pongo* in apparently hospitable lowland evergreen rainforest of Peninsular Malaysia. Among the hypotheses about this extinction, human hunting might have been a contributing factor in the Quaternary decline and ultimate extinction of *Pongo* in Southeast Asia Late Pleistocene like in Niah (Hooijer, 1960). However, in Sumatra and Borneo forest refugia allowed local *Pongo* to survive through environmental conditions of the terminal Pleistocene to modern times.

Archaeological evidence shows that in Borneo (and presumably in Sumatra) human predation was continuous from 40 ka to the present without exterminating the population (Hooijer 1960; Barker *et al*., 2007). It is therefore reasonable to conclude that the lack of zooarcheological records points to terminal Pleistocene climatic conditions, rather than human hunting, to account for the present day absence of *Pongo* in what is now apparently hospitable lowland evergreen rainforest of Peninsular Malaysia.

As for the Bearded Pig, *Sus barbatus*, the species found in the Malay Peninsula, Sumatra, and Borneo extends to the extreme southwestern Philippines and also to the Riau Islands and Bangka (Corbet & Hill, 1992). It was common in many pre-Late Pleistocene fossil sites in Indochina such as in Laos at Tam Hang (Bacon *et al.*, 2008a & 2011), in Thailand at Wiman Nakin (Tougard, 1998 & 2001), and have continued into the Late Pleistocene in both Sundaic and Indochinese sites such as in Sumatra at Lida Ajer and Sibrambang (de Vos, 1983) and Niah in Borneo (Harrison, 1996). In Peninsular Malaysia, *Sus barbatus* was recorded from archaeological sites at Bukit Chuping in Perils (Collings, 1937) in the north west coast of Peninsular Malaysia, at Gua Madu and Gua Cha in Kelantan (Tweedie, 1940; Groves, 1985; Davison *et al*., 1987) in the north-eastern corner of the peninsula, and at Gua Kechil in Pahang (Medway, 1969) in the central part of the peninsula bordering to the east coast, and now at Batu Caves (central part of west Peninsular Malaysia) indicating a significant extension of the historical range of the species in the western coast of Peninsular Malaysia (more details with location map in chapter 3).

The Bearded Pig species was fairly abundant and widespread in the Peninsula Malaysia until recently (Caldecott *et al*., 1993). As late as 1990, herds of Bearded Pigs were reported south of Taman Negara National Park and the southern state of Johor (Kawanishi *et al*., 2006), but between 1999 and 2001 there was no record of their presence (Kawanishi & Sunquist 2004, in Kawanishi *et al*., 2006). The species has seriously declined in Peninsular

Malaysia over the last fifteen years, and it is certainly no longer common there except in a few places like in Pekan and Johor (Kawanishi *et al*., 2006; Francis, 2008). After being around for a few hundred years, this species will probably follow the Orangutan into extinction. This is probably the same case for *Rhinoceros sondaicus* which was listed among the recently extinct mammals by Davison & Zubaid Akbar (2007).

The local extinction of this species may be related to different factors including the destruction of their natural habitat by logging and agricultural activities. Habitat degradation through logging is believed to have reduced the availability of food and loss of habitat for foraging and breeding. Hunting by humans might have been another contributing factor to this Quaternary extinction.

Some species we found confirm the biogeographical affinity either to the Sundaic region or to Indochinese region like the Long-tailed Macaque, *Macaca fascicularis* which was previously recorded only from Sundaic region in Java at Ngandong in the Late Pleistocene (van den Bergh *et al*., 2001), in Borneo at Niah (45 ka - Holocene) (Barker *et al*., 2007), and in Peninsular Malaysia at Gua Cha (date to approximately 10000-3000 BP and 3250-1000 BP) (Adi Haji Taha, 1985). Its presence in Batu Caves confirms that this species was present in the Sundaic region at 66 ka.

6.6 Late Middle and Late Pleistocene migration routes

Drastic climatic changes caused the sea level to drop about 160 m during the Late Middle Pleistocene and 120 m during the Last Glacial Maximum (Gascoyne *et al*., 1979; Hopkins, 1982; Yang & Xie, 1984) in Heaney (1991). Dropping sea levels to120 m was enough to connect Borneo, Sumatra and Java to the Malay Peninsula and Indochina in a single giant block called “Sundaland” (Lekagul & McNeely, 1977; Heaney, 1985).

The Sunda islands remained connected to one another by land bridges and through the Malay Peninsula, to mainland Indochina until about 9500 years ago when the sea levels rose to about 40 m below present (Voris, 2000) (Figure 6.7).

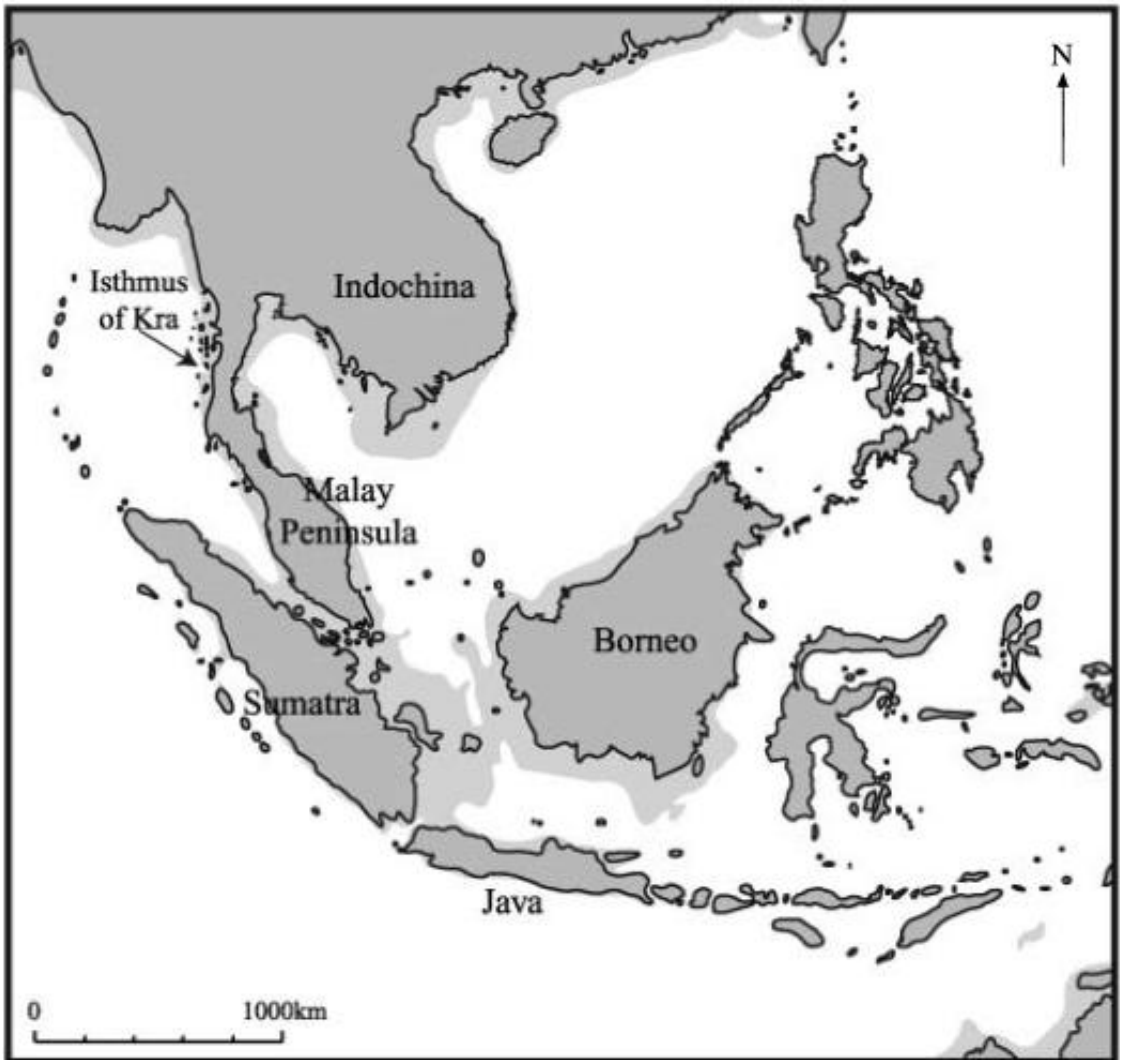

Figure 6.7 The Sunda region of Southeast Asia showing the extent of land area at sea levels 40 m below present. Adapted from the maps of Voris (2000).

Wallace (1892) was one of the first to link sea level lowering during the Pleistocene glacial period to connect islands with similar fauna that until now is still considered as a major factor in species extensions.

This was how migration pathways for the continental fauna and also for the island faunas took place in the past. Two possible migration pathways that can be considered are (Figure 6.8):

1) A continental pathway via Myanmar, Thailand, Laos, Vietnam, Cambodia to Peninsular Malaysia.
2) Insular pathway via Taiwan and the Philippine Archipelago.

Von Koenigswald (1935) suggested that during the Pleistocene, fauna migrated to Java via the Philippines and Borneo on the basis of the fauna with Chinese affinity naming the pathway as the “Sino- Malayan” migration route. This hypothesis has been rejected by van den Bergh *et al*., (1996) and Tougard (2001) because the Philippines and Sulawesi have endemic island faunas and these are not part of the migration route. The Philippines has a high rate of endemism justifying critical isolation, against low rate of endemic species in the Malay Peninsula, Sumatra and Java, suggesting that a connection existed between these places and continental Sundaland in recent years (Heaney, 1985) as these provinces of Indochina and Peninsular Malaysia, Sumatra, Java, and Borneo share greater similarities in species compared to the Philippines (Lekagul & McNeely, 1977; Corbet & Hill, 1992) with the exception of Borneo and Palawan which was considered to be the only Philippine island connected to the Asian mainland via Borneo during Middle to Late Pleistocene time based on the significant fauna relationship to Borneo relative to fresh water fish species from rivers of Lower Pleistocene or Pliocene in age (Heaney, 1985).

Colbert (1943) discussed the influence of fauna from Java over that of Myanmar and in reverse based on the faunal compositions of both the sites with identical ages.

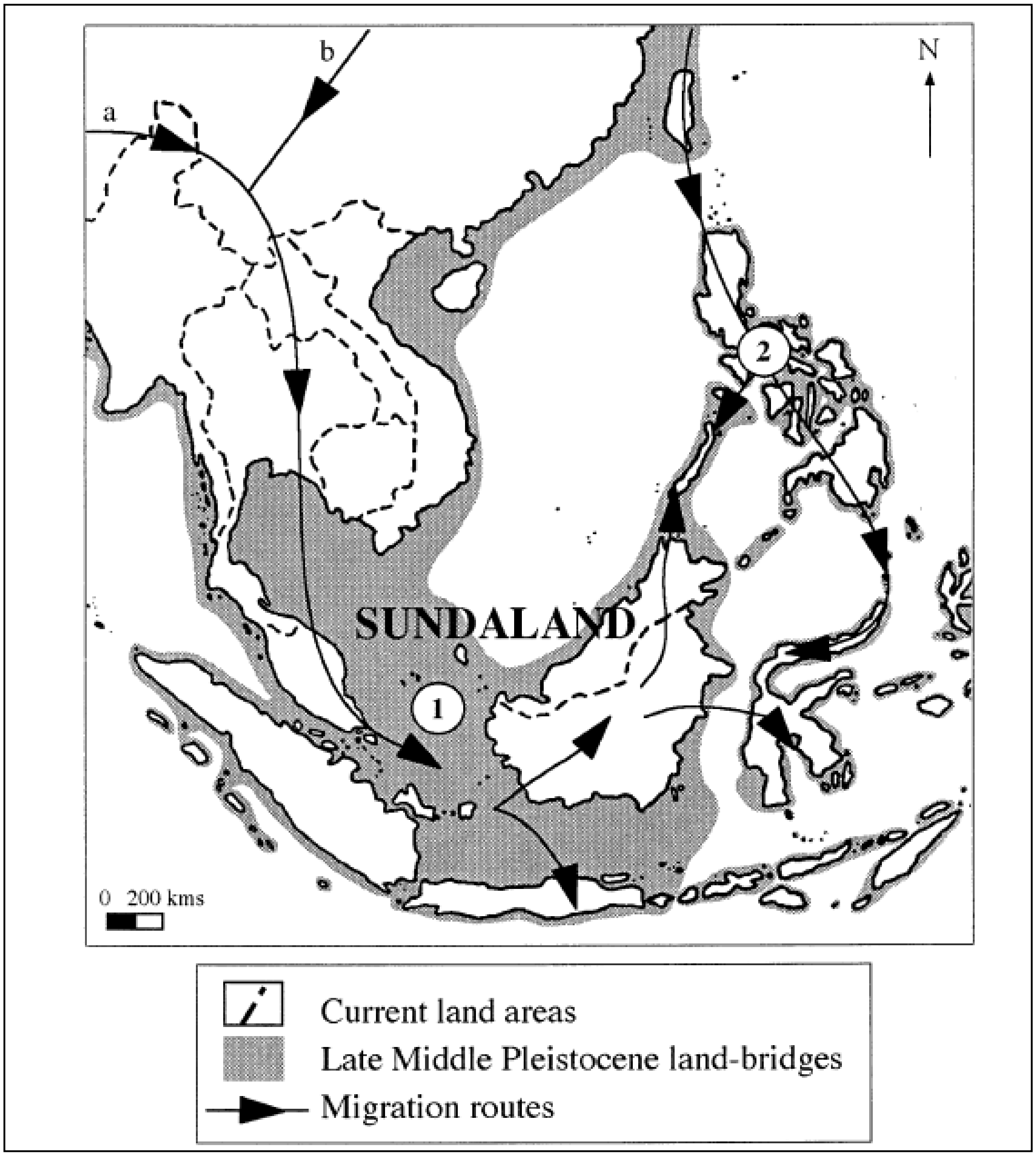

Figure 6.8 Map of Southeast Asia showing the Sundaland boundaries with the migration routes hypothesis are illustrated by the arrows: (1) continental way, (2) insular way, a: Siva-Malayan route, b: Sino-Malayan route, from Tougard (2001).

Von Koenigswald (1939 in Shutler & Braches 1986) considered the oldest fauna in Java to have entered by the “Siva-Malayan” migration route. The Sino- Malayan fauna joined the Siva-Malayan fauna on Java at a later time.

Around the end of the Early Pleistocene and during the Middle Pleistocene, more extensive land connections allowed for more mainland faunas to enter Java.

Medway (1971) suggested that during the Pliocene an ecological barrier existed and prevented many continental fauna to reach Java and during the Middle Pleistocene the Sino-Malayan fauna contained a large number of forest-dwelling species that existed to facilitate the movement of forest-adapted mammals between continental Southeast Asia and Sundaland. He thought that the Bornean species might have reach Borneo by a north-western land bridge. However Java shared some fauna with the Malayan Kinta Valley site; the occurrence *Duboisia santeng* in Tambun (Hooijer, 1962a) which was found only in Javanese Lower Pleistocene sites indicated that there was probably fauna exchange between Indonesia and mainland Southeast Asia and this species could have migrated through the Siva-Malayan migration route when the sea level was low and Java was not isolated from the rest of Sundaland. On the other hand, the occurrence of *Pongo* specimens from Badak Cave C at 500 ka greatly extends the known range of Middle Pleistocene *Pongo* in continental Asia.

The exposed Sundaland allowed fauna exchange from continental Southeast Asia to the Indonesia islands and inversely by the land bridge connections between the landmasses when the sea level was low. The current discovery of Middle and Late Pleistocene fauna from Peninsular Malaysia allow us to link and compare the northern fauna of Southeast Asia to the southern ones, from south China to Indonesia and provide new data for the hypothetical continental migration route to include Peninsular Malaysia as a part of the Sino-Malayan route that had previously been based on fauna from Sumatran Caves, Niah (Borneo), Punung (Java), Thum Wiman Nakin and Thum Phra Khai Phet (Thailand) (de Vos, 1995; van den Bergh *et al*., 1996; de Vos *et al*., 1999; Tougard, 1998 & 2001).

6.7 Paleoenvironment

Because the fauna recovered from the two sites contains a mixed and diverse ungulate mammal assemblage and lack other obligate closed forest specialists such as the Langurs (*Presbytis* or *Trachypithecus*) or Gibbons *(Hylobates* or *Symphalangus*), an advanced paleoenvironmental analysis cannot be carried out but some general ecological trends can be observed. In (Figure 6.3) the higher percentage of Artiodactyla in both sites (42.1% in Batu Caves and 50.0% in Lenggong Valley) suggested a forested environment. Primates and Carnivora appears in equal abundance in Lenggong Valley (16.7%) with higher Carnivora percentage (26.3%) at Batu Caves implying that the habitats might have been mixed during the Late Pleistocene at 66 ka.

Both assemblages from Batu Caves and Lenggong Valley are characterized by macro or large mammals such as Ursidae, Tapiridae, Rhinocerotidae, and Bovidae, which suggest humid environments, mostly forests. According to the literature, this humid condition existed in Middle and Late Pleistocene Southeast Asian sites such as the Vietnamese Tham Khuyen and Lang Trang (Olsen & Ciochon, 1990; Long *et al*., 1996; respectively), Lida Ajer and Punung in Sumatra and Java respectively (de Vos, 1983), and also to the north, in Yenchingkou in south China (Colbert and Hooijer, 1953).

The Malayan Sun Bear, *Helarctos malayanus,* inhabits dense forests at all elevations and Asiatic Black Bear *Ursus thibetanus* frequents moist deciduous forests, especially in the hills and mountains (Lekagul & McNeely, 1977). Both species were found in Batu Caves and Lenggong Valley in equal percentages.

Tapirus indicus lives in various types of forests ranging from dry dipterocarp to deciduous or evergreen forests and also in swampy areas, and is rarely found at high altitudes (Nowak, 1991). This species was found in Batu Caves (Cistern Cave).

Dicerorhinus sumatrensis is found on lowland rain forests and swamps to mountain moss forests (Nowak, 1991).

The Bovidae is represented from both sites by two taxa, *Capricornis sumatraensis* and an indeterminate genus and species of Bovinae. A large number of fragmented large and long bones was observed in Badak Cave C in Lenggong including long bones closely related to *Bubalus bubalis* with others still unexcavated inside the cave. Most of living bovids are adapted to grassland and scrubland, although some inhabit such diverse habitats as swamps and forests (Prothero & Schoch, 2003).

The two species of Cervidae, *Cervus unicolor* and *Muntiacus muntjak* which both prefer wooded areas (Corbet & Hill, 1995) were found at both sites.

The diversified mammalian fauna recovered from the current study shows no major differences in species composition and are mainly characterised by the modern fauna of Peninsular Malaysia except for some species are locally extinct such as the Orangutans. The genus *Pongo* has currently a Sundaic habitat (Sumatra and Borneo) represented by two species: *Pongo abelii* confined to the island of Sumatra and *Pongo pygmaeus* in Borneo (Groves, 2001a; Brandon-Jones *et al.*, 2004).

Pongo can well cope in several types of early forests from swampy to hilly places. Both living species are characteristic members of evergreen tropical rain forest communities within their ranges (MacKinnon, 1974; Davies, 1986; Payne & Prudente, 2010). In modern circumstances, both species have also proved capable of surviving in altered and degraded forest types (Wich *et al*., 2008) including separated blocks of secondary forest preserved as conservation strips in plantations (Cranbrook & Piper, 2011). In paleontological or archaeological reconstructions of past environments, the presence of *Pongo* among fossil assemblages has been accepted as a definite indication of an environment in which forest forms a significant element (Tougard, 1998; Storm *et al*., 2005; Louys *et al*., 2007) including, for instance, the "slightly open forest environment" (Tougard and Montuire, 2006; van den Bergh *et al*. 2001; Storm *et al.*, 2005; Louys *et al.*, 2007; Cranbrook & Piper, 2008; Louys & Meijaard, 2010).

During the Quaternary period, cyclical changes in global climate have continuously affected the Sunda subregion of South-east Asia in two ways: the total area of exposed (subaerial) land has varied with fluctuating global sea levels and the ambient temperatures had followed the global cycles of the long glacials and briefer interglacial periods.

Bird *et al*. (2005) and Wurster *et al*. (2010) have adduced strong evidence that at the Last Glacial Maximum a corridor of savannah habitat extended from Java to the Thai-Malay Peninsula, from which obligate forest-dwelling mammals, including *Pongo* spp., would have been excluded.

The persistence of *Pongo* at Batu Caves at 66 – 33 ka is a significant indication that the environmental changes impacting Java from 80 ka had not proceeded to Peninsular Malaysia at that time. It is possible that the cycle of environmental factors responsible for the creation of a savannah environment progressed northwards from a southern origin, being established in the Thai-Malay Peninsula tens of millennia later than in Java.

Subsequently, during the terminal Late Pleistocene through the Last Glacial Maximum, although lowered sea levels probably created land connections, the prevailing refugial forest habitat in Sumatra contrasted with environmental conditions in Peninsular Malaysia which fell within the savanna corridor (Bird *et al*., 2005, Wurster *et al*., 2010). According to this scenario, by the time the post-Glacial climatic amelioration restored rainforest habitats in Peninsular Malaysia, the local Late Pleistocene population of *Pongo* was extinct. A renewed sea barrier then prevented re-colonisation from the rainforest refugium in Sumatra.

The ecological versatility and adaptability of *Pongo* is illustrated in these mixed faunal assemblages suggests a partially open, probably evergreen forest biotope, with humid conditions. Further information is needed to build a more detailed picture of a holistic and integrated of paleoenvironments in Southeast Asia. This is not possible at present because most of the known Pleistocene fauna are mainly composed of large mammalian species whereas the medium and small taxa are less well known with the exception of fauna from Thailand (Chaimanee & Jaeger, 1993; Chaimanee, 1998). The second reason is paleoenvironmental and palynological data for some older sites are not available (i.e. Yenchingkuo in South China). Generally, there are not many climate and palynological data available from Southeast Asia during the Pleistocene period. Data that is available covers recent ages only. Palynological studies done in Thailand (Penny, 2001) indicate cooler and probably drier than present day conditions similar to contemporary vegetation described in China (Zheng & Lei, 1999) and west Java (Stuijts, 1984) and the centre of Sumatra (Morley, 1982; Newsome & Flenley, 1988), indicating that mountainous vegetation areas during the last strongly glacial era were present at lower altitudes than today. Louys & Meijaard (2010) concluded that the heterogenous vegetation complex with the habitats comprising a mix of both woodlands and grasslands characterized the Pleistocene of Southeast Asia.

Unfortunately, the case is similar for Peninsular Malaysia with a lack in information on small mammal fossil remains and poor paleoenvironmental and palynological details. Stauffer (1973) described plant remains in Late Tertiary coal beds in basins of the Malay Peninsula. Coal at Batu Arang near Kuala Lumpur contained a forest flora indicative of a drier climate than now with several periods of perhumid conditions during the Pleistocene from peat, wood, laterite, and oxidized iron.

Morley (1999) suggested that *Pinus* savannah was probably widespread in the Malay Peninsula at 660 ka until 22 ka. Heaney (1991) mentioned that pine-grasslands were found near Kuala Lumpur at 160 ka. All these took place during times of low sea levels and presumably drier, slightly cooler conditions. Later on, between 80 ka and 55 ka, the climate in the lowlands of Peninsular Malaysia was probably the same as that prevailing today (Kamaludin & Azmi, 1997). Before the Last Glacial Maximum, an evergreen vegetation type perhaps existed in the area close to present day Kuala Lumpur as indicated by carbon-dated peat and wood samples of around 36.4 ka and 41.2 ka (Ayob, 1970). Dapper (1987) concluded that during the Last Glacial Maximum, the vegetation in these areas was much more open, and only reverted to tropical rainforest in the Holocene. Price *et al*. (1997) suggested that bauxite formation in the Malay Peninsula took place continuously from 115 ka to the present which would suggest mostly warm and wet conditions.

Louys & Meijaard (2010) wrote “the vegetation zones along the peninsula shifted from open woodlands to closed deciduous and evergreen rain forest with the changing climatic patterns of the glacial–interglacial fluctuations”.

We can conclude from the literature that during most of the Early and Middle Pleistocene, Peninsular Malaysia might have been dominated by mixed habitats, with evidence of closed and more humid habitats during this period. However, this conclusion remains uncertain until confirmed by future palynological and other work.