CHAPTER ONE

INTRODUCTION

1.1 Preface

I was offered a scholarship by the Higher Education Council of the Education Ministry of Iraq to do a PhD specifically in vertebrate palaeontology while I was lecturing at Baghdad University in 2007. While searching for a suitable PhD project and university overseas to do it, I was informed by Professor Lee Chai Peng of the University of Malaya, Kuala Lumpur, Malaysia that abundant vertebrate fossils had been discovered in several limestone caves in Malaysia but had not been seriously researched. He also informed me that a PhD on vertebrate fossils had been completed by Yaowalak Chaimanee in neighboring Thailand and it would be interesting to extend her studies into Peninsular Malaysia.

The prehistoric Quaternary palaeontological data in Peninsular Malaysia is still rather few compared to that of other countries in the region. Although the study of vertebrate fossils has made great strides in most Southeast Asian countries, no detailed studies on macrovertebrate fossils had been done in Peninsular Malaysia. A few faunal lists were available in the published literature but they were just small parts of essentially archaeological studies focusing mostly on the artifacts and stone tools for Holocene sites with no detailed description of the accompanying fauna from those sites.

Generally, non-human remains were poorly documented and analyses of these were few in the available literature. For those reasons, it became invaluable to have a detailed study of these remains which is the subject of this research.

Peninsular Malaysia (Malaya) is the western part of Malaysia which shares common borders with Thailand in the north, Singapore to the south and Sumatra to the west.

Located between 1˚- 7˚ N and 100˚- 104˚E, it is biogeographically part of Indomalayan Region and belongs to the Sundaic subregion (Corbet & Hill, 1992) (Figure 1.1).

Its area is about 131,598 square kilometers and lies wholly within the equatorial region with a hot and wet climate which allows a luxuriant evergreen tropical rain forest to cover the land surface at lower altitudes. The unique geographical position of being the southernmost part of the Eurasia Continent and ecologically different from the more seasonal rain forest environment in the north make the study of the Quaternary faunas in Peninsular Malaysia much more interesting especially in view of the generally poor record of available data pertaining to the relative role played by the Malay Peninsula in the biogeographic evolution and migration of mammal faunas in Southeast Asia during the Quaternary Period.

This part of the country contains many scattered limestone hills especially in the north (Gobbett, 1965). Their precipitous cliffs rise abruptly above the surrounding country and form local relief up to 600 m. In their lowest 20 m (Hutchison & Tan, 2009) these cliffs often carry notches and deep horizontal grooves. Many of the hills have caves and rock shelters in various dimensions and many of them contain traces of prehistoric human activity. However, if undisturbed these hills obviate several of the natural and modern difficulties in archaeological and palaeontological preservation (Davison *et al*., 1987). Tropical soils and tropical rainfall between them destroy much of the evidence of occupation preserved under different climatic conditions. Human and animal bones are attacked by acid soils and leave no trace (Sieveking, 1955). Furthermore, modern human activities like guano collection, quarrying, road building, mining, and unplanned developments lead to poor documentation of the data, and undeniably vast amounts of the prehistorical material must have been lost before there is a chance to record and study them systematically.

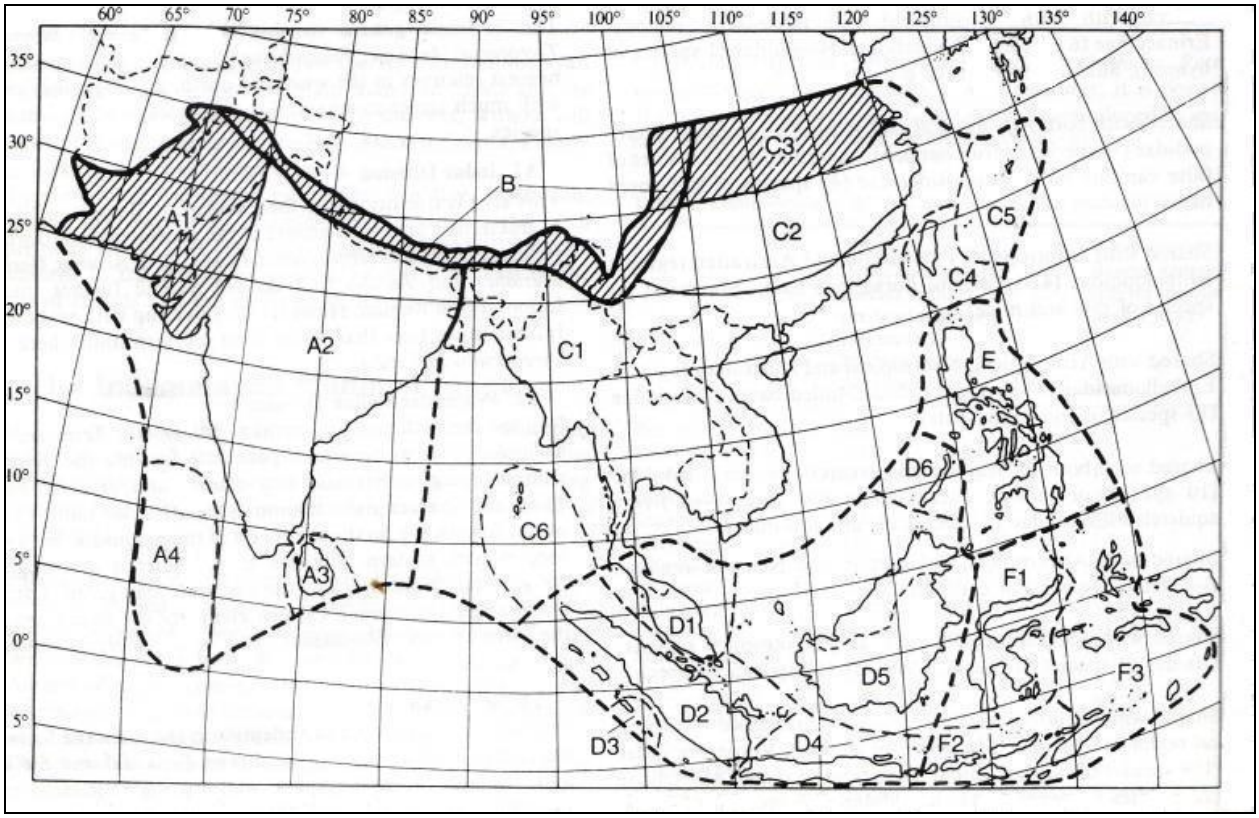

Figure 1.1 The subdivision of the Indomalayan Region modified from Corbet and Hill (1992). The shaded areas are transitional to the Palaearctic Region.

A is Indian subregion: Al (Indus division), A2 (Peninsular Indian division), A3 (Sri Lanka), and A4 (Maldive and Laccadive Islands).

B is Himalayan subregion.

C is Indochinese subregion: Cl (Indochinese division), C2 (Southern Chinese division), C3 (Central Chinese division), C4 (Taiwan), C5 (Ryukyu Islands), and C6 (Andaman and Nicobar Islands).

D is Sundaic subregion: Dl (Malayan division), D2 (Sumatran division), D3 (Mentawai division), D4 (Javan division), D5 (Bornean division), and D6 (Palawan division).

E is Philippine subregion.

F is Wallacean subregion: Fl (Sulawesi division), F2 (Lesser Sunda division), and F3 (Moluccan division).

Some of these hills and the associated caves are being used as temples or tourist attractions while others are left in their natural state. The nature and origin of these caves have been fully discussed by (Wilford, 1964; Gobbet, 1965). The highly diversified fauna in Southeast Asia provides excellent opportunities for the study of biogeography which may lead to a better understanding of palaeoenvironmental changes across the region.

The opportunities of filling the gap in our knowledge of the geological and biological history of Peninsular Malaysia during the Quaternary period look so important and allow for new correlations with other Southeast Asia Pleistocene sites and improve our understanding about the palaeontology of the region, animal migrations and large mammal biogeography distribution. This is the first time that chronometric dating has been utilized to age fossil sites.

1.2 Aims and objectives of study

The aim of this study is to link between Peninsular Malaysia and to other continental Middle and Late Pleistocene sites based on faunal comparisons and fills a gap in the paleogeographical distribution of the macrofauna in the region and allow for new fauna correlations between the two biogeographic provinces: the Indochina province in the north (southern China, Vietnam, Laos, Cambodia, Myanmar, and Thailand), and the Sundaic province in the south (Peninsular Malaysia, Sumatra, Java and Borneo). The scope of this PhD study was limited by the short time available for this project. Limitation of time meant that it was not possible to include some other studies like detailed microvertebrate fossils and palynology that would have complimented and further added to the value of studying the macrovertebrate fossils.

This is the first time that non-human vertebrate fossils are found and systematically studied in such numbers from a number of limestone caves in Peninsular Malaysia (Yasamin *et al*., 2012). The current study consists of recent discoveries of vertebrate fossils collected from six cave localities from the central and northern parts of western Peninsular Malaysia, and two reexamined caves in northern parts in the Peninsular in order to identify all the taxa found from those areas and complete with a preview of work on vertebrate fossils from Malaysia and surrounding region.

The objective of this research is to analysis the teeth and bones recovered from the caves sites and use this assemblages to identify palaeoenvironments through comparison of the structure and composition of the Middle and Late Pleistocene mammals communities this will lead to comparing between the Indochinese and Sundaic province faunas under the changing influence of climate and sea level changes that lead to a new redistribution of faunal distribution that indicate the limit between these two provinces with biogeographical evidence during the Middle and Late Pleistocene and explain the migration patterns. This will support the hypothesis of a migration route through Peninsular Malaysia and establish its importance in mammalian distribution in Southeast Asia.

1.3 Previous studies of Quaternary vertebrate fossils from Southeast Asia

The Quaternary is an active period in Southeast Asia in geologic, tectonic and volcanic contexts with climatic fluctuations (Heaney, 1991). Those changes had huge impacts on the evolution and distribution of mammals and the extinctions of certain species due to the ice ages. By the end of the last major ice age the sea level rose to create new continental margins. All these changes provide important indicators of paleoenvironments.

In my study, my scope will be on comparing the distribution of Pleistocene mammalian macrofauna found in western Peninsular Malaysia with those reported from surrounding

countries west of the Wallace's Line close by which might have similar ecological conditions. These include southern China, Laos, Cambodia, Vietnam, Thailand, Myanmar, Indonesia (Java and Sumatra) and Borneo.

Large numbers of excavations have taken place in China (Pei, 1934a, b, 1957; Weidenreich, 1934; Young, 1939; Xue & Zhang, 1991 in Bekken *et al.,* 2004), most of them focused on understanding the taxonomic richness and diversity of Quaternary localities and early archaeological sites with paleontological studies across the country provide a rich understanding of potential interactions of early humans with mammalian species. Stegodont fauna and rhinoceros remains associated with stone artifacts and human remains found in Panxian Dadong, a Middle Pleistocene cave in south China (Bekken *et al*., 2004; Schepartz *et al*., 2005; Schepartz & Antonio, 2008) suggest that humans played an important role in the formation of the Dadong faunal assemblage.

While the Quaternary offered a great variety of fossils in China, this is not so in Laos. Fromaget (1936) and Fromaget & Saurin (1936) documented the existence of an early hominid site in northern Laos (Tam Hang Cave) while a juvenile hominid was recovered from the same site by Arambourg & Fromaget (1938). Isolated teeth of middle- to large-sized of mammals were descripted by Bacon *et al*. (2008a & 2011) deposited in fossiliferous calcareous breccia layers in the same cave.

Carbonnel & Guth, (1968) in Tougard (1998), reported the discovery of a cave complex in southern Cambodia which yielded a mammalian fauna they dated as Lower Pleistocene. Subsequent detailed analysis of the fauna by Beden & Guérin (1973) suggested instead a terminal Middle Pleistocene age for the materials from the same cave based on the species composition of the faunal assemblage.

In Vietnam, several excavations by Vietnamese and American teams covering mainly cave sites in northern Vietnam led to the discovery of prehistoric human tools and bones associated with fragments of large and small mammals (Kahlke & Nghia, 1965; Davidson, 1975).

More recent systematic description, discussion, comparison and reexamination of vertebrate fossils recovered from caves in Vietnam (Lang Trang, Tham Khuyen, Ma U'Oi, and Duoi U'Oi) was done by de Vos & Long (1993), Schwartz *et al*. (1994, 1995), Long *et al.* (1996), and Bacon *et al*. (2004, 2006, 2008b).

Many Quaternary mammal fossils have been reported from Thailand. Lekagul (1949) found six species in the central part of Thailand: a skull of *Hippopotamus* sp., bones of *Stegodon insignis*, and some fragments of skull and teeth of *Bubalus* sp., Takai (1961) added a few species such as the mandible of *Cuon alpina infuscus*. In the northern part of Thailand, Pope *et al*. (1981) reported on the existence of a less diversified fauna related to the discovery of human tools. Mammalian fossils consisting of isolated teeth were discovered from various Quaternary sites in Thailand and were documented in detailed studies on the systematic, phylogenetic, biochronological and paleoecologcal aspects for both micro-rodent fauna and macromammals by Chaimanee (1998) and Tougard (1998).

The first reported discovery of Quaternary mammals in Southeast Asia was by Lydekker (1876), in which he documented a number of species collected from the Irrawady sediments and caves near the village of Mogok. De Terra & Movius (1943) who established the geological chronology of early man in Burma thought that Burma with its intermediate geological position between India and Southeast Asia might fill the stratigraphic and archeological gap in the region. Several recent studies were focused on the rhinoceros remains discovered from the Irrawady formation in central Myanmar (Zin-Maung-Maung-

Thein *et al*., 2008, 2011). They appeared to have dispersed to the islands of Southeast Asia from continental Asia during the early Pleistocene to middle Pleistocene.

This was followed by the important the discovery of *Homo erectus* from Trinil, Java (Indonesia) by Dubois (1891) and later work by Koenigswald (1934, 1939), Hooijer (1952), Badoux (1959).

At least three caves from the Padang Highlands of western central Sumatra were excavated (Lida Ajer, Sibrambang, and Djamboe) by Dubois (1891) before his more famous and productive prospecting in Java with some fossil taxa subsequently reported by Hooijer (1947a). Later on, de Vos & Sondaar (1982) reviewed and evaluated the real importance of the Dubois collection focusing mainly on the finds from Trinil and Kedung Brubus. Van den Brink (1982) described fourteen species of vertebrate fauna including (*Homo sapiens*) collected by Dubois (1891) from the Wajak Cave in Java. The transition from the early to middle Pleistocene was noted by van den Bergh *et al*. (2001). They studied the fossil faunal succession of the islands of Java, Sulawesi and Flores and the distribution of these fauna related to the change in sea levels and palaeoenvironments.

The Niah Cave in northern Sarawak is the most famous cave in Borneo and has provided a most important archaeological record in Southeast Asia. The site was excavated many times: Harrison (1996) re-examined the primate fauna to try to prove that ecological change associated with global ecstatic fluctuations had a more profound impact on the diversity and distribution of the late Quaternary large mammal fauna of Borneo during the last 40,000 years than did environmental disturbance by humans. Hooijer (1960) described the Niah Orangutan as well as the other non-human primates. He believed that the bone and teeth found in this cave represent the remains of human food brought into the cave by man. Fossil remains of the Malayan Tapir (*Tapirus indicus*) from Niah Cave discovered by

Medway (1960a) indicates that the Malaya Tapir was widespread in Southeast Asia during the Pleistocene period and ranged from southern China to Java.

The Borneo mammalian fauna has been reviewed many times and each time the number of known wild land mammalian species has increased. Many researchers (Medway, 1977a; Cranbrook, 1986) studied the remains of both the Wild Pig (*Sus scrofa*) and Bearded Pig (*Sus barbatus*) and the domesticated pigs as they represented the most prominent mammals found by Pfeffer & Caldecott (1986), Cranbrook (1979) and Medway (1973) there. Pig remains have been conspicuous in many cave sites excavated in Borneo leading to the motivation to distinguish the characters between the wild and domestic forms. Most of the Quaternary fossils reported from previous studies are very much limited in time. The localities are well distributed geographically but not stratigraphically or chronologically, for example: the lower Pleistocene fauna are found in many places in Java but species diversity varies among sites.

Some of the species were reviewed and the absolute age of many localities are tenuous and unreliable at best like the cases of fauna from Vietnam (Olsen & Ciochon, 1990), Borneo (Harrison, 1996), and from Sumatra (de Vos, 1983).

1.4 Previous studies of vertebrate fossils from Peninsular Malaysia

The Peninsular Malaysian fossil record for non-human vertebrates was poorly known from the Pleistocene. A relative lack of fauna data did not allow the distribution of mammals in the past to be known and the diversity was based on only a few sites and a small quantity of fossils. Most of them have been confined to mammalian remains found in alluvial tin-mines or in cave deposits associated with past human activities. Perak was the most significant area with many finds. Andrews (1905) found a tooth belonging to the extinct *Elephas*

namadicus in Salak but the species identification of this specimen has been disputed by Peacock and Dunn (1968).

Hooijer described three elephant molars, one of them identified as an upper molar (M^2 or M^3) probably belonging to the extinct *Elephas namadicus* collected from a small cave in a limestone hill west of Kuala Berang in Ulu Kelantan.

The other two elephant teeth found by tin miners in alluvial deposits near Lukut in western Negri Sembilan were identified as upper molars (milk teeth or M^1) representing *Elephas maximus* or the modern Asiatic elephant. Savage (1937), Richardson (1939) and Ingham and Bradford (1960) reported finding *Elephas maximus* teeth within the alluvial sediments in the Kinta Valley. The remains of a rhinoceros, a suid, deer, turtle, shells, and the spine of a catfish were identified from a collection of vertebrate fragments by Bill Bush from a mine near Batu Gajah in southern Kinta Valley. Hooijer regarded the age of this collection as probably Pleistocene (in Hutchison & Tan, 2009). Hooijer (1962a) reported the most significant collection of Middle Pleistocene palaeontological material found at a depth of about 30 feet in a limestone cave in the Tambun area near Ipoh which included an extinct antelope (*Duboisia santeng*) and hippo (*Hippopotamus* sp.), indicating a habitat of grassland interspersed with swampy patches (more details in next chapters). The Gua Cha shelter in Kelantan is the most important site in Peninsular Malaysia and has yielded rich animal remains. Some of them are juvenile pig bones belonging to immature individuals (Sieveking, 1954). Hooijer (1963a) identified teeth belonging to *Rhinoceros sondaicus*. Food remains obtained through flotation by Groves, (1985) included animal bones and teeth, shells, carbonized rice and other organic remains. Excavation carried out for another two sites in Kelantan (Gua Madu, and Gua Musang) reported by Tweedie, (1940) found artifacts, food remains (bones and teeth of vertebrate animals) and human remains. Davison *et al*. (1987) recorded over 40 mammal species using caves and living around caves at

present compared to those known from ancient bones found in caves referred to as prehistoric bone remains as reported by Adi Haji Taha (1985). Medway (1969) described materials excavated from Gua Kechil, Pahang including 1546 pieces of animal bones and teeth belonging to fishes, reptiles, birds and mammals. He also compared the measurements between the teeth of *Sus scrofa* and *Sus barbatus* found. Many important sites were discovered as a result of systematic archeological research conducted in the Lenggong Valley. One of these is Gua Gunung Runtuh, a cave where the famous 10,000 years old human skeleton named the Perak Man was buried together with other archeological remains and discovered in 1990 (Zuraina, 1994, 2005). Davison (1994) had reported on remains of vertebrate fossils bones and teeth found during the excavation in Gua Gunung Runtuh and nearby Gua Kelawar in Lenggong, Perak. The materials examined included 108 items identified as parts from 18 mammals: Horsehoe Bat (*Hipposideros* sp.), Macaque (*Macaca* spp.), Langur (*Presbytis* spp.), Human (*Homo sapiens*), Porcupine (*Hystrix* sp.), Bamboo-Rat (*Rhizomys* sp.), Civet, Wild Dog (*Cuon alpinus*), Malayan Bear (*Helarctos malayanus*), Tiger (*Panthera tigris*), , Tapir (*Tapirus indicus*), Wild Boar (*Sus scrofa*), Large Mouse-deer (*Tragulus napu*), Muntjac (*Muntiacus muntjak*), Sambar Deer (*Cervus unicolor*), Gaur (*Bos gaurus*), and 4 reptiles: fresh water turtle, tortoise, monitor lizard, snake. He postulated that these remains were mainly from parts of animals used for food. At the same area just about 5 km from the Perak Man site, Badak Cave C, is one of several small caves given the same name, Ros Fatihah Muhammad and Yeap (2000) reported on an exceptionally rich deposit of fossilized teeth and bones of mammals including *Bos gaurus* (Gaur or Seladang), *Cervus unicolor* (Sambar Deer), *Muntiacus muntjak* (Barking Deer) and *Paradoxurus* sp. (Civet Cat).

1.5 Quaternary geology of Peninsular Malaysia

In the early years the absence of palaeontological data led geologists to regard all the limestones occurring in the Malay Peninsula as belong to a one formation referred to as the "Calcareous Series" and probably confined to the Carboniferous or Carboniferous-Permian. This was proved wrong subsequently with more recent collections of fossils and the limestones are now to belong four separate groups: Ordovician/Silurian, Lower Carboniferous, and Permian (most of the Malayan limestones are of this age), and Upper Triassic (Paton, 1961).

Quaternary sediments in Peninsular Malaysia were first described by Scrivenor (1931) and Rastall (1927) who divided the unconsolidated sediments in Kinta Valley into an older (high level alluvium) and younger (low level alluvium). Later Walker (1956) divided the sediments into four units: Boulder Beds, Old Alluvium, Young Alluvium, and Organic Mud and Peat. Suntharalingam (1983) classified the sediments based on lithology, age, and environmental of deposition into the following main units (Figure 1.2):

- Simpang Formation: oldest lithostratigraphic unit equivalent to the Old Alluvium deposits consisting of clay, silt, sand, gravel, and peat deposited in a terrestrial environment and of Early to Middle Pleistocene age.

- Kempadang Formation: not exposed on the surface but was penetrated in boreholes in Pahang, south Perak and south Selangor, comprising clay, silt, sand, gravel deposited in a marine environment.

- Beruas Formation: equivalent to the Young Alluvium deposits, consisting of clay, silt, sand, gravel, and peat deposited in a terrestrial environment overlying Simpang Formation and is Holocene in age. Fossils in the Beruas Formation of the Kinta Valley are of modern varieties with the occasional reported teeth of modern elephants (Jones *et al.*, 1966).

The Quaternary sediments of Peninsular Malaysia include extensive deposits of unconsolidated gravel, sand, mud, and clay occupying the coastal lowlands and floors of some inland valleys and also as erosion remnants of higher level deposits. All these are referred to as "the alluvium" in which most of the vertebrate fossils in this study were collected from within the limestone caves at different levels.

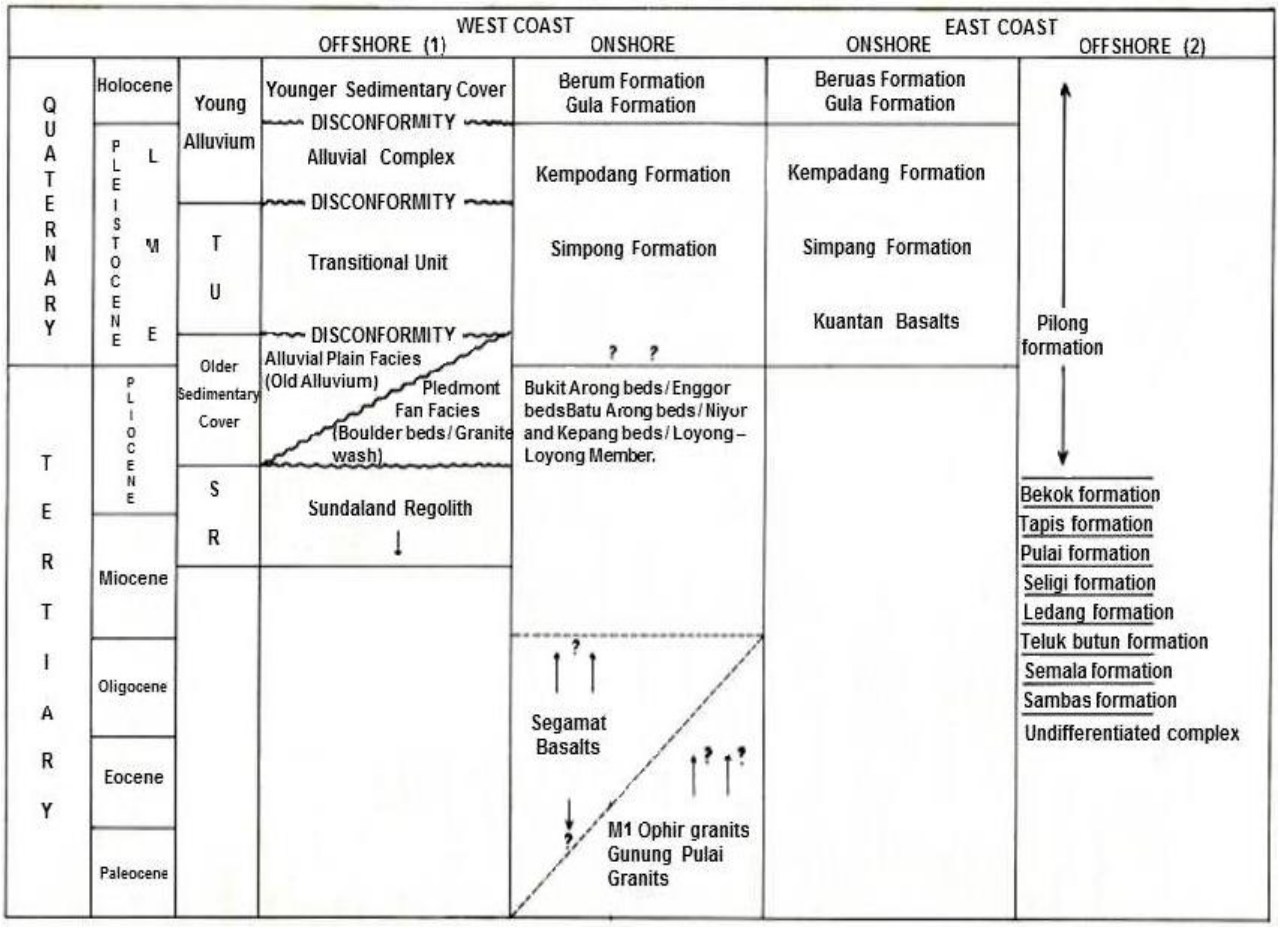

Figure 1.2 Cenozoic correlation chart for Peninsular Malaysia, after Suntharalingam (1983).

The Quaternary sediments cover most of the east and west coastal plains and inland river valleys (Figure 1.3).

Their distributions in the various states of Peninsular Malaysia are as below:

North Kedah and Perlis: represented by Gula Formation occurs mainly within the coastal plain, the bed rock below the costal plain mainly consists of Carboniferous sediments. On Langkawi Island the Quaternary is found only in the area around the main towns.

South Kedah and Penang: the coastal plain extends from south of Gunong Jerai to the Penang-Perak state border. The sands of the beach ridges overlie the Gula Formation while further inland the formation is overlain by a thick sequence of sand and sandy clays belonging to the Beruas Formation. On Penang Island the Quaternary sediments are found only in the narrow coastal plains on its east and west sides.

North and central Perak: the Quaternary sediments cover all the coastal plain of north and central Perak south of Penang Island and is represented by Gula Formation. The Simpang and Beruas Formations cover the landward edge of the coastal plain. Peat is also found in some localities which overlies the Simpang Formation in some places where it overlies Holocene deposits in others.

South Perak: Beruas Formation is found only in the central and northern sectors of south Perak overlying the Simpang Formation. The coastal plain is underlain mainly by the Gula Formation and the Simpang Formation exposed only in the more inland areas.

Kinta Valley: Quaternary sediments are found north and south of Ipoh with great variety and irregular thicknesses. The bedrock is Paleozoic limestones that forms spectacular karst topography around Ipoh while the sides of the Kinta Valley are of Triassic granites. The Pleistocene sediments of the Kinta Valley known as the Old Alluvium are now mapped as the Simpang Formation overlain by Young Alluvium now mapped as the Beruas Formation.

Selangor: The Quaternary deposits in Selangor are represented by three formations:

Gula Formation containing wood remains but no shells, Beruas Formation containing soft marine clay with shells, and Simpang Formation containing sand and hard clay.

Figure 1.3 Distribution of Cenozoic sediments in Peninsular Malaysia modified from Geological Survey of Malaysia (1985) and Raj *et al.* (1998).

Kuala Lumpur: the area around Kuala Lumpur is underlain by the Simpang Formation which contains tin deposits. The bed rock is of Paleozoic limestone and metasediments and

Triassic granites giving rise to hills which surround the low lands that is covered with alluvium of various thicknesses.

Negeri Sembilan and Malacca: Quaternary sediments are found only along river flood-plains and valleys where the Beruas Formation is not so thick in Malacca.

Johor: the Gula Formation is present along a narrow coastal plain in the east coast of Johor while the flood plains are underlain by the Gula and Beruas Formations. In south Johor, the Simpang Formation extends to about 70m above sea level from the lowland area. In northwest Johor, the coastal plain is underlain by the Gula Formation.

Pahang: the Simpang Formation occurs mainly to the north of Pahang and to the western part of the coastal plain. The Gula Formation is underlain by the Kempadang Formation.

South and central Terengganu: Quaternary deposits are found along beach ridges and major river valleys while the swamps are underlain by the Simpang Formation.

North Terengganu and Kelantan: the coastal plain is covered by a series of parallel low beach ridges consisting of beach sand while the Simpang Formation is found within the broad valley of Kelantan River and its delta.

1.6 Distribution of non-marine mammals in Peninsular Malaysia

The living mammals in Peninsular Malaysia are represented by 236 species belonging to 11 orders and 34 families based on the latest status of mammalian biodiversity in Malaysia **(**Davison & Zubaid Akbar, 2007), (Table1.1), the taxonomic framework for Francis (2008). The numerically most abundant representatives are bats of the order Chiroptera represented by 35 genera and 108 species (45.8%) (Figure 1.4).

They consist of large Megachiroptera and small Microchiroptera species that are also the more diverse order among the extant non marine mammals. The order Rodentia with 28 genus and 56 species (23.7%) represents the second largest group.

Comparison between the extant small mammals (Insectivora, Chiroptera, Scandentia, and Rodentia) with the extant macromammals (Primate, Carnivora, Perissodactyla, and Artiodactyla) shows that the small mammals represent about (19.0%) while the macromammals represent (5.7%) of the total number of living mammalian species in Peninsular Malaysia. Each of the orders Dermoptera, Pholidota, and Proboscidea is represented by one species (0.4%).

In this study, most of the specimens (bones and teeth) collected from the limestone caves belong to the large and medium sized mammals while this group of mammals represents only a small part among the living mammals in Peninsular Malaysia such as the Artiodactyla (3.8%) and Perissodactyla (1.3%).

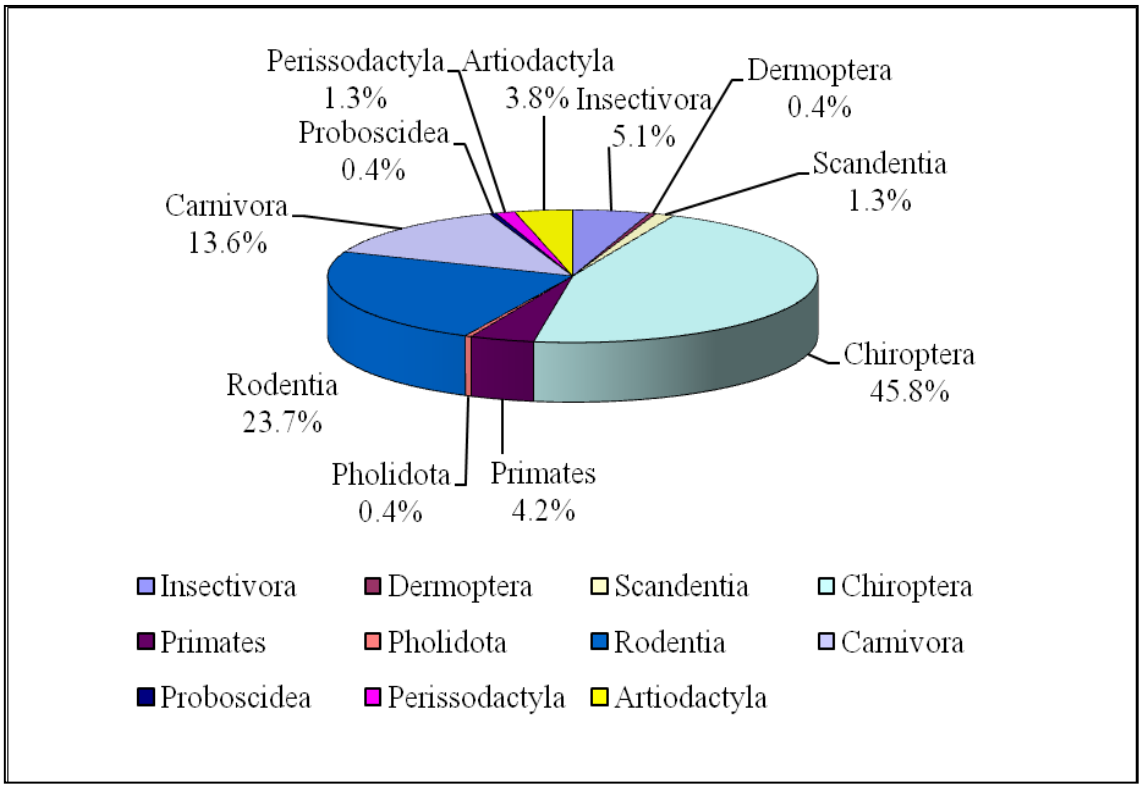

Figure 1.4 The relative abundance of the extant non-human land mammals (orders) in Peninsular Malaysia.

Table 1.1 Extant/ recently extinct non-human land mammals in Peninsular Malaysia.

Taxa	Common Name
Order Insectivora **Family Erinaceidae**	
Echinosorex gymnura	Moonrat
Hylomys suillus	Lesser Gymnure
Family Talpidae	
Euroscaptor micrura	Short-tailed Mole
Family Soricidae	
Suncus murinus	House Shrew
Suncus malayanus	Malayan Pygmy Shrew
Crocidura malayana	
Crocidura fuliginosa	Southeast Asia White-toothed Shrew
Crocidura negligens	Kinabalu White-toothed Shrew
Crocidura attenuata	
Crocidura monticola	Sunda Shrew
Chimarrogale phaeura	Sunda Water Shrew
Chimarrogale hantu	Hantu/Malayan Water Shrew
Order Dermoptera **Family Cynocephalidae**	
Cynocephalus variegatus	Flying Lemur
Order Chiroptera **Family Pteropodidae**	
Rousettus amplexicaudatus	Geoffroy's Rousette
Rousettus leschenaulti	
Pteropus vampyrus	Malayan Flying Fox
Pteropus hypomelanus	Island Flying Fox
Cynopterus 'brachyotis' (open-country taxon)	Malaysian Fruit Bat
*Cynopterus 'brachyotis' (*forest taxon)	
Cynopterus horsfieldi	Horsfield's Fruit Bat
Cynopterus sphinx	Short-nosed Fruit Bat
Penthetor lucasi	Dusky Fruit Bat
Dyacopterus spadiceus	Dayak Fruit Bat
Balionycteris maculata	Spotted-winged Fruit Bat
Chironax melanocephalus	Black-capped Fruit Bat

Table 1.1, continued

Taxa	Common Name
Aethalops alecto	Grey Fruit Bat
Megaerops ecaudatus	Tailless Fruit Bat
Megaerops wetmorei	Wetmore's Fruit Bat
Eonycteris spelaea	Cave Fruit Bat
Macroglossus minimus	Common Long-tongued Fruit Bat
Macroglossus sobrinus	Hill Long-tongued Fruit Bat
Family Emballonuridae	
Emballonura monticola	Lesser Sheath-tailed Bat
Taphozous melanopogon	Black-bearded Tomb Bat
Taphozous longimanus	Long-winged Tomb Bat
Taphozous saccolaimus / Saccolaimus saccolaimus	Pouch-bearing Bat
Family Nycteridae	
Nycteris javanica	Hollow-faced Bat
Nycteris tragata	Malayan Slit-Faced Bat
Family Megadermatidae	
Megaderma spasma	Malayan False Vampire
Megaderma lyra	Indian False Vampire
Family Rhinolophidae	
Rhinolophus affinis	Intermediate Horseshoe Bat
Rhinolophus stheno	Lesser Brown Horseshoe Bat
Rhinolophus robinsoni	Peninsular Horseshoe Bat
Rhinolophus lepidus	Blyth's Horseshoe bat
Rhinolophus pusillus	Least Horseshoe Bat
Rhinolophus malayanus	North Malayan Horseshoe Bat
Rhinolophus acuminatus	Acuminate Horseshoe Bat
Rhinolophus macrotis	Big-eared Horseshoe Bat
Rhinolophus sedulus	Lesser Woolly Horseshoe Bat
Rhinolophus trifoliatus	Trefoil Horseshoe Bat
Rhinolophus luctus	Woolly Horseshoe Bat
Rhinolophus coelophyllus	Croslet Horseshoe Bat
Rhinolophus marshalli	Marshall's Horseshoe Bat
Rhinolophus pearsonii	Pearson's Horseshoe Bat

Table 1.1, continued

Taxa	Common Name
Rhinolophus shameli	Shamel's Horseshoe Bat
Rhinolophus convexus	
Rhinolophus chiewkweeae	Chiew Kwee's Horseshoe Bat
Rhinolophus borneensis	Bornean Horseshoe Bat
Rhinolophus megaphyllus	Smaller Horseshoe Bat
Hipposideros 'bicolor' (131kHz taxon)	Bicolour Roundleaf Horseshoe Bat
Hipposideros 'bicolor' (142 kHz taxon)	Bicolour Roundleaf Horseshoe Bat
Hipposideros pomona	
Hipposideros nequam	Malayan Roundleaf Horseshoe Bat
Hipposideros ater	Dusky Roundleaf Horseshoe Bat
Hipposideros dyacorum	Dayak Roundleaf Horseshoe Bat
Hipposideros sabanus	Lawas Roundleaf Horseshoe Bat
Hipposideros cineraceus	Least Roundleaf Horseshoe Bat
Hipposideros ridleyi	Singapore Roundleaf Horseshoe Bat
Hipposideros orbicularis	
Hipposideros cervinus	Common Roundleaf Horseshoe Bat
Hipposideros galeritus	Cantor's Roundleaf Horseshoe Bat
Hipposideros lylei	Shield-faced Bat
Hipposideros lekaguli	Lekagul's Roundleaf Horseshoe Bat
Hipposideros armiger	Great Roundleaf Horseshoe Bat
Hipposideros larvatus	Large Roundleaf Horseshoe Bat
Hipposideros pratti	Pratt's Roundleaf Horseshoe Bat
Hipposideros diadema	Diadem Roundleaf Horseshoe Bat
Aselliscus stoliczkanus	Trident Horseshoe Bat
Coelops robinsoni	Malayan Tailless Horseshoe Bat
Coelops frithi	East Asian Tailless Horseshoe Bat
Family Vespertilionidae	
Myotis muricola / *Myotis mystacinus*	Whiskered Bat
Myotis montivagus	Burmese Whiskered Bat
Myotis horsfieldii	Horsfield's Bat
Myotis hasseltii	Lesser Large-footed Bat
Myotis hermani / Myotis formosus	Lesser Large-footed Bat

Table 1.1, continued

Taxa	Common Name
Myotis rozendaali / Myotis ater	Grey Large-footed Bat
Myotis adversus	
Myotis ridleyi	Ridley's Bat
Scotophilus kuhlii	House Bat
Philetor brachypterus	New Guinea Brown Bat
Tylonycteris pachypus	Lesser Flat-headed Bat
Tylonycteris robustula	Greater Flat-headed Bat
Hesperoptenus tomesi	Large False Serotine
Hesperoptenus blanfordi	Blanford's False Serotine
Hesperoptenus doriae	Doria's False Serotine
Nyctalus noctula	Noctule
Pipistrellus stenopterus	Malaysian Noctule
Pipistrellus macrotis / Hypsugo macrotis	Brown Pipistrelle
Pipistrellus circumdatus / Arielulus circumdatus	Gilded Black Pipistrelle
Pipistrellus societatis / Arielulus societatis	Benom Pipistrelle
Pipistrellus javanicus	Javan Pipistrelle
Pipistrellus tenuis	Least Pipistrelle
Glischropus tylopus	Thick-thumbed Pipistrelle
Miniopterus medius	SEAsian Bent-winged Bat
Miniopterus schreibersii	Schreibers's Bat
Murina suilla	Brown Tube-nosed Bat
Murina cyclotis	Round-eared Tube-nosed Bat
Murina huttoni	Hutton's Tube-nosed Bat
Harpiocephalus mordax	Hairy-winged Bat
Kerivoula papillosa	Papillose Bat
Kerivoula hardwickii	Hardwicke's Forest Bat
Kerivoula pellucida	Clear-winged Bat
Kerivoula intermedia	Small Woolly Bat
Kerivoula minuta	Least Forest Bat
Kerivoula picta	Painted Bat
Kerivoula krauensis	Whitehead's Woolly Bat
Phoniscus atrox / *Kerivoula atrox*	Groove-toothed Bat
Phoniscus jagorii / Kerivoula jagorii	Frosted Groove-toothed Bat
Mops mops	Free-tailed Bat

Table 1.1, continued	
Taxa	**Common Name**
Family Molossidae	
Chaerephon johorensis	Dato Meldrum's Bat
Cheiromeles torquatus	Hairless Bat
Order Scandentia **Family Ptilocercidae**	
Ptilocercus lowii	Feather-tailed Treeshrew
Family Tupaiidae	
Tupaia glis	Common Treeshrew
Tupaia minor	Lesser Treeshrew
Order Primates **Family Lorisidae**	
Nycticebus coucang	Slow Loris
Family Cercopithecidae	
Presbytis cristata / Trachypithecus cristatus	Silvered Leaf Monkey
Presbytis obscura / Trachypithecus obscurus	Dusky Leaf Monkey
Presbytis melalophos	Banded Leaf Monkey
Macaca fascicularis	Long-tailed Macaque
Macaca nemestrina	Pig-tailed Macaque
Macaca arctoides	Stump-tailed Macaque
Family Hylobatidae	
Hylobates lar	White-handed Gibbon
Hylobates agilis	Agile Gibbon
Hylobates syndactylus	Siamang
Order Pholidota **Family Manidae**	
Manis javanica	Malayan Pangolin
Order Rodentia **Family Sciuridae**	
Ratufa bicolor	Black Giant Squirrel
Ratufa affinis	Cream-coloured Giant Squirrel
Callosciurus notatus	Plantain Squirrel
Callosciurus caniceps	Gray-Bellied Squirrel
Callosciurus erythraeus	Pallas's Squirrel
Callosciurus prevostii	Prevost's Squirrel
Callosciurus finlaysonii	Variable Squirrel (Feral)
Callosciurus nigrovittatus	Black-banded Squirrel

Table 1.1, continued

Taxa	Common Name
Sundasciurus hippurus	Horse-tailed Squirrel
Sundasciurus tenuis	Slender Squirrel
Sundasciurus lowii	Low's Squirrel
Tamiops macclellandi	Himalayan Striped Squirrel
Lariscus insignis	Three-striped Ground Squirrel
Rhinosciurus laticaudatus	Shrew-faced Ground Squirrel
Petaurillus kinlochii	Selangor Pygmy Flying Squirrel
Hylopetes spadiceus	Red-cheeked Flying Squirrel
Hylopetes lepidus	Grey-cheeked Flying Squirrel
Petinomys genibarbis	Whiskered Flying Squirrel
Petinomys setosus	White-bellied Flying Squirrel
Petinomys vordermanni	Vordermann's Flying Squirrel
Iomys horsfieldii	Horsfield's Flying Squirrel
Pteromyscus pulverulentus	Smoky Flying Squirrel
Aeromys tephromelas	Large Black Flying Squirrel
Petaurista petaurista	Red Giant Flying Squirrel
Petaurista elegans	Spotted Giant Flying Squirrel
Family Spalacidae	
Rhizomys sumatrensis	Indomalayan Bamboo Rat
Rhizomys pruinosus	Hoary Bamboo Rat
Family Muridae	
Chiropodomys gliroides	Pencil-tailed Tree-mouse
Hapalomys longicaudatus	Marmoset Rat
Pithecheir melanurus	Monkey-footed Rat
Pithecheir parvus	Malayan Tree Rat
Mus musculus	Asian House Mouse
Mus caroli	Ricefield Mouse
Rattus rattus	House Rat
Rattus tiomanicus	Malaysian Wood Rat
Rattus argentiventer	Ricefield Rat
Rattus exulans	Polynesian Rat
Rattus annandalei	Annandale's Rat
Rattus norvegicus	Brown Rat
Sundamys muelleri	Muller's Rat
Sundamys bowersii = Berylmys bowersi	Bowers's Rat
Niviventer cremoriventer	Dark-tailed Tree Rat

Table 1.1, continued

Taxa	Common Name
Niviventer rapit	Long-tailed Mountain Rat
Niviventer fulvescens	
Maxomys surifer	Red Spiny Rat
Maxomys rajah	Brown Spiny Rat
Maxomys inas	Malayan Mountain Spiny Rat
Maxomys whiteheadi	Whitehead's Rat
Lenothrix canus	Grey Tree Rat
Leopoldamys sabanus	Long-tailed Giant Rat
Leopoldamys edwardsi	Edwards' Rat
Bandicota indica	Large Bandicoot Rat
Bandicota bengalensis	Lesser Bandicoot Rat
Family Hystricidae	
Hystrix brachyura	Malayan Porcupine
Atherurus macrourus	Brush-tailed Porcupine
Trichys fasciculata	Long-tailed Porcupine
Order Carnivora **Family Canidae**	
Cuon alpinus	Wild Dog
Family Ursidae	
Helarctos malayanus	Malayan Sun Bear
Family Mustelidae	
Martes flavigula	Yellow-throated Marten
Mustela nudipes	Malay Weasel
Aonyx cinerea / *Aonyx cinereus*	Small-clawed Otter
Lutra sumatrana	Hairy-nosed Otter
Lutra lutra	Common Otter
Lutra perspicillata / *Lutrogale perspicillata*	Smooth-coated Otter
Family Viverridae	
Viverra tangalunga	Malayan Civet
Viverra zibetha	Large Indian Civet
Viverra megaspila	Large Spotted Civet
Viverricula indica	Little Civet
Prionodon linsang	Banded Linsang
Paradoxurus hermaphroditus	Common Palm Civet
Paguma larvata	Masked Palm Civet
Arctictis binturong	Binturong

Table 1.1, continued

Taxa	Common Name
Arctogalidia trivirgata	Small-toothed Palm Civet
Hemigalus derbyanus	Banded Palm Civet
Cynogale bennettii	Otter Civet
Family Herpestidae	
Herpestes brachyurus	Short-tailed Mongoose
Herpestes edwardsii	Indian Grey Mongoose (Feral; Extinct recently)
Herpestes hosei	Hose's Mongoose
Herpestes javanicus	Javan Mongoose
Herpestes urva	Crab-eating Mongoose
Family Felidae	
Panthera tigris	Tiger
Panthera pardus	Leopard
Neofelis nebulosa	Clouded Leopard
Catopuma temminckii	Golden Cat
Prionailurus bengalensis	Leopard Cat
Prionailurus planiceps	Flat-headed Cat
Prionailurus viverrinus	Fishing Cat
Pardofelis marmorata	Marbled Cat
Order Proboscidea **Family Elephantidae**	
Elephas maximus	Asian Elephant
Order Perissodactyla **Family Tapiridae**	
Tapirus indicus	Malayan Tapir
Family Rhinocerotidae	
Rhinoceros sondaicus	Javan Rhinoceros (Extinct recently)
Dicerorhinus sumatrensis	Sumatran Rhinoceros
Order Artiodactyla **Family Suidae**	
Sus scrofa	Eurasian Wild Pig
Sus barbatus	Bearded Pig
Family Tragulidae	
Tragulus javanicus	Lesser Mouse-deer
Tragulus napu	Greater Mouse-deer

Table 1.1, continued

Taxa	Common Name
Family Cervidae	
Muntiacus muntjak	Red Muntjac
Cervus unicolor	Sambar
Family Bovidae	
Bos gaurus / *Bos frontalis*	Gaur
Bos javanicus	Banteng (?Extinct recently)
Capricornis sumatraensis	Serow