Action Plan for Conservation and Sustainable Use of Palaeobiodiversity in Sri Lanka



Biodiversity Secretariat
Ministry of Environment and Renewable Energy

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Cover page picture: Palaebiodiversity research in Sri Lanka was conducted mainly by Prof. P.E.P. Deraniyagala who was the former Director of the National Museum, Colombo. He published more than 400 research articles during his lifetime. They were mainly on Palaeobiodiversity. The cover page has been designed using the paintings drawn by him in his articles. These pictures have been used to create a symbolic representation of Palaeobiodiversity by Mr. Kelum Manamendra- Arachchi.

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Message of the Hon. Minister of Environment & Renewable Energy

Palaeobiodiversity is a new subject addressed by the Ministry of Environment and Renewable Energy. Extinct flora, fauna, prehistoric man and his environment are some aspects of palaeobiodiversity. The excavations and studies carried out in Sri Lanka have revealed the rich biodiversity which existed during ancient times. Fossils dating to millions of years ago are found in the Jurassic and Miocene beds. Human settlements over 125,000 years of age are found in the ancient landscape of Sri Lanka.

Unfortunately, not all the sites, especially in the North and East, have been documented. Development activities and infrastructure expansion have destroyed some sites of palaeobiodiversity value. There are many palaeobiodiversity sites located both within and outside the Protected Area system. Hence, the Ministry of Environment and Renewable Energy proposed in the action plan to identify and demarcate palaeobiodiversity sites and to create awareness among the general public in order to document and conserve all accessible sites. These palaeobiodiversity sites provide opportunities for diversification of tourism as mentioned in Mahinda Chinthana, highlighting the rich heritage of our country.

This action plan provides the background for state agencies to plan the strategy to strike a balance between conservation and development. It provides a holistic approach and links institutions to implement the goal of the conservation and sustainable use of palaeobiodiversity in Sri Lanka.

I hope that this endeavour will bring about a national awareness of the palaeobiodiversity in our country and create an effort towards its conservation and sustainable use in keeping with the principles of Mahinda Chinthana.

Hon. Susil Premajayantha
Minister of Environment & Renewable Energy

Message of the Secretary

It is with great pleasure that the Ministry of Environment and Renewable Energy launches the Palaeobiodiversity Action Plan to promote the conservation and sustainable use of palaeobiodiversity in Sri Lanka.

The Palaeobiodiversity Advisory Committee was appointed by the Ministry of Environment in 2007 since the focal point of the Convention on Biodiversity is the Biodiversity Secretariat of the Ministry of Environment and Renewable Energy. It consists of members representing several government departments, universities and NGO's. Since then, the advisory group has studied the issues, problems, gaps in related policy documents and formulated the Palaeobiodiversity Action Plan to address the current issues and carry out a plan of action to conserve and use sustainably the palaeobiodiversity resources in Sri Lanka.

In Sri Lanka, although much attention has been paid to the preservation of historically important cultural sites such as those at Anuradhapura, Polonnaruwa, Yapahuwa etc., the fossiliferous and sub fossiliferous flora and fauna of Sri Lanka have not been adequately explored and studied. Due to economic development activities mainly exploration, mining and construction, sites of palaeobiodiversity value are wiped out. No attention has been paid by developers and policy makers to preserve and conserve this natural and cultural heritage which has considerable national and tourism value. Both preservation and sustainable use are integral parts of conservation. Whilst in certain cases it is necessary to preserve a particular resource in order to ensure its sustainability, care should be taken that the resource is utilised sustainably *i.e* to use the resources today in a manner that assures their availability to the future generations.

Therefore, this action plan intends to highlight the importance of preserving such sites for the benefit of the future generations as well as for the use of science where fossils, sub fossils and artefacts have become the backbone of predictions of the climate and the reasons for extinction of species.

My special thanks go out to the Biodiversity Secretariat, Department of Archaeology and members of the Palaeobiodiversity Advisory Committee for taking the initiative to introduce this subject of Palaeobiodiversity and for obtaining the support of relevant institutions to implement the action plan.

B.M.U.D Basnayake
Secretary
Ministry of Environment & Renewable Energy

Message of the Chairman/ Palaeobiodiversity Advisory Committee

Archaeology and Environmental Sciences merge into and overlap one another. These subjects have been separately dealt with in Sri Lanka primarily due to the fact that the respective government departments come under separate Ministries. Taking this into consideration the Action Plan has been formulated to bring together all institutions concerned into the unifying act of conservation and sustainable use of the palaeobiodiversity in Sri Lanka.

The optimum level of conservation of any resource will depend on how well the overall landscape is managed with a minimal loss. In respect to Palaeobiodiversity, it is very important to consider conservation aspects of the landscape in its entirety. The needs of the people and their activities must be reconciled with the maintenance of Palaeobiodiversity. The management of fossil sites, prehistoric sites and other sites of palaeobiodiversity related artefacts should be on the same planning framework as the development activities like sacred area development, infrastructure development, industrial development, agrarian and agriculture projects etc. The Action Plan has been prepared on these principles.

The initial draft of the action plan was prepared by the Biodiversity Secretariat and finalised with contributions and comments from members of the Palaeobiodiversity Advisory Committee which consists of members representing the following government departments, universities and NGOs : Ministry of Environment & Renewable Energy, Department of Archaeology, Department of Wildlife Conservation, Forest Department, Department of National Museums, Geological Survey and Mining Bureau , Gem and Jewellery Training Institute, Central Cultural Fund, Postgraduate Institute of Archaeology (PGIAR), University of Sri Jayawardenapura, University of Ruhuna, University of Peradeniya, and World Conservation Union (IUCN, Sri Lanka) and other stakeholders.

As Chairman of the Advisory Group, I am proud to state that we have been able to implement programmes to create awareness of Palaeobiodiversity among the general public and have held many workshops in a number of provinces in Sri Lanka. Newsletters, brochures and posters have been created on the subject. Furthermore, in collaboration with the Ministry of Environment & Rewable Energy the PGIAR has commenced a Diploma in Palaeobiodiversity and a Certificate course in osteoarchaeology.

My sincere thanks go out to Mr Gamini Gamage former Director/ Biodiversity who was instrumental in the formulation of the Action Plan, Ms Padma Abeykoon present Director/ Biodiversity for launching the publication, Mr Kelum Manamendra - Arachchi (Research Officer/ PGIAR) and Ms Hasula Wickremasinghe (Programme Assistant/ BDS) for compiling the Action Plan, Mr Pradeep Jayatunga for the editing work and Ms Sonali Premaratne (Research Assistant/ PGIAR) for her assistance in the finalising of the action plan.

With the support of the stakeholders I am confident that we will be able to implement the action plan and achieve the national goal of conservation and sustainable use of the palaeobiodiversity in Sri Lanka.

Senior Archaeologist Prof. A.M.G.Adikari
Director General/ Central Cultural Fund
Professor/ Postgraduate Institute of Archaeology

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Abbreviations used in the Action Plan

BDS- Biodiversty Secretariat
CCD- Coast Conservation Department
CCF- Central Cultural Fund
CEA- Central Environment Authority
DoA- Department of Archaeology
DWC- Department of Wildlife Conservation
FD- Forest Department
GSMB- Geological Survey & Mines Bureau
MoE&RE – Ministry of Environment & Renewable Energy
NARA- National Aquatic Resource & Research Agency
NSF- National Science Foundation
PBDAP- Palaeobiodiversity Conservation Action Plan
PGIAR-Postgraduate Institute of Archaeology

1.0 Introduction

The beginning of the earth took place 4600 million years ago. At least, for nearly one thousand years since its origin the earth had no life. As a result of gradual evolutionary change, organisms evolved to make earth what it is today.

Due to the geological evolution and palaeoclimatic changes many organisms have become extinct whilst others have evolved. The diversity of the biological environment is known as biodiversity. Many environmental factors contribute to the presence of both floral and faunal diversity. Accordingly, palaeo-environmentalogists study the major diversification of life, e.g. prehistoric evidence of flora, fauna, human beings and their ethological artefacts etc., to come to conclusions or hypothesize about the behaviour of past environments.

The broad topic of biodiversity includes sub disciplines of physical sciences (geophysics, geochemistry, geobiology, petrology, soil science, sedimentology, stratigraphy, geochronology, ethnobotany, geomorphology, palynology) and social and biological sciences (anthropology, architecture, sociology, agriculture, animal husbandry, Industry, economics, political science, religion etc). The systematic study of all fossil animal/plant groups with special focus on palaeoenvironmental investigations; palaeoecosystems and climate changes in earth's history; environment-organism interaction; comparison of modern and ancient sedimentary environments; palaeoecology and palaeobiogeography are incorporated into 'Palaeobiodiversity'. Similarly, cultural, religious, social and economic aspects related to archaeology should also be considered in addition to the biological aspects for a holistic approach of conservation and sustainable use of Palaeobiodiversity.

Therefore, Palaeobiodiversity can be defined as "the biodiversity of ancient times up to the historic period and man and his interactions with the palaeoenvironment".

The sands of time have covered many marks left by the ancient flora and fauna of Sri Lanka. It is through exposure or excavation that many of the fossils and sub fossils have been revealed. Many that have been preserved are those that have not decomposed, have withstood physical, biological and chemical degeneration or have undergone the process of fossilisation.

In Sri Lanka, although much concern has been expressed over the preservation of historically important cultural sites such as those at Anuradhapura, Pollonnaruwa, Yapahuwa etc., the fossiliferous and sub fossiliferous flora and fauna of Sri Lanka have not been adequately explored and studied. Due to economic development activities - mainly exploration, mining and construction - palaeostratigraphy, palaeodeposits and Palaeolithic sites are wiped out. No attention is paid by developers, policy makers and politicians to preserve and conserve this natural and cultural heritage which has considerable national and tourism value.

Both preservation and sustainable use are integral parts of conservation. Whilst in certain cases it is necessary to preserve a particular resource in order to ensure its sustainability, care should be taken that the resource is utilised sustainably i.e to use the resources today in a manner that assures their availability to the future generations.

Therefore, this action plan intends to highlight the importance of preserving such sites for the benefit of the future generations as well as for the use of science where fossils, subfossils and artefacts have become the backbone of predictions of the climate and the reasons for extinction of species.

In this Action Plan, various time units are used,
BC + 2000 yrs = yBP/BP (years Before Present)

2.0 Sri Lanka and its Palaeobiodiversity – an Overview

From time to time, Sri Lanka separated from Gondwanaland and drifted aprt as an island, the flora, fauna and humans who crossed the land bridges to inhabit Sri Lanka and the already existing biodiversity of the island intermingled and, through evolutionary processes, evolved. The altitude, geography, topography and changing climate contributed towards speciation resulting in endemism and high biodiversity. The following are components that resulted in the palaeobiodiversity of the island.

2.1 Geological and Physical features

India separated from Gondwanaland c. 195 Ma, and collided with Asia in the late Eocene. India would have acted as a raft carrying taxa from Africa to Asia, which could have spread over Southeast Asia and West Malaysia after collision. During its rift it came in close contact with the still northward moving Sumatra, which means that an exchange of floral and faunal elements could have taken place. It is possible that during the close contact between Sumatra and India, India became populated by Southeast Asian elements which still exist in the forests of Kerala and Sri Lanka (Erdelen, 1984; Erdelen, 1998).

The island of Sri Lanka has been a part of a Pre Cambrian land mass that maintained some integrity through the upper and lower Paleozoic. The other rocks of the island were formed during the Jurassic and Miocene times which provide the earliest fossil evidence. The Indian shield was subjected to fault movements that were wide spread during the Jurassic and Cretaceous period. These movements may have been responsible for the block uplift of the mountain masses of Sri Lanka and Southern India. At the end of the Jurassic, the break up of Gondwanaland caused the Indian shield to separate from Africa and begin its northerly movement into the Tethys Sea (Senanayake, 1994).

The landmass that was to become the island of Sri Lanka remained above sea level from this time until the Miocene, as there is no evidence of any marine deposits being recorded within its boundaries. During this period the peneplanation of the hills of Sri Lanka and Southern India took place (Cooray, 1984).

Sri Lanka is situated in the Indian Ocean between 5° 52'E -9° 54 N and 79 °30 E '- 81° 55'E with maximum length of 432km (Devundara to Point Pedro) and maximum breadth of 224km (Colombo to Sangamankanda). Within this landmass, the physiographic divisions create variations of temperature, atmospheric pressure, precipitation, duration of sunshine and winds. Other elements may include humidity, cloudiness, extreme weather conditions such as thunder storms and even the type of soil.

The Miocene was marked by an arm of the Tethys Sea that encroached into the land surface between India and Sri Lanka, turning Sri Lanka into an Island for the first time. By the middle Miocene global sea levels attained much the same levels as today and the island retained its general outline and remained above sea level for the period following the Miocene. However, there have been repeated, protracted connections with the mainland.

In the north and northwest the Jurassic sediments are unconformably overlain by an extensive sequence of sandstone and limestone (important regional aquifers) of Miocene age (23.0- 5.3 Million years); the Mannar sandstone and the Vanathavillu Limestone (formerly the Jaffna Limestone), the latter being a major source of raw material for cement manufacture. Also, on the southeast coast an undated sequence of fossiliferous shales and limestones overlaid by coarse continental clastics ("red beds") comprises the Minihagalkande beds.

Sri Lanka has been subjected to at least three major uplifts during Jurassic, Miocene, and Pleistocene times. The uplifts broke up the island's sedimentary beds and altered its topography. As a result, the earlier sedimentary deposits have disappeared from the greater part of Sri Lanka while the youngest (the Pleistocene deposits) have survived these changes better and are best in evidence in the strike valleys of the province of Sabaragamuwa (National Atlas, 2007).

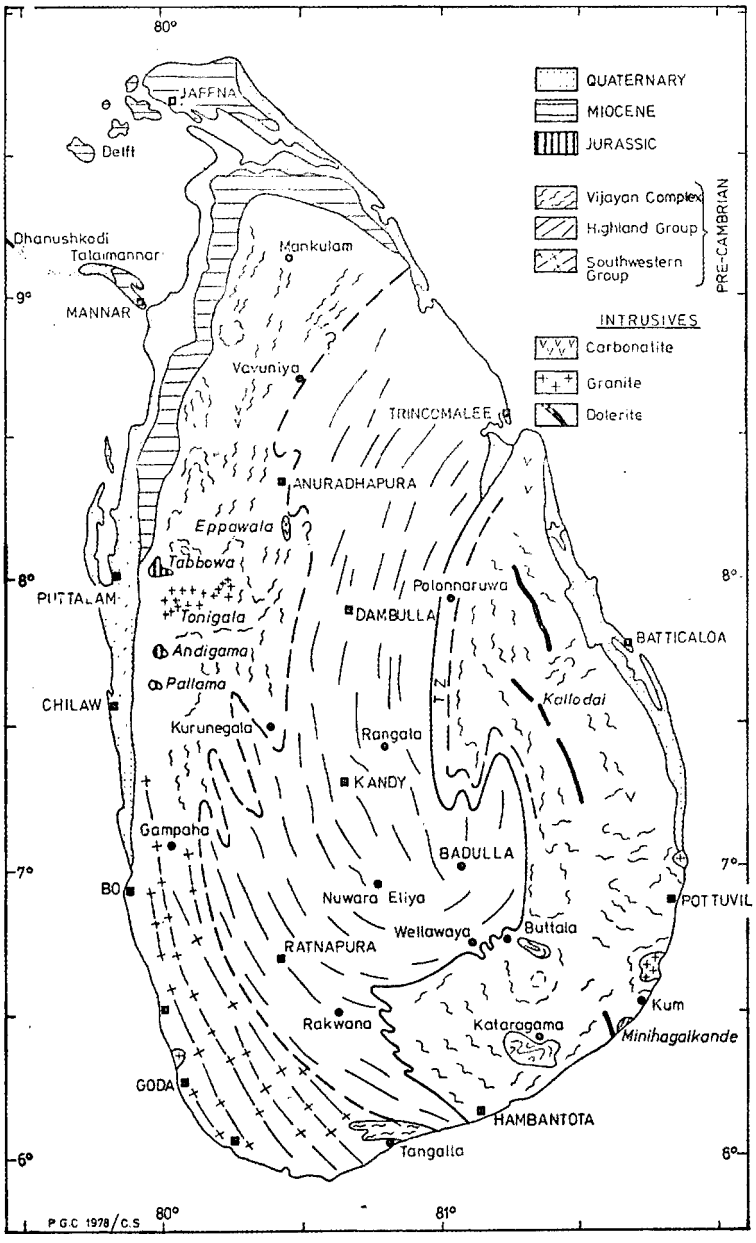


Figure 1: Geological zones (Cooray, 1984)

Physical features

The island of Sri Lanka is tear-drop shaped with a wide area in the south which narrows towards the north. The geological and structural affinities in the form of trend lines indicate the continuity of the South Asian land-mass. The total land area is 65,625km^2. Sri Lanka's territorial sea extends to a distance of 12 nautical miles from its coastline and its exclusive economic zone (EEZ) covers a distance of 200 nautical miles. Thus, although Sri Lanka's land mass is relatively small, its marine economic zone comprising some 230,000 km^2 is nearly four times its land area.

The continental shelf encircling the island covers 26,000 km^2. It is situated on the same submarine platform as the South Asian land mass. Its mean width is 20 km^2 and is narrowest in the south (under 10km) and widens (30-60 km) towards the north from the Kalpitiya peninsula.

The continental slope situated beyond the edge of the continental shelf is a concave feature leading to the deep-sea plain. Here, depths exceed 2000km. The steepest gradients of the continental shelf have been recorded from the east coast near Trincomalee.

The south central area of the island is mountainous. The central mountain region is surrounded by a plain which

spreads over two thirds of the island. It is characterised by inselbergs. Therefore, the general configuration of the island can be characterised as belonging to three peneplains or "well-marked plains of erosion".

Physiographic regions

The relief pattern of the island varies from one area to another. Nine major physiographic provinces have been identified by Wickramagamage (1998) on the basis of climate, lithology, structure and elevation;

they are:

1. Highland Province and its sub- divisions.
2. Elahera Ridge
3. Southwestern Lowland Plain
4. Lowland Plain Vijayan
5. Lowland Plain Wanni
6. Coastal Plain I (General)
7. Coastal Plain II (Northwestern)
8. Limestone Plateau
9. Continental Shelf

An analysis of the altitude-area relationship clearly indicate that almost 75% of the land area of the country lies below an elevation of 300m and the balance in the Central Hill country. Above mentioned physiographic regions have no direct relationship with relief zones, but they show diversification of the distribution of water, climate, soil and ecology.

Sri Lanka contains a total of 103 distinct natural stream basins and 54 waterfalls. The drainage pattern of the island is radial, beginning from the central highlands and radiating outwards in all directions towards the sea. It is subdivided into drainage patterns of dendritic, parallel, trellis, rectangular, multi basinal and contorted. The longest rivers in Sri Lanka are the Mahaweli, Malwatu Oya, Kala Oya and Kelani. There are 16 major rivers that are more than 100km in length in Sri Lanka (National Atlas, 2007)

Climate

The climate experienced in a 12 month period in Sri Lanka has been categorized into four climatic seasons as follows, with each season having typical features (Abeysingha, 2007).
1. First Intermonsoon Season, March- April.
2. Southwest Monsoon Season, May- September
3. Second Intermonsoon Season, October- November.
4. Northeast Monsoon Season, December-February.

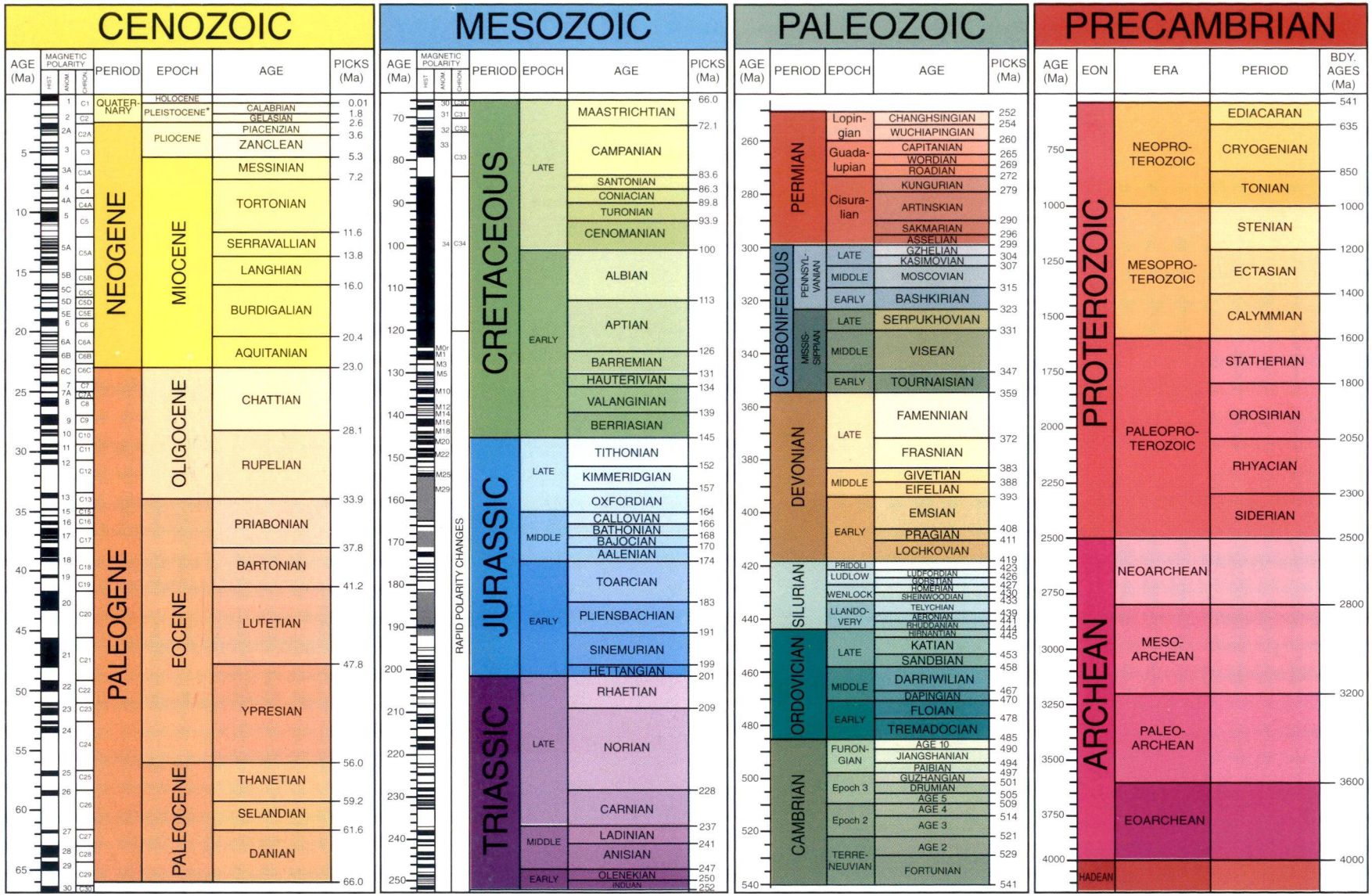
Although each season has typical features, the mean annual temperature in Sri Lanka is manifested largely by homogenous temperatures in lowlands and rapidly increasing temperatures in the highlands. In the lowlands up to an altitude of 100m -150m the mean annual temperature varies between 26.5 °C to 28.5 °C, with an average annual temperature of 27.5 °C. In the highlands the temperature falls quickly as the altitude increases with a mean annual of 15 °C.

2.2 Geological Time scale

The Geological Time scale describes a systematic sequence of chronologic measurements which relates the stratigraphy of geological formations with the time measurements.
In the action plan mainly the 'Geological Timescale' (Table 1) is used to describe the palaeobiological and/or related events. In addition, the 'Archaeological Timescale' (Table 2) indicates the important and pivotal events of human and cultural evolution.

Table 1: Geological Time Scale (USGS, 2012)

GSA GEOLOGIC TIME SCALE v. 4.0



*The Pleistocene is divided into four ages, but only two are shown here. What is shown as Calabrian is actually three ages—Calabrian from 1.8 to 0.78 Ma, Middle from 0.78 to 0.13 Ma, and Late from 0.13 to 0.01 Ma.

Walker, J.D., Geissman, J.W., Bowring, S.A., and Babcock, L.E., compilers, 2012, Geologic Time Scale v. 4.0: Geological Society of America, doi: 10.1130/2012.CTS004R3C. ©2012 The Geological Society of America.

The Cenozoic, Mesozoic, and Paleozoic are the Eras of the Phanerozoic Eon. Names of units and age boundaries follow the Gradstein et al. (2012) and Cohen et al. (2012) compilations. Age estimates and picks of boundaries are rounded to the nearest whole number (1 Ma) for the pre-Cenomanian, and rounded to one decimal place (100 ka) for the Cenomanian to Pleistocene interval. The numbered epochs and ages of the Cambrian are provisional.

REFERENCES CITED Cohen, K.M., Finney, S., and Gibbard, P.L., 2012, International Chronostratigraphic Chart: International Commission on Stratigraphy, www.stratigraphy.org (last accessed May 2012). (Chart reproduced for the 34th International Geological Congress, Brisbane, Australia, 5–10 August 2012.)

Gradstein, F.M, Ogg, J.G., Schmitz, M.D., et al., 2012, The Geologic Time Scale 2012: Boston, USA, Elsevier, DOI: 10.1016/B978-0-444-59425-9.00004-4.

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2.3 Archaeological time scale

The action plan contains descriptions of (Archaeological) events and information on Sri Lanka explained in different types of time scales (Table 2). The terms Jurassic, Miocene, Pleistocene, Quaternary etc. are according to the geological time scale; 'lithic' (Palaeolithic, Mesolithic etc.) is used according to the tool culture/ tradition time scale; 'history' (pre history, proto history etc.) is used according to the present day time scale.

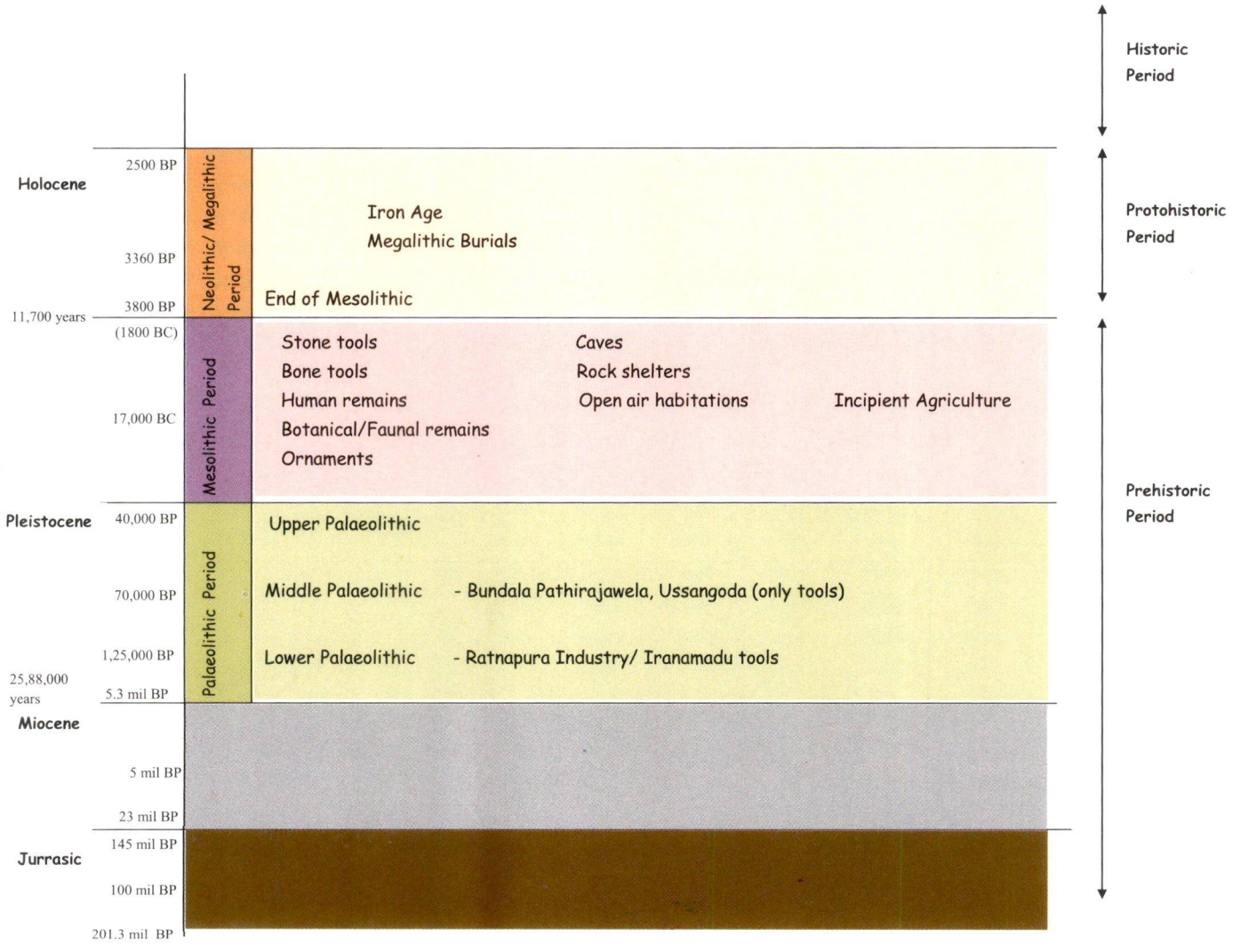


Table 2: Palaeobiodiversity events and information in Sri Lanka according to geological and cultural time scales (Kelum Manamendra-Arachchi, Hasula Wickremasinghe & Sonali Premarathne)

2.4. Palaeobiodiversity Era's of Sri Lanka

Archaeological research conducted so far has revealed the evidence of artefacts, fossils and subfossils of flora and fauna. These fossils can be categorised according to the geological time scale. Sri Lanka contains diverse ecosystems and bioregions, and it is in these varied ecosystems that the first flora and fauna colonized the land mass and, with the passing of time, became fossils.

A palaeobiodversity era could be defined by the type of its fossils and bioartefacts. These fossils and artefacts can be further classified using the geological time scale.

Therefore, according to the time the Palaeobiodversity of Sri Lanka can be divided into:
a) Jurassic Period

b) Miocene Period
c) Pleistocene Epoch
d) Holocene Epoch

The geographical evidence for the Jurassic beds is restricted to North-Western Sri Lanka whereas the Miocene beds are to be found in the North, North-West and South-East. However, the Pleistocene and Holocene evidence is scattered throughout the island. The following map (Figure 2) has been constructed based on certain documented evidence and principal research findings. What is interesting to note is that very little research has been carried out in the North-East leaving a dearth of information of the area (see annex 1 for a provisional list of palaeobiodiversity sites in Sri Lanka).

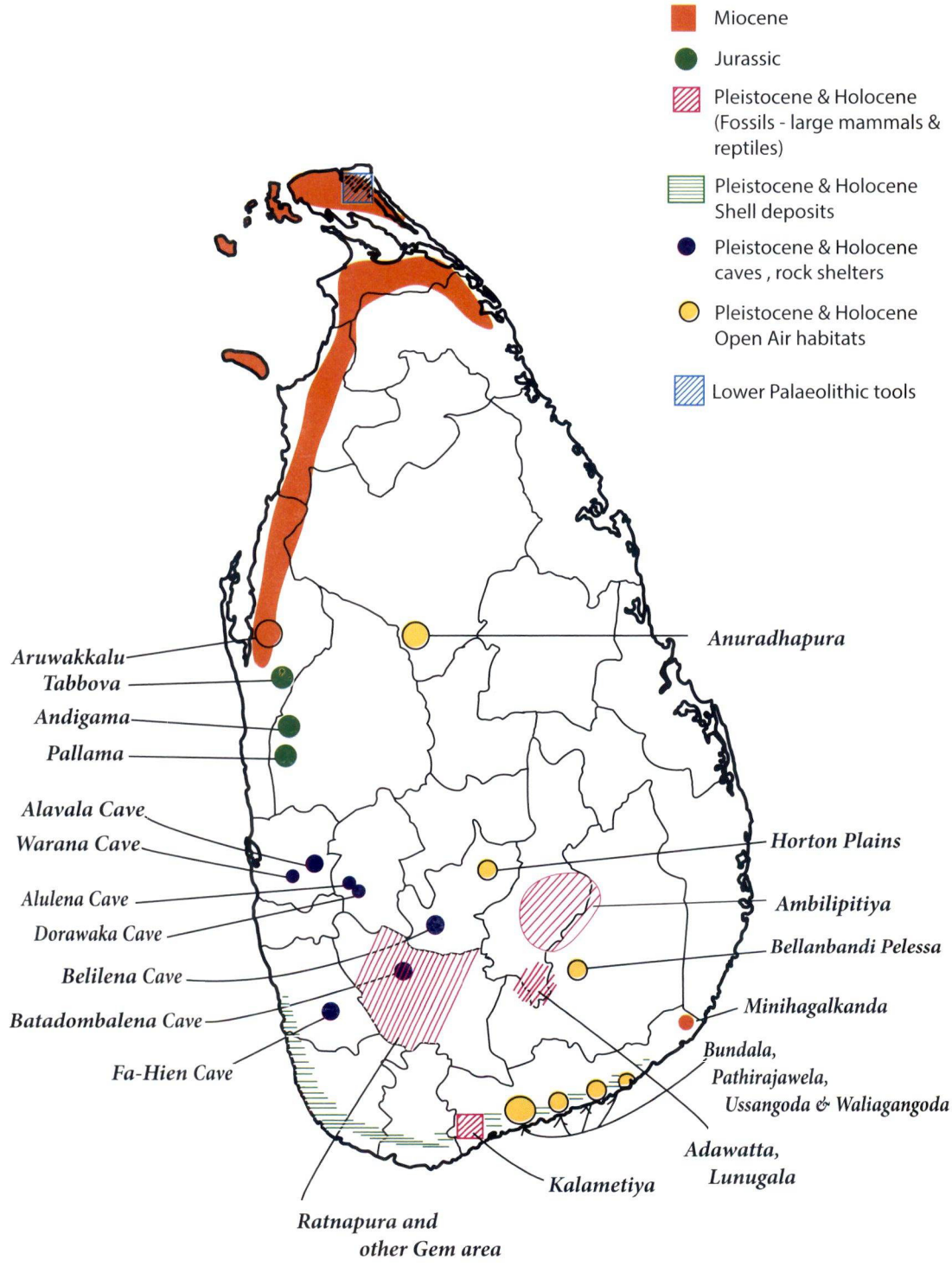


Figure 2: A representation of some of the important palaeobiodiversity sites of Sri Lanka
(Kelum Manamendra - Arachchi)

2.4.1 The Jurassic Period in Sri Lanka

The Jurassic rocks occur in two faulted basins within the Vijayan series and lie in an almost straight line to the similar faulted basins near Madras in Southern India. These rocks are well embedded and represent a series of sandstone, arkose, siltstones and mudstones. The mudstones contain imprints of fossiliferous plants. The sedimentary features of these plants suggest that these stones were originally brackish or fresh water sediments laid down in shallow deltas. It has been hypothesized that a semi- arid climate would have existed in the area due to the absence of coal bearing, or even carbonaceous, beds and that the plants represented in the rocks may have been carried down from cooler, wetter, mountain systems. Nearly 18 plant species have been recorded from these rocks and of these, several of the fern species have also been recorded from the Jurassic beds of India. These species are characteristic of the upper Gondwana formations suggesting that India and Sri Lanka shared a Gondwana derived biota.

Despite the fact that the Jurassic is popularly known as the 'Age of the dinosaurs', the evidence discovered in Sri Lanka are mainly the Conifers. The Jurassic region is represented by fossils from Tabbova, Andigama and Pallama (all in the North Western Province). In general, the Jurassic can be dated to 201-145 million Years.



(a) *Nilssonia fissa*
(b) *Cladophlebis zeylanica*
(c) *Otozamites* sp.
(d) *Taeniopteris spatula*
(e) Tabbova – rocks in which Jurassic fossils have been discovered

Figure 3: (a-d) Jurassic plant fossils & (e) Tabbova rocks (photos © KMA)

Two distinct plant bearing horizons have been identified in the Tabbova beds. The two layers can be tentatively termed as Wayland's *Cladophlebis* horizon of pipe clay and the *Ginkgophyte* horizon of coarse grit, both possibly belong to the latter part of the Jurassic and have been heavily affected by faulting (Deraniyagala, 1955a). The fossils at Tabbova (Figure a-d) consist mainly of leaves, stem fragments and shoots of coniferous trees, cycads and ferns (Pteridophyta). It is also known that sediments similar to those at Tabbova are found in the Mannar area, lying below 76.2m of the Miocene limestone.

A small basin of Jurassic sediments, somewhat similar to those at Tabbova, are to be found at Andigama. These beds do not appear as outcrops but can only be seen in wells dug over an area of several square miles. Drilling activities conducted in the late 1960s indicate that the Andigama bed covers an area of 13 sq. miles or more, and that it extends to Pallama, 7 miles south of Andigama. There is evidence to also indicate that it has been fragmented into several smaller basins (Cooray,1984).A piece of stem recorded by Deraniyagala and *Elatocladus plana* and *Cladophlebis* sp., which was obtained from a concretionary haematite/ crystalline coal and described by Sitholey in 1944, were at the time the only known macro fossils from Andigama.

The organic matter revealed spore, pollen, cuticles and wood fragments. They indicate the presence of the plant groups Pteridophyta, Bennettitales and Coniferales. These have also been reported from Tabbova
(Appendix 2: (a-b) Provisional list of the Jurassic flora and fauna in Sri Lanka)

Jurassic fauna

The first vertebrate fossils recorded in Sri Lanka were from Tabbova. The type locality is the bank of the Nanneri Oya about 100m north-west of the new spill of Tabbova reservoir. On closer examination a fin spine and a tail belonging to an Acanthodes fossil (figure 4) was revealed (Deraniyagala, 1939).

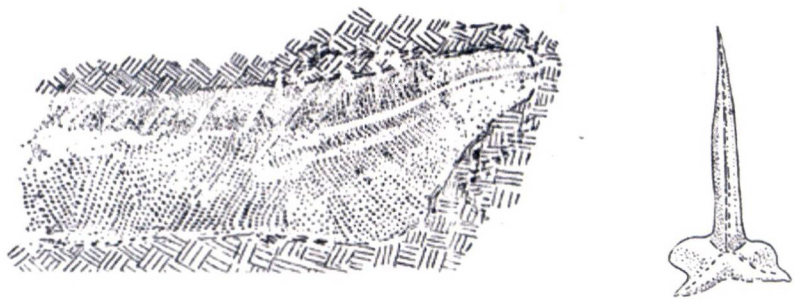


Figure 4: *Acanthodes* fish fossil (P.E.P.Deraniyagala, 1939)

2.4.2 Oligocene Period

A fossil described as *Kuphus arenarius* 'Giant Teredo' (Family - Teredidae) had been discovered by Deraniyagala from Arna Kallu in 1969. Here, he speculates the existence of an Oligocene in Sri Lanka since *Kuphus* sp. has been known to occur in deposits that are considered to be of lower Miocene or upper Oligocene (Deraniyagala, 1969a;1969b). In 2008, a Giant Teredo fossil (which was exposed on the rock face after a blast) was discovered at the quarry site at Aruwakkalu by Sampath Goonetilleke (Figure 5)



Figure 5: *Kuphus* fossil
(Giant Teredo)
© Dilup Chandranimal

2.4.3 The Miocene Period in Sri Lanka

During the Miocene Period, Sri Lanka was separated from mainland India due to the submersion of the land between the two countries. This period is known to have had a temperature similar to a greenhouse climate. The important events that took place during the Miocene period were the elevation of the Himalayan mountain range and the separation of parts of Asia from the mainland to form large islands (Sri Lanka, Sumatra, Borneo etc.). Mammals like hyenas, giraffes, antelopes and deer appeared in Asia and Europe. The Sireneans were represented by several genera and Cetatheris whales first appeared during the lower Miocene (Goonetilleke, 2000).

Miocene limestone is found in the extreme north of Jaffna peninsular whilst Miocene sandstone is found in the extreme Southeast at Minihagalkanda (Cooray, 1984).

Development activities have taken place covering the Jaffna limestone and what has remained are the fossils at Aruwakkalu (Figure 6) underlying the Red Earth. Both the Miocene limestone in the Jaffna peninsula and at Minihagalkanda is degenerated limestone. This also contains only corals and bivalves, being a representation of the intertidal region. The soil type in the Puttalam area was named the 'Red Bed'. A highly ferrous thick soil (red in colour) overlay the Miocene. Only the Miocene at Aruwakkalu contains fossils of large invertebrates and vertebrates representing a high biodiversity. Thus, the available calcium percentage is higher resulting in the Aruwakkalu area being mined for the production of cement. The fossils at Aruwakkalu (Figure 7) represent gastropods, bivalves, echinoderms, marine algae, tube worms, sting rays, whales, dolphins, fish, tortoises and turtles. (Appendix 3: Provisional list of the Miocene fauna in Sri Lanka). Deraniyagala, 1969(b) describes a site at Arna Kallu named by him as 'Malu member' where fossils of six fish were located on a fossiliferous matrix rock. It can be surmised that the Aruwakkalu area had been exposed after the Miocene due to the lowering of the sea level. The presence of fossils of dugong, gastropods and bivalves indicates an inter tidal region and the presence of whales and dolphins indicates a deep sea level (Figure 8). Further, the presence of water worn gravels and pebbles, river sand and some gastropods that are freshwater forms reconstructs that a fresh water river also ran through that area during the Miocene period.

At Minihagalkanda situated in Block II of Yala National Park, fossils of the shell *Ostrea virletti* were found together with fossil sponges and corals in which was once a beach during prehistoric times. But, no vertebrate fossils have been found here.



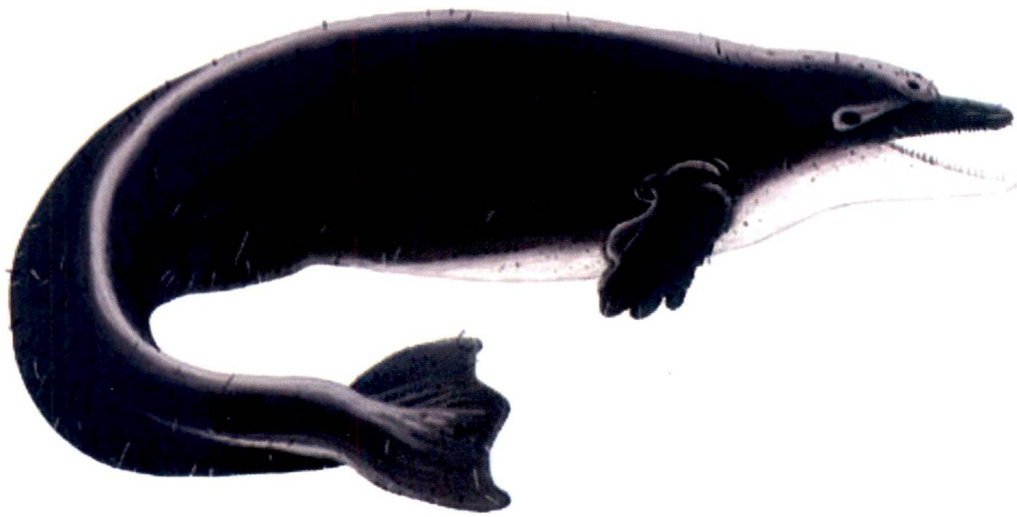
Figure 6: Cross section of the Miocene deposit (white) with the 'Red Bed' above ©(MP)



Figure 7: Fossils of the Miocene deposit (© KMA)



(a) *Miocaretta lankae*- Sea Turtle (© SDS)



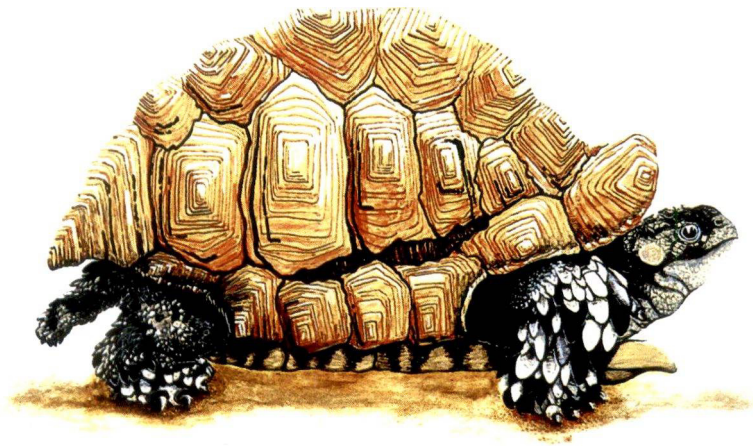
(b) *Miotursiops mulla* – Dolphin (© SDS)



(c) *Mioceta bigelowi* – Cetotheriid Whale (© SDS)



(d) *Miodugong brevicranius* –Dugong (© SDS)



(e) *Miotestudo ibba* – Land tortoise (© SDS)

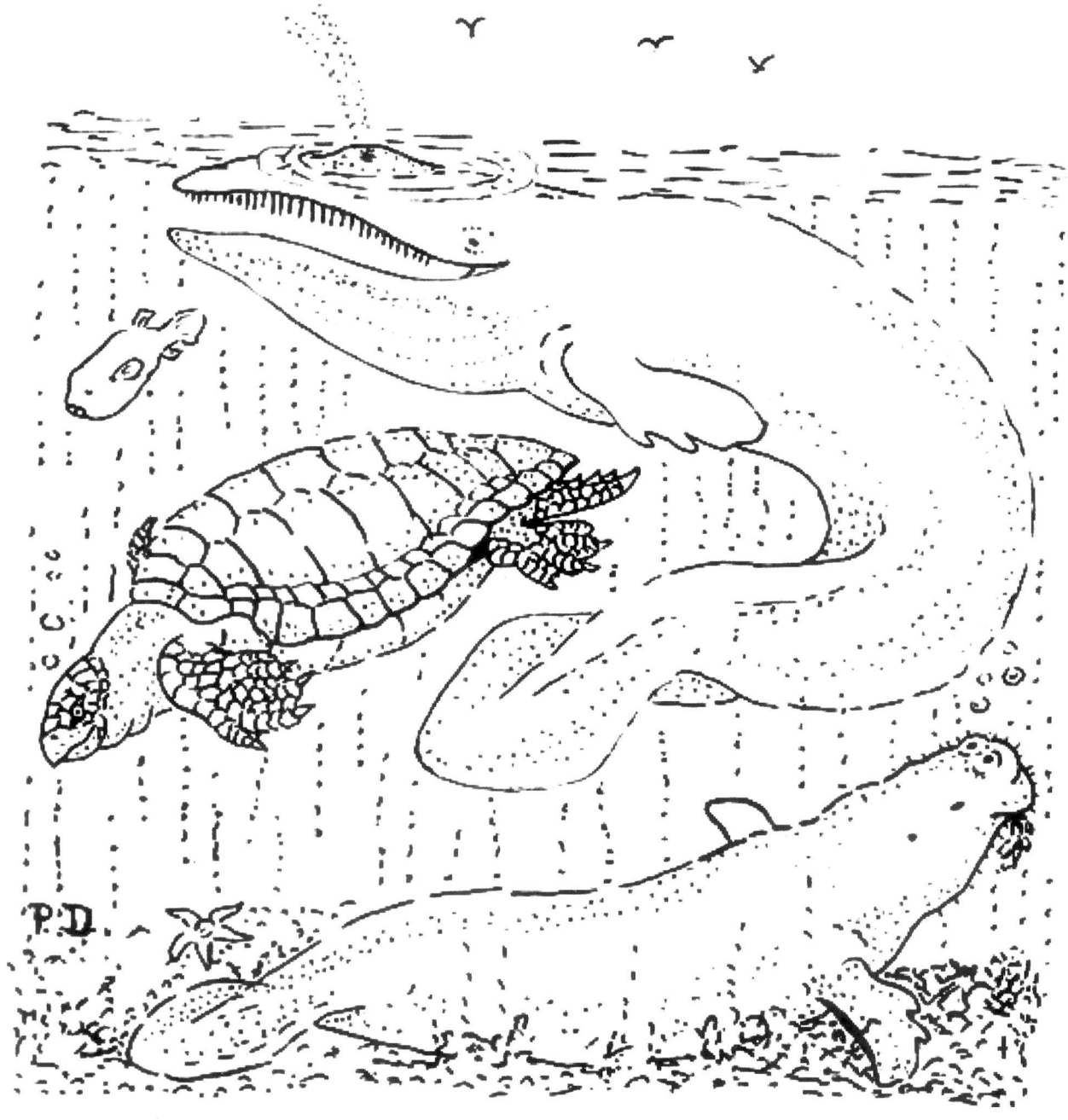


Figure 8: (a-e) Reconstructed paintings of extinct Miocene fauna (© SDS) and (f) a Miocene marine representation by P.E.P. Deraniyagala (1969).

2.4.5 The Pleistocene and Holocene

The Pleistocene and Holocene epochs are discussed together since these epochs have a certain fauna overlap.

The evolution of modern man in Africa and his dispersal / migration to other countries; the extinction of certain animals due to hunting; the production of stone tools (evolution of technology); the development of human settlements and domestication of both flora and fauna occurred during the Pleistocene (2.6-0.01yBP).

Fauna

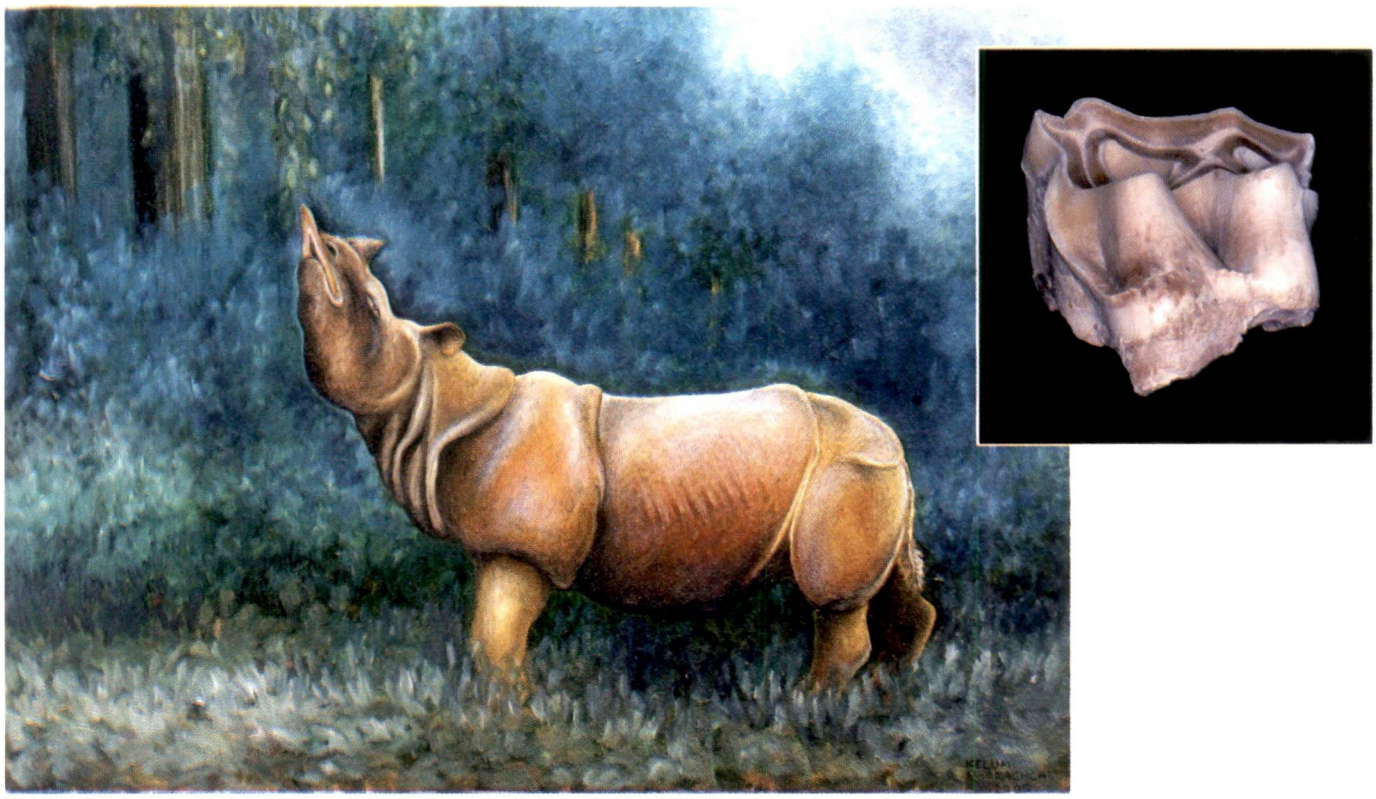
Pleistocene and Holocene fossil remains are found mainly in the alluvium of the Ratnapura District. Alluvium is usually found in lagoons, river banks and coastal areas. Fossils in alluvium are found in gem pits due to the fact that animal remains carried away by water torrents had remained for thousands of years deposited in the low lying area

The fossils of Sri Lanka are closely related to those found in Narmada and Shivalik in India. Since Sri Lanka and India

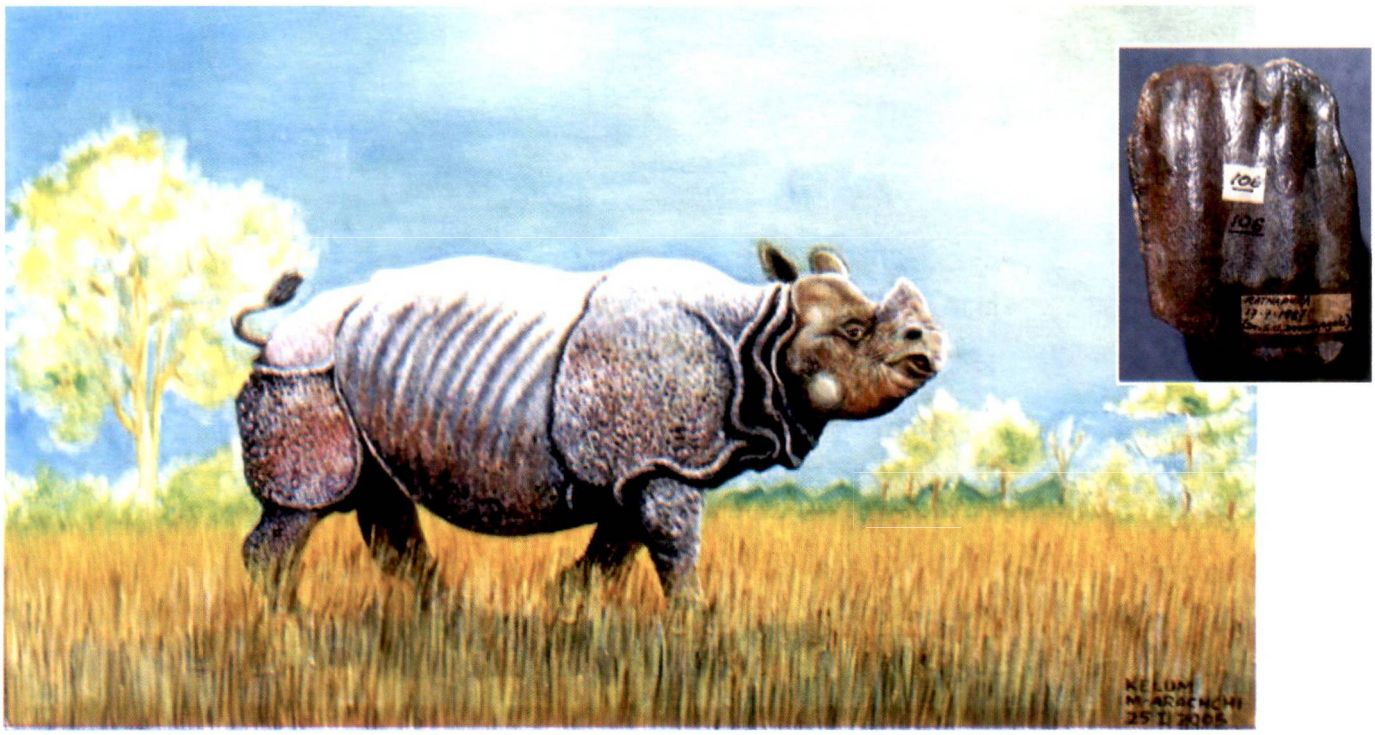
were separated only by a narrow strip of land, the fauna would have migrated to and fro according to its needs. Furthermore, similar or identical fauna is also found in Java, Sumatra and Borneo Islands and in Burma. This reveals the evolutionary links of these countries to one large landmass.

The 'Ratnapura Fauna' is represented by three species of elephant, two species of rhinoceros and a species each of hippopotamus, lion, tiger, gaur, wild dog, wild boar, black turtle and soft shelled terrapin (Figure 9) to name a few of the extinct animals of Sri Lanka (Appendix 4 : Provisional list of the Pleistocene fossils in Sri Lanka).

The Rhinoceros teeth found at Lunugala near Adawaththa have been dated by thermoluminescence to 80,000BP (margin of error 20,000) Deraniyagala (2004).



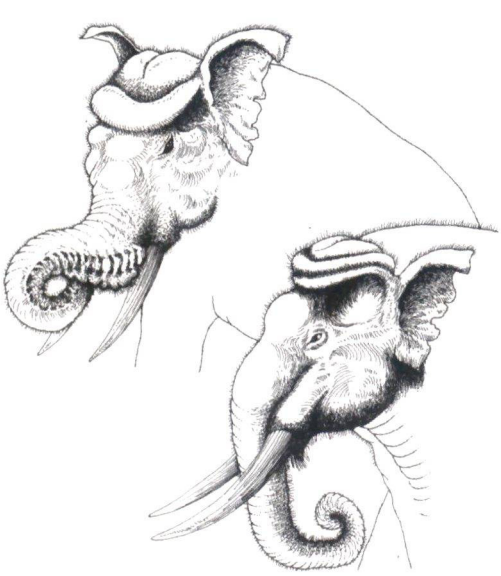
(a) *Rhinoceros sinhaleyus* and its fossil molar tooth (© KMA)



(b) *Rhinoceros kagavena* and its fossil molar tooth (© KMA)

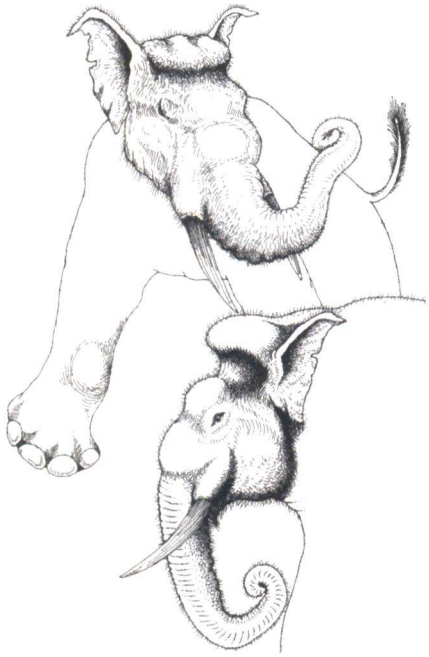


(c) Fossil of Tiger phalanx *Panthera tigris* from Batadombalena cave (© KMA)





(d) *Elephas namadicus* (©P.E.P.Deraniyagala, 1958) and fossil molar tooth (© KMA)





(e) *Elephas hysudricus* (© P.E.P.Deraniyagala, 1958) and fossil molar tooth (© KMA)



(f) *Hexaprotodon sinhaleyus* Hippopotamus and fossil premolar tooth (© KMA)

Figure 9: (a-f) Reconstructed paintings of extinct Pleistocene fauna and photographs of some of their fossils

Pleistocene flora

Evidence of Pleistocene flora is derived from pollen analysis and identifications made from stem fragments found in gem pits. Puri (1941) records a cylindrical monocotyledonous stem piece identified as *Bambusa vulgaris* from the Ratnapura beds. He also records a dicotyledonous leaf identified as belonging to *Wrightia flavido-rosea* occurring in the same bed.

Vishnu-Mittre and R.D.Robert analysed the pollen content in soil samples from Ellavala in the Ratnapura District in 1965. These were obtained from the same layer as some extinct middle Pleistocene mammals. They were able to distinguish an arboreal vegetation comprising of Myrtaceae with considerable undergrowth of *Strobilanthes*. Other vegetation types comprised of Moraceae, Sapindaceae, Anarcadiaceae, and Rutaceae. The ground vegetation consisted of Graminae, Cyperaceae, Geraniceae and *Impatiens* together with some members of Caryophyllaceae and Labitatae. Ferns such as *Adiantum*, Polypodiaceae, *Polypodium* and *Pteris* was also identified. Chowdhury (1965) was able to identify some wood remains from the Upper Pleistocene gem pits at Sabaragamuwa. A *Mesua* sp. (47,000 BP) was identified from Pelmadulla and *Lagerstroemia speciosa* (7520 ± 150 BP) was identified from Balahapuva.

The lack of Pleistocene flora in gem deposits maybe due to the fast decomposition in the alluvial soil. Pollen studies have not been conducted for cave deposits. Sieving methoods have revealed only *Canarium* sp., *Cyathea* sp., *Artocarpous* sp. and *Eleaocarpus* sp. due to their hard seeds.

Pleistocene climate

According to Deraniyagala,P.E.P.(1958a) the Pleistocene climate consisted of three distinct phases termed Ratnapura Phase, Palagaha Turai Phase and Colombo Phase (Early Holocene).

The Ratnapura Phase was characterised by wet and cool climatic conditions. The fossil beds from this stage contain lake dwelling animals such as the hippopotamus *(Hexaprotodon)* and aquatic vegetation suggestive of large lakes and swamps. The Palugaha Turai Phase is represented by highly oxidised red earth and wind blown sands suggesting a dry and arid period, overlying the beds of the Ratnapura Phase. The Colombo Phase is essentially of the Early Holocene Age, during which conditions became wetter and stabilized themselves in the climatic conditions experienced today (Senanayake, 1994)

According to pollen studies conducted by Premathilake, R. and J.Risberg (2003) the climate in Horton Plains indicates the presence of an arid climate in the Late Pleistocene. He also identifies an increase in precipitation by the presence of a predominantly montane environment between 12,000-11,000 BP. A further change is depicted during the Holocene. It indicates an increase in precipitation in the intervals during 8000 -7000 and 4000-3000 BP and an arid phase from 6000-5000 BP and also another short wet phase around 600 BP.

Pleistocene (The Ratnapura phase)

The extinct vertebrates during this phase indicate that they inhabited savannah country with rain forest and many large natural lakes and rivers fed by heavy rainfall. There were various stages from the torrential river, slow river, to the lake and swamp.

The fauna representing the Ratnapura phase were; *Melanochelys trijuga sinhaleyus* (Black turtle), *Lissemys punctata sinhaleyus* (soft shelled terrapin), *Crocodylus sinhaleyus* (crocodile) , *Homo sapiens* (man), *Hystrix sivalensis sinhaleyus* Porcupine), *Cuon javanicus sinhaleyus* (wild dog), *Panthera tigris* (Tiger), *Leo sinhaleyus* (Lion) *Hypselephas hysudricus* –now known as *Elephas* (elephant sp.), *Palaeloxodon namadicus* (elephant sp.), –now known as *Elephas* , *Rhinoceros kagavena, Rhinoceros sinhaleyus* (Rhinoceros), *Sus sinhaleyus* (wild boar), *Hexaprotodon sinhaleyus* (hippopotamus) , *Rusa unicolor* (sambhur), *Axis axis* (deer), *Bos sinhaleyus* (gaur) and *Bubalus bubalus* (wild buffalo) *Gona sinhalaya* (wild cattle), *Muva sinhalaya* (deer)

Late Pleistocene (The Palugahaturai phase)

The Palugahaturai phase prevailed when aridity commenced. The lakes and many swamps dried up. Extensive tracts of red earth (Iranamadu Formation) and sand had been deposited by wind especially in the North, North–West and South of the Island during this phase. The once swampy zones gradually withdrew and lost their permanent water table.

Holocene (Colombo phase)

This covers wet and dry zones which is the climate of today. This phase subdivided into a cool and warm area, depending on altitude, while the weathering of the bedrock and its proximity to the surface influence the growth of vegetation upon it. This type of land is the first to be affected by a general climatic change and today it supports the dry zone forest, dry zone patana and savannah that occupy much of Sri Lanka's lower and intermediate peneplains (Deraniyagala, 1958).

Fauna of the Holocene

The fauna of the late Pleistocene and early Holocene are quite similar. Whilst some species went extinct others survive to date. Of these, the gaur was an animal that had remained up to the Holocene but is currently extinct. Its presence in the island has been documented in the Kandyan era by Robert Knox in 1681.

2.5 Palaeogenetic diversity of Sri Lanka

Some of the taxa that existed during the prehistoric period exist today. Unlike the taxa of the Jurassic and Miocene Epochs, some of the Pleistocene fauna are still to be found today, albeit evolved into new species. Species of the genera such as *Acavus* sp., *Rus* sp., *Paludomus* sp., *Bubalus* sp., *Tor* sp., *Panthera* sp., *Canis* sp., *Melanochelys* sp., *Lissemys* sp., *Lyriocephalus* sp., *Ceratophora* sp., *Cophotis* sp., *Lankanectus* sp., *Cyathea* sp., *Artocarpus* sp. and *Canarium* sp. and many more have not shown diverse evolutionary changes and exist in the same form that they existed during the Pleistocene. However, new 'types' have emerged in the course of time.

2.6 Palaeohumandiversity of Sri Lanka

Peopling in Sri Lanka

Humans first inhabited Sri Lanka during the Pleistocene period (Figure 10a). The history of inhabitation of the human in Sri Lanka has been revealed through the stone tool evidence from excavations which date from 125,000 BP.

Recent findings of stone tools from Jaffna peninsula indicate the presence of *Homo erectus* from lower Palaeolithic (based on tool type). According to the tool technology it can be dated to 0.6- 1.6 million years ago (pers.com Siran Deraniyagala, 2011). A fossilised upper incisor of a human was discovered by P.E.P. Deraniyagala in a Ratnapura gem pit (Karangoda) along with a Hippopotamus, Rhinoceros and extinct elephant fossils. Since the tooth showed primitive characters it was assigned to *Homopithecus sinhaleyus.* (Deraniyagala, 1958).

A heavily mineralised part (around the supra orbital) of a skull was discovered in a gem pit at Radalla, Kuruvita in 1957 (Deraniyagala, 1957). This had been named as a skull fragment of *Homo sinhaleyus* (Figure 10b).

However, *Homopithecus* and *Homo sinhaleyus* are not mentioned among 'Hominid Classification'.

In, 1945 Ravana ella (Figure 10a 1) was excavated by P.E.P. Deraniyagala and the human osteological remains were designated the name *Homo sapiens balangodensis*, popularly known as the Balangoda Man. Later, during the 1980s this fossil was re-examined by S.U Deraniyagala and Kenneth Kennedy. They however, concluded that the fossil was not of a sub species but that of an early *Homo sapiens.*



Figure 10 a1: Excavation at Ravana-ella, 24 July 1945, a sketch by Deraniyagala, the type locality of *Homo sapiens balangodensis*

Sub fossilised human fragments were found at Kuruvita Batadombalena cave in 1982. These fossils were dated to 37,000 -12,000 BP. More human osteological remains (approximately, of over 80 individuals) have been unearthed from the Fa Hien cave (Paahiyangala) at Bulatsinhala, Kuruvita Batadomba cave, Belilena at Kitulgala and Belanbendipelessa in the Uda Walawa National Park. The skeletons at Paahiyangala and Batadombalena were dated at 48000 (Nimal Perera, pers.com : 2012) and 37000 BP respectively. Therefore, these human remains could be identified as the oldest pre-modern humans found in the South Asian region (Kennedy & Deraniyagala, 1989).

Chronologically, the human osteological remains found in Sri Lanka could be dated from ca. 48000 yBP to present; Paahiyangala 48000 (Nimal Perera, pers.com : 2012) , Batadombalena 37000, Kitulgala Belilena 16000, Ravana Ella 6500, Sigiri Potana 6000, Mantota 1800 yBP. Some of the other Sri Lankan protohistoric sites too represent the human osteological remains belonging to the above sequence.

Human remains were also found in shell middens at Hungama and Pallemallala in the South. These were dated to 6000 yBP.

The Sarasin cousins excavated caves where Veddahs were residing during the late 1800s and discovered many skeletons. These skeletons are now reposited at the Basel Museum in Switzerland. Despite the fact that Sarasins hypothesised that the skeletons may have belonged to prehistoric man, these skeletons have been now ascribed to ancestors of the Veddahs with some probably from the end of the Balangoda Culture (Mesolithic).

According to S.U. Deraniyagala, Keneth Kennedy and Diane Hawkey the Veddahs are a race with genes coming from a diverse collection of immigrants to the island. They assume that only 5% of the Veddah genes are from the Balangoda Man (Deraniyagala, 1992).

Hawkey's (2002) examination of morphological characteristics of teeth of the prehistoric, iron-age, early historic, tribal and recent man in South Asia revealed that the Sri Lankan hunter-gatherer is closely related to the Sri Lankan Iron-Age man. These two are completely isolated in the clade. The Sri Lankan veddah (Figure 10 c, d) shows close affinities to South Indian people and the present day Sinhalese show a close relationship to the Deccan farmers, Deccan Iron Age people, Nepalese and the people of Myanmar.

Figure 10 (a) An open air site: Prehistoric man manufacturing stone tools (© KMA)

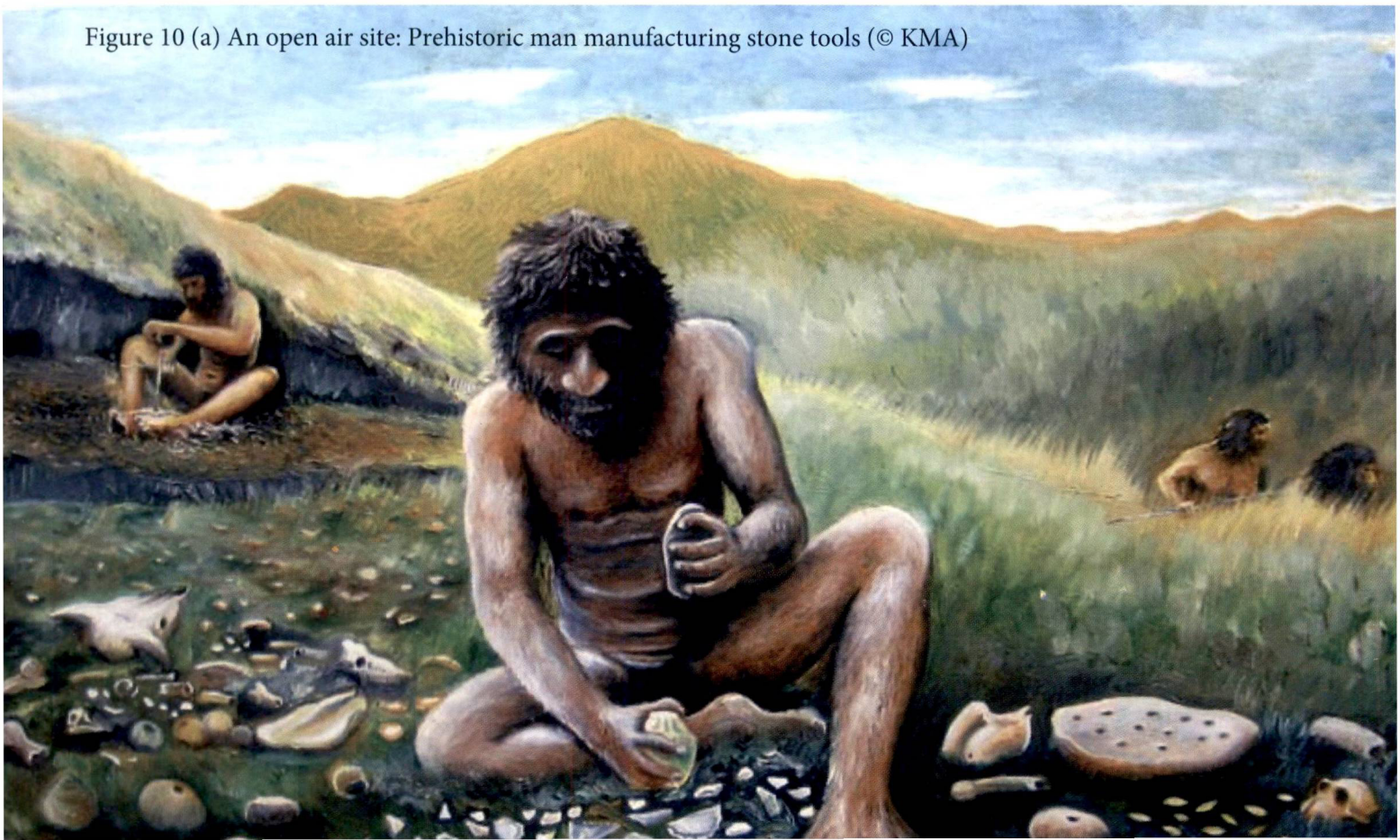




Figure 10: (b) upper incisor of *Homopithecus sinhaleyus* (scale bar =10 mm) (© KMA)





Figure 10: (c) a Veddah male and (d) a Veddah female (© Sarasin & Sarasin, 1887-1908)

2.7 Material culture and Stone tool traditions in Sri Lanka

The material culture and the stone tool tradition of Sri Lanka are highlighted in the late Pleistocene and early Holocene. These can be categorised according to the type of stone (lithic) tools used.

Lower Paleolithic

The Lower Paleolithic has not been reliably documented in Sri Lanka. The alluvial (gem - bearing) gravels of the Ratnapura district referred, to as the Ratnapura beds, have yielded man-made chopping and cutting tools (Ratnapura Industry), in association with a fossil fauna (Ratnapura fauna), which could tentatively be assigned to the Paleolithic. Tools found associated with high-level coastal deposits in the north and south-east of the island (Iranamadu formation) and recent findings from Jaffna (Figure 11 a) can also be assigned tentatively to the Lower Paleolithic pending scientific dating of these occurrences.

Middle Paleolithic

The Middle Paleolithic has been recorded in Sri Lanka. A few sites in the coastal gravels of the Iranamadu formation have been dated to between 125,000 and 75,000 BP. There are numerous occurrences on the surface of the Iranamadu formation (Figure 11 b) and some in the Ratnapura beds, which are likely to have been of this phase of technology.

Upper Palaeolithic

According to tool technology it is difficult to clearly distinguish between the upper Palaeolithic and Mesolithic phases. As a result, speculation exists as to the existence of an upper Palaeolithic phase in Sri Lanka (Deraniyagala, 1992 and Perera, 2010).

Mesolithic

The Mesolithic period in Sri Lanka (Balangoda culture) has been dated from approximately 48,000 – 3,800 yBP. The stone tools made of chert and quartz displays the highest degree of workmanship, notably the geometric microliths (Figure 11c,d) and the exquisite pressure-flaked Balangoda points (Figure 11e) which resemble arrowheads. Some pitted pebbles used for producing fire and grinding purposes have been made from granitic rocks. Bovine and cervis incisor teeth have been sharpened and used as tools, (Figure 12 a,b) these tools and beads made of sea shells and

Shark teeth occur from 50,000 years onwards (Figure 13 a,b,c). Animals (perhaps cattle) may have been herded and the domestication of plants could have reached an incipient stage. Pottery seems to have been produced in the final stages. The human of the Mesolithic Sri Lanka was an anatomically modern *Homo sapiens*, popularly known as the Balangoda man. These humans are considered to be the direct ancestors of the Veddas of recent times.

Postmesolithic

A Postmesolithic or transitional period from Mesolithic to protohistoric Iron Age which is characterised by pottery and stone tools (microliths) is described from 3700 to 2600 yBP. This phase is evident in the findings from excavations carried out at Ranchamadama and Haldumulla clay burial sites.

Neolithic

Some Sri Lankan archaeologists envisage the beginning of animal husbandry and the incipient domestication of oats and barley as early as 17,000 yBP in Sri Lanka's montane grasslands. These prehistorians believe these early experimentations evolved into a matured phase of cultivated oats and barley by 10,000 yBP. Pottery has been found in association with Mesolithic tools at cave habitation sites, and a few stone axes with grinding on their faces have also been discovered. It is not feasible as yet to separate the numerous Mesolithic sites characterized by microliths into pre-farming and farming (Neolithic) phases. (Deraniyagala, 2004)

Prematihilake and Nilsson (2001) indicate the presence of a pre farming/pastoral culture from 14,000 - 10,000 yBP at Horton Plains. This is further evidenced by the presence of *Hordeum* sp. and *Avena* sp. from 9000 to 6500 yBP. Only limited agricultural activity can be identified after this. Their investigations further revealed that from around 3000 yBP the plains were abandoned until the cultivation of *Triticum* sp. between 800 to 200 yBP.

Microliths, pottery and some grains found in an excavation at Dorawaka Lena in Kegalle, dated 6000 yBP, reveal evidence of a Neolithic period (Wijayapala, 2010; Deraniyagala, 1992).



(a) A chert Hand Axe from Jaffna (© KMA)



(b) Middle Palaeolithic chert stone tool from Bundala Pathirajawela (© KMA)



(c) Geometric microlith (© KMA)



(d) Geometric microlith (© KMA)



(e) Balangoda point (© KMA)

Figure 11: (a-e) Stone tools belonging to various tool traditions



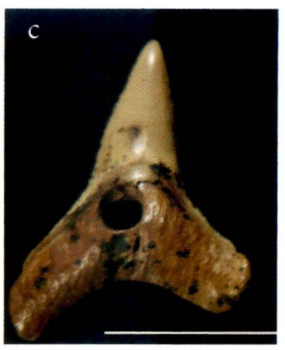


(a) A sharpened bovine incisor tooth (© KMA)
(b) Bone point (© KMA)

Figure 12: (a-b) Bone tools







(a) Shell bead
(b) shell bead
(c) Shark tooth ornament

Figure 13: (a-c) Shell Beads and ornaments (© KMA)

2.7.1 Protohistoric period / Formulative phase

The protohistoric or the 'early iron age' is identified as the formulative phase in Sri Lankan history. This is also known as 'the twilight zone' due to the transitional aspects of the social evolution, the beginning of literacy and incipient agriculture.

The formulative period is associated with two processes: The horizontal dynamic which is represented by the techno-cultural matrix spread over the physical region and the vertical dynamic represented by the uneven development of institutional formation in time and space.

The wind and ocean currents brought many foreign visitors to the island. Inevitably, there was interaction with South India, North India and also European cultures. A riverine trade was evident. Boats came inland along the Yan Oya and Malwathu Oya for the purposes of trade. The Mantai port was world famous as a centre for trade (evident by the Chinese porcelain found). A barter system would have been used for trading. There are records of natives leaving ivory, mahogany, spices, gems etc. in the open and being on the look-out concealing themselves in the scrub jungle bordering the beaches when foreign ships reached the coast. In return the European (Greek/ Roman) and Indian traders left behind Kohl sticks, tools made of iron, etc. The protohistoric Sri Lankan man had identified iron but, had still not commenced to utilize it. Crafts began to develop and goods and products were bartered.

There was a transition from hunter-gatherer societies towards sedentary life . With the protohistoric phase commenced the incipient agriculture. The people left the highlands and moved into the valleys and slopes to grow grains. Belanbendipelessa shows evidence of chena cultivation. Research conducted in Horton Plains by Premathilake (2001) also indicates the same trend.

Towards the end of this phase there is evidence of the manufacture and utilisation of iron tools. The villages surrounding Seruwavila contain proof of the use of the copper-magnetite deposit found there.

Evidence is to be found of the commencement of literacy during this period and the resulting changes in social cultural aspects. Non-Brahmi symbols are present on capstones in megalithic graves and establishment of groups of tribal people and the emergence of stratified societies and groups of elite folk had occurred at the time. They were

pastoralists and had been able to accumulate wealth.

The elite were able to construct and maintain burials. These were of the megalithic type. Cist burials were the most prominent type, e.g. Ibbankatuwa where a crematorium platform is evident. Despite the fact that the burial at Ranchamadama was not of a megalithic type but an earthen canoe burial, the use of iron is evident in the cutting of sand stone for the construction. The material culture of the protohistoric period is also evident from the presence of the type of material found at these burial sites. These include grinding stones, clear quartz tools, clay bowls made of Black and Red Ware (BRW), Red Ware (RW) and Polished Red Ware (PRW), beads made of materials such as carnelian, shells, quartz, glass and onyx, kohl sticks, agricultural implements made of copper and iron, iron and copper alloy bracelets and bangles and tools made of bone and shells. Since some of the raw materials such as chalcedony are not found in Sri Lanka, it can be surmised that these objects were obtained from other groups that entered the island. The presence of stone tools with Black and Red Ware and copper items indicates an assimilation of two cultural traditions.

2.8 Human habitation

Man was primarily a hunter-gatherer and his main concern was to find a place where food was abundant. Evidence of what he had utilised from the environment reflects the kind of environment which existed during the time. Furthermore, it also reflects the types of ecosystem which existed in Sri Lanka during the Pleistocene and the Holocene.

The snail fauna *(Acavus phoenix, Acavus prosperus)* at Batadombalena and of Belilena followed by Alulena at Attanagoda indicate that moisture conditions during this time-span of Late upper Pleistocene to early Holocene were scarcely drier than those prevailing today. The Quaternary environments of Sri Lanka would have been integral with those of peninsular India. Wet zone habitat molluscs in certain Mesolithic deposits in the dry zone such as Bellanbendipellessa and Aligala shelter near Sigiriya indicate a relative homogeneity between sub zones and macro zones. Fossils of spotted deer, lion and water buffalo in the Ratnapura Beds suggest that during certain episodes in the Quaternary the lowland wet zone of Sri Lanka showed relative aridity resulting in a biome that was 'dry'.

2.8.1 Caves

Caves were used during the rainy season and open air habitations during fine weather by man. Most Mesolithic evidence has been from wet zone cave sites dated 48,000 yBP onwards (Figure14 a,b). A majority of archaeological remains have been found only in cave habitations in the wet zone. The reason for the absence of such remains in the dry zone being the donation of the caves to Buddhist monks for meditation. These caves had been cleared of the surface deposits thus unwittingly erasing valuable archaeological evidence from history.

2.8.2 Open air habitations

The oldest open-air habitations in Sri Lanka have been found at Bundala - Pathirajawela dated 125,000 BP (Figure 14 c). Most of the evidence in open air habitations either get washed away or become oxidised. Therefore, all that can be found frequently in this type of habitation are stone tools. Out of the open-air sites examined, faunal and human remains have been found only at Bellanbendipelessa, Miniethilya and Pallemalala.

The stone tool evidence at Bundala-Pathirajawela can be linked to the "Out of Africa Theory' of Paul Mellars, 2006. With evidence from mitochondrial DNA he states that humans dispersed from Africa more than 50,000 years ago and subsequently reached South Asia. Manamendra- Arachchi (2012) queries the findings of stone tools at Bundala-Pathirajawela which, dated by type indicate that they were manufactured by *Homo sapiens* more than 125,000 yBP (Deraniyagala, 1992). Therefore, the theory followed by facts is questionable.

The ethnographic data on settlements indicate that the minimum size of a hunter-gatherer band in Sri Lanka during the Quaternary would have been 2 - 15 individuals with the maximum being around 50.

In the Uva basin and Handapan Ella area, it is estimated that an extent of ca.50m^2 base camps existed. This could have been occupied by ca.8 individuals constituting 1-2 nuclear families. The exceptionally large sites at Bandarawela and

Bellanbendipelessa could have held individuals upto 25 (Deraniyagala, 1992).

The Veddahs are known to have had discrete territorial units for each family within the larger communal caves or shelters. Each family had its own cooking hearth although food tended to be shared.

The unique site at Bellanbendipelessa has had its faunal remains preserved by the limestone bedrock and gives evidence to Mesolithic subsistence practices. The range of animals exploited was very wide with the extant evidence showing up a strong component of spotted deer, wild boar, sambur, monkeys and porcupine. The Mesolithic horizon at Nilgala Cave has yielded many spotted deer and sambhur remains, within a mixed assemblage of miscellaneous vertebrates. The anthropogenic Damana parkland would have been conducive to exploitation of spotted deer. It is probable that the Veddahs' preference of grey langur, land monitor and pig could also have had its prehistoric analogue.

Fa Hien Cave, Batadombalena and Belilena comprise of a faunal assemblage of small vertebrates, porcupine, mouse deer, giant squirrel, flying squirrels, civets, pangolin and monkeys. Occasional finds of tiger and elephant are also present. Skeletal remains of a domestic dog ca. 12,000 BP from Bellanbendipelessa indicate that prehistoric man in later phases kept domesticated dogs for driving game.

Several varieties of birds (Sri Lanka spur fowl and Sri Lanka jungle fowl), snakes (python and ratsnake), hard and soft shelled terrapin, fish (barbs and mahsier), freshwater crustaceans and large quantities of arboreal and aquatic snails (*Acavus* and *Paludomus*) have been consumed by man. Hunting would have been performed by the male, while women and children concentrated on gathering food. Meat was probably eaten raw, roasted or dried; boiled food would have been the exception as receptacles suitable for cooking/boiling were lacking.

Evidence from food plants is scarce due to the poor preservation in open - air sites. But certain hard parts of the plants help in their identification. Yams (*Dioscorea*), cambium (*Mangifera zeylanica*) , kernels (*Terminalia belerica, Cycas*) fruit (*Manilkara hexandra, Nephium longana*) and flowers (*Bassia longifolia*) as well as several masticatories. *Canarium zeylanicum nuts* and wild breadfruit (*Artocarpus nobilis*) had been eaten apparently baked in hearths since well over 18,000BP. Remains of wild banana (*Musa paradisica*) and Gal veralu (*Eleocarpus* sp.) have been identified from mixed strata.

The occurrence of marine mollusc shell fragments in Mesolithic deposits suggests that these had been introduced as items of trade and ornamentation too, in addition to consumption, e.g. Batadomba lena, Belilena and Bellanbendipelessa. Salt would have been a major barter-item in the prehistoric Sri Lanka. The lagoonal snail (*Potamides cingulatus*) found in unrefined rock-salt which forms on coastal track was found at Belilena (Deraniyagala,1992).



(a) Batadombalena at Kuruvita (© KMA)



(b) Fa Hien cave at Bulathsinhala (© KMA)

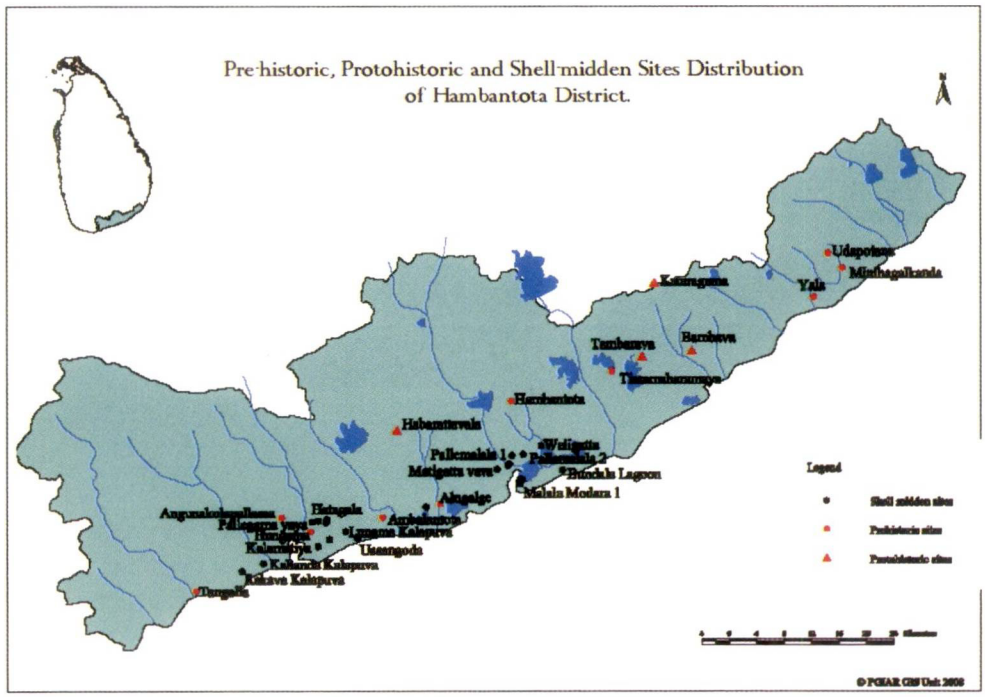


(c) Bundala Pathirajawela (Open air habitation) (© KMA)

Figure 14: (a-c) Some human habitation sites in Sri Lanka.

2.8.3 Shell middens

Shell middens are mainly found in coastal areas of the South (Figure 15). These are believed to be the remnants of deposits after sea level change. Some settlements have been discovered in the Southern region where the middens contain both natural and man-made deposits. Mesolithic burials have been excavated at Miniethiliya dated 6000 yBP and Pallemalala within the shell middens. These are flexed burials where the skeleton had been placed in a foetal position in a pit. Faunal remains, especially, that of large mammals such as buffalo, wild boar, spotted deer etc. have also been found. Furthermore, a rhinoceros tooth belonging to the Pleistocene period has been found at nearby Kalametiya. Currently, large scale exploitation of these middens are being made to produce chicken feed.



(a) Map of the shell middens (© Gamini Adikari, after Katupotha, 1995 b)



(b) A shell midden at Hathagala ©MP



(c) Excavated shells ©MP

Figure 15: Shell middens

2.8.4 Sand dunes

Sand dunes occur in the North-West and other arid regions of Sri Lanka. Formations had been present in Colombo in the past but not any more. These are areas where the monsoonal winds do not occur and as a result, in time, large sand dunes have formed. Remains of stone tools which indicate the presence of human settlements are evident in the sand dunes. Wayland examined the Iranamadu formation (Figure 16) in the Northern Dry Zone and described the geometric microliths and the Palaeolithic microliths found within the deposit. Mohan Abeyratne dated the sand of Bundala Pathirajawela to 125,000-70,000 yBP. The Red Beds found over the Miocene deposit at Aruwakkalu could be more than 125,000 yBP since stone implements are found within the gravel layer of this deposit.



Figure 16: Iranamadu Formation by R.Y. Deraniyagala 1978

2.8.5 Marine

Marine investigations of paleobiodiversity is sadly lacking in Sri Lanka. What has been explored are only the ship-wrecks in the coastal sea. There is a dire need to investigate underwater caves located in and around the coastal regions of Sri Lanka.

Human dispersal occurred along the coastal belt and according to Mellars (2006) it is possible that the evidence has

been lost due to sea level rise. Therefore, research in this aspect is a necessity.

2.9 Burials

Prehistoric burials had occured in two forms. One was a flexed burial where the dead were buried in foetal position in a pit (primary burial practice) Figure 17a. The other was where the skeleton was left to decompose and the skull fragments were coated in red pigment and buried in a pit inside a cave (secondary burial practice). Evidence of pigmented skull fragments in Fa Hien cave, Batadomba cave, Ravana Ella, Belilena and Alawala cave indicates secondary burial practices. This is an indication of rituals practiced after death.

Burials are also evident in the protohistoric period in the megalithic tradition. It is believed that megalithic burials were constructed to protect the spirit of the dead. Burials were a secondary activity because after death, the ashes of bones were deposited in the burial. Some burials contain food, tools and ornaments besides the ashes (which contained charred teeth and bone fragments). Most often the burials were situated at locations where there was a paucity of water and the path leading to the burial site was kept cleared. While some burials were isolated others were kept in 'cemeteries'. Furthermore, with the new findings of variations of cist burials (more than 9 sub types –Ranjith Bandara pers.com :2014) at Yan Oya Middle Basin by Ranjith Bandara the classification will be further modified. Therefore, a brief description of the main types of burials found in Sri Lanka is presented.

1. Urn burials
2. Cist burials
    a) dolmenoid cist
    b) simple cist
    c) standing slab cist
3. Earthen Canoe
    a) earthen slab
    b) clay lump wall
4. Cairn burials
    a) cairn heap
    b) cairn circle
    c) stone ring

2.9.1 Urn burials

Urn burials have been recovered from Pomparippu (Figure 17e). These urns are enormous in size and constructed from clay. Whilst the mouth is small, the bottom is large and oval shaped. The entire urn was buried underground and its mouth closed by a capstone which is shaped square or round. The urn contained several other (7- 12) clay vessels that contained ritual offerings, ornaments and tools. The entire skeleton was not kept in the vessel but only the main bones such as the head, arms and legs.

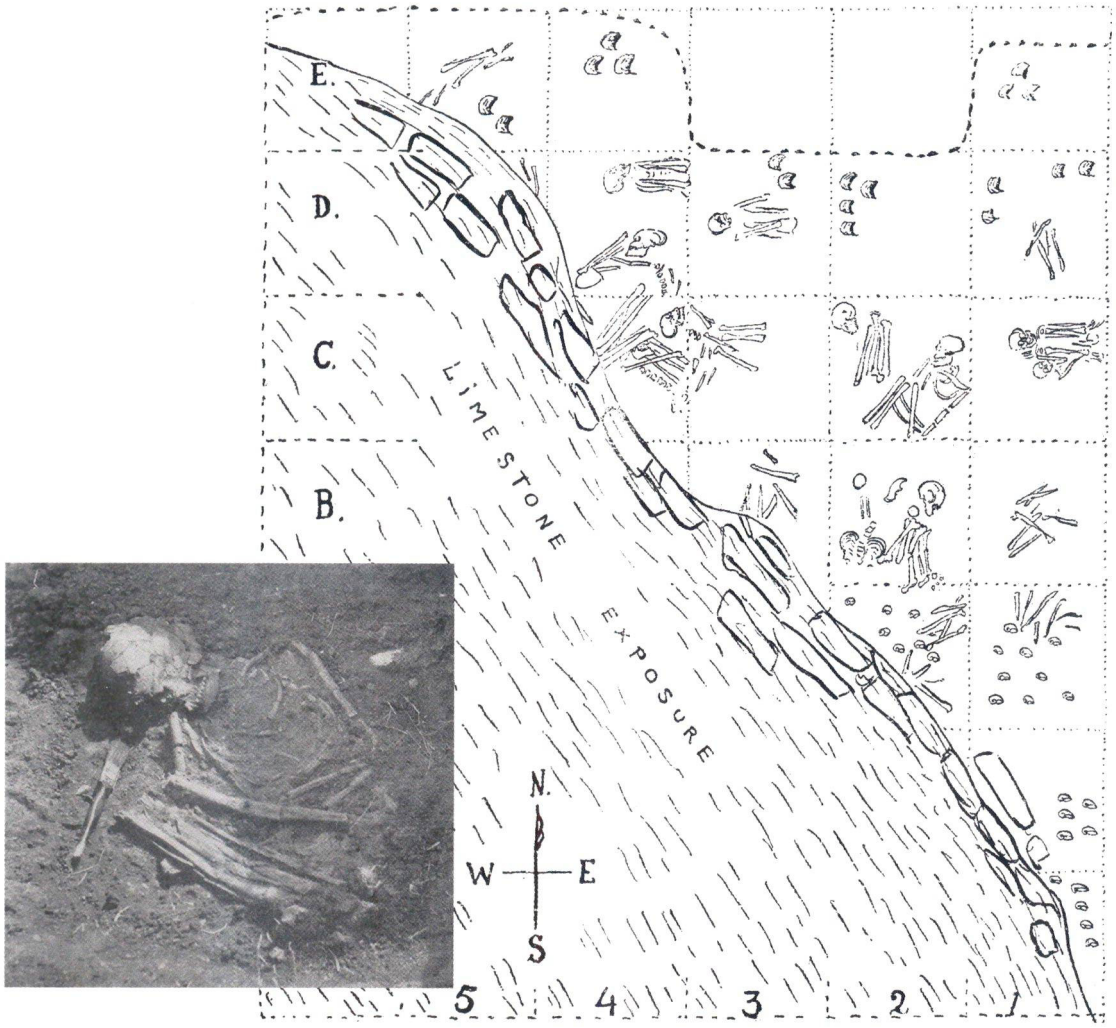
2.9.2 Cist burials

Cist burials were the type that was most frequently used during the Megalithic culture. This type of burial is found at Ibbankatuwa (Figure 17c), Pinweva, Machchagama, Rambewa, Divulweva, Kokabbey, Gurugalhinna, Galathara, Thammannagodalla, Aluthbombuva and Yatigalpottha. Four slabs of stones were located at angles in the form of a rectangle in a pit. Vessels containing ashes/ bone fragments and the belongings used by the individual during his/her lifetime were laid within the cist and a flat slab of rock was kept on top covering the burial. At Ibbankatuwa there is a large flat slab of rock which had served crematorial purposes. One of the cist burials at Ibbankatuwa contained a large hollowed space/ pit which could contain the ashes of nearly 10 - 12 individuals.

2.9.3 Earthen canoe type

The earthen canoe type has been found at Mahalenama, Ranchamadama at Embilipitiya, Nikawelamulla (Figure 17b) at Ruwanwella and Haldummulla at Beragala, Matara-Bandattara, balangoda- Hatharabage, Attanagalla –kalotuvava and many more sites. Clay had been used to construct a canoe like burial. Vessels contained within enclosed ashes/ bone fragments and items of use. One of the earthen canoes served as a crematorium where the body was burned and ashes or skeletal remains were transferred into another burial canoe.

The earthen slab type is present at Nikawelamulla and clay lump wall has been observed at Ranchamadama. The burials at Haldummulla contain few balangoda points. No other burial had contained these.



(a) A diagramatic representation of the burial site at Bellanbendi - Pelessa Deraniyagala, 1939 b



(b)Earthen canoe burial at Nikawelamulla (© S. Madanayake)



(c) Megalithic burial at Ibbankatuwa



(d) a dolemenoid cist at Padavigampola



(e) Urn burial at Pomparippu

Figure 17: (a-e) Types of Burials

2.10 Paintings and petrography

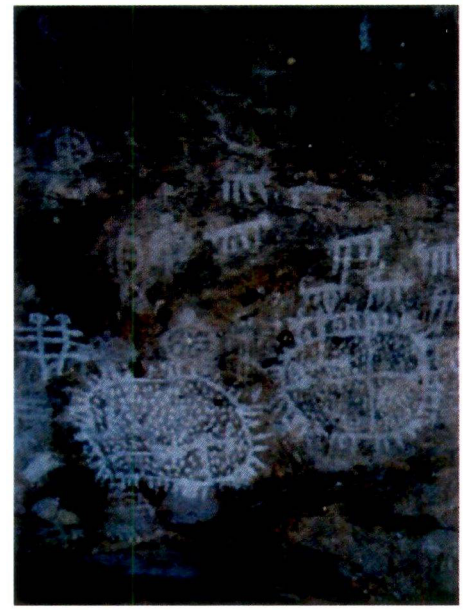
Art of a primitive character consisting mainly of drawings or scribbles on rock surfaces is referred to as 'rock art'. H.C.P. Bell (Sri Lanka's first Commissioner of Archaeology) was the first to discover a set of rock art in 1897 in the North Central Province of Sri Lanka. These were situated at Konatte-goda-gala and Arangoda-gala. The drawings have been attributed to Veddah artists.

Most of the drawings occur in caves that have been used as monastic dwellings in ancient times. Since the caves were thoroughly cleaned before being donated to monks there is meagre chance of the survival of the earliest rough drawings. Therefore, a majority of the pictographs that are extant may be of the early historic periods. However, the engravings at Dorawakakanda and paintings at Billawa may belong to the prehistoric era.

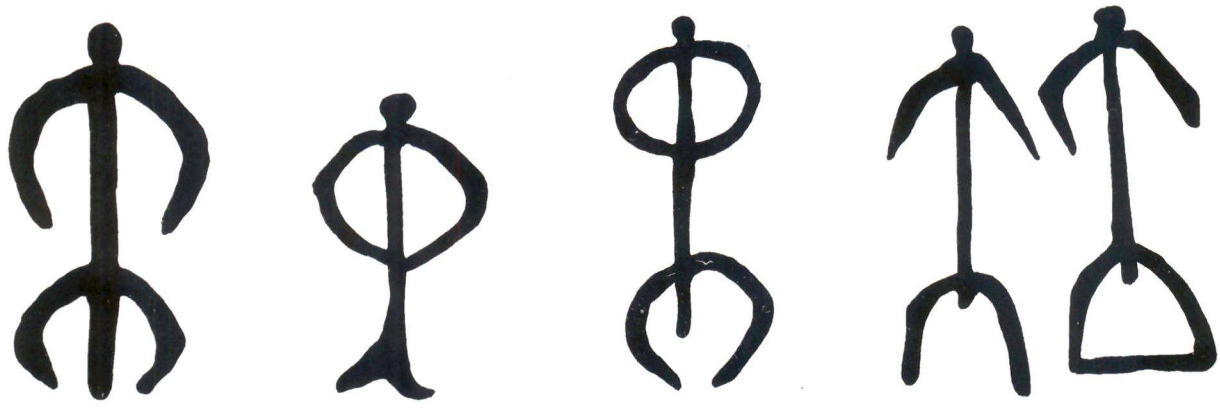
Human beings and animals (Figure 18 a-d) appear to be the principal subject of Sri Lankan rock art. Among the animals drawn are elephant, leopard, lion, cattle, crocodile, centipede, deer, sambur, monkey and peacock.



(a) Magulmahavihara © Chinthaka Wijetunga



(b) Budungehela © Chinthaka Wijetunga



(c) Tanthirimale, Anuradhapura District, Human Figures © KMA



(d) Billawa, Anuradhapura District, 'Unintelligible' and 'Sambhur". © KMA

Figure 18: (a-d) Rock art found in caves

Whilst most of the rock art has been drawn by Veddah women, ash, kaolin, ochre and lime are said to have been used as pigments in these drawings (Seligman & Seligman, 1911). Many researchers state that the forefinger of the artist would have been used as the brush. A stick with a softened end may have been used to apply the pigments to fill in the sketches on the bare rock which had not been plastered or treated in any way to hold the pigments (Nandadeva, 1986). Forty one rock art sites have been documented by Nandadeva. Subsequently, further additional sites were documented by Somadeva (2012). (Appendix 6: Provisional list of rock art found in Sri Lanka).

2.11 The history of the contributions of archaeologists towards palaeobiodiversity in Sri Lanka

The first Jurassic fossils from Sri Lanka were discovered from Tabbowa, by James Parsons in 1905, while he was traveling from Puttalam to Anuradapura. However, he identified the fossils as recent marine sandstone. In 1915, E. J. Wayland re-examined Parsons' discovery. He was able to collect some fossilized plants. The fossils were sent to A. C. Seward and R. E. Holttom at Cambridge who, in 1922, identified seven plant fossils using the specimens. In 1920, Wayland described the fossiliferous beds and documented the detailed geological characters of the Tabbowa Jurassic beds (deposits), (Wayland, 1925). After these findings, Jakob (1938) and Sitholey (1944) also described some plant fossils from Tabbowa. P. E. P. Deraniyagala (1939a ; 1940) recorded a new Jurassic deposit containing Pteridophytes, Cycadophtes, and Conifer fossils from Andigama (sixteen miles south of Tabbowa). In late 1930s, D. N. Wadia collected the first vertebrate Jurassic fossil (scales of fishes with a cartilaginous skeleton) which was handed over to Deraniyagala for identification (Deraniyagala, 1938; 1939c). Sahni and Janet (1941; 1942) published some notes on Jurassic microfossils from Andigama and Tabbowa using the samples sent by Wadia and Deraniyagala. Satish Chandra Das Sah (1953) re-examined the whole sample and described 35 different types of spores and pollens, cuticle pieces of bennettitalean and coniferous affinities, and wood fragments. Finally, Deraniyagala (1955a) summarized the results of his 1939 Tabbowa collection and divided the upper Jurassic to two horizons, namely *Cladophlebis* horizon and *Ginkgophyte* horizon.

In 1923, Wayland and Davies first discovered the Miocene beds from Sri Lanka. Davies (1923) was able to identify the invertebrate fossils belonging to Gastropoda, and Lamellibranchia from Minihagalkanda area. Deraniyagala discovered the first vertebrate Miocene fossils from Northern Miocene beds (Deraniyagala, 1935; 1937a; 1937b). It included an extinct terrapin and a marine mammal, six genera of cartilaginous selachian fishes and three genera of bony fishes. Eames (1950), and Tewari and Tandon (1960) attempted to determine the age of certain Upper Tertiary Miocene beds of India and Sri Lanka. Tewari and Tandon (1960) also recorded several micro-fauna from Jaffna beds. For the first time, Deraniyagala (1960a; 1960b) recorded Echinodermates, Sponges, corals and vertebrate fossils from Minihagalkanda. He suggested that some degree of volcanic activity had probably caused the faulting of the Minihagalkanda ridge. In 1967, Deraniyagala described two species of chelonids and one Marine fossil mammal from the Miocene bed. Deraniyagala (1969 a; 1969 b) described a range of marine fauna such as sharks, whales, dugongs, sea turtles and dolphins, ranging from deep sea to intertidal and terrestrial fauna such as the tortoise from Aruwakkalu.

A majority of the Pleistocene fossil studies were carried out by P.E.P.Deraniyagala. In 1935 and 1938, Deraniyagala listed completely mineralized fossil fragments of *Hexaprotodon sinhaleyus*, *Rhinoceros sinhaleyus*, *Bibos sinhaleyus*, *Elephas maximas sinhaleyus* and *Panthera leo sinhaleyus* from gem pits of Ratnapura area. During excavations made in the several test pits at Udupiyan Galge near Diyavinna, Batadomba Lena and Batatota Lena near Kuruvita he discovered some fossilized bone fragments of gastropods, reptiles and mammals together with stone tools made by early Stone Age humans (Deraniyagala, 1939b).

Thereafter, Deraniyagala (1939c) discovered new reptilian fossils (crocodile, and terrapin) and mammalian fossils (hippopotamus, rhinoceros, deer, bovines, and elephants) which belonged to Upper Pleistocene, from Kuruvita, Pelmadulla, Nagoda, Ambala, and Elapata. In 1940, Deraniyagala described seven existing plant fossils from Sabaragamuwa. In, 1941, G. S. Puri examined some of the plant fossil samples collected by Deraniyagala and identified them as *Bambusa vulgaris* and *Wrightia flavido-rosea*. Deraniyagala (1944) revised the subspecies of Hippopotamus and Rhinoceros into the species level and described a new subspecies of elephant (*Hypselephas hysudricus sinhaleyus*) and a Rhinoceros and Hippopotamus respectively from Nagoda and Kuruvita. Deraniyagala (1946; 1947) discovered the fossils of the *Rhinoceros sinhaleyus* and a boar *Sus sinhaleyus* from Nivitigala and Gonapitiya near Kuruvita respectively. Based on the recorded fossils, he calculated the thickness of the Sri Lankan Pleistocene deposits at Ratnapura. From 1939, Deraniyagala found evidence of Stone Age man from Sri Lankan caves. He (1945a) described *Homo sapiens balangodensis* by using a small dolicocephali skull discovered from Ravana Ella cave. Candappa, in 1948, studied the Odontolite of the bovine teeth from Ratnapura gem pits. In the middle of the 1950s, Deraniyagala was able to record fourteen extinct species from Ratnapura Pleistocene deposits. He presented the land oscillation pattern in the northwest of Sri Lanka to explain the possible links those species had with Indian Siwalik fauna (Deraniyagala, 1955b and 1955c.).A piece of fossilized human eyebrow (supra-orbital ridge) was discovered from Karangoda (near Kuruvita) gem pit in 1954 and named as *Homo sinhaleyus*. Deraniyagala, (1958a.) published "The Pleistocene of Ceylon", including a list of Pleistocene flora and fauna (10 plant fossil species, 5 Arthropods, 16 Molluscs, 4 Reptiles, and 23 Mammals) of Sri Lanka, and the detailed descriptions of the Pleistocene climate, vegetation, and faunal stages. Nine fossilized human skeletons which were related to proto-austroloid man were discovered from Bellanbeddipelassa, Balangoda in Upper Walave basin. This was the first record of an open-air habitation of Balangoda man (Deraniyagala, 1958c).

Chowdhury, (1965) described the wood remains form Ratnapura gem pits and calculated their age. Mittre and Robert (1965) too, analyzed pollen samples from Ellavale at Ratnapura gem pits.

In 1971, S. U. Deraniyagala recorded all fossil faunal species, which had been discovered up to 1968. In 1971, Gunaratne, excavated the prehistoric cave settlement at Beli-lena Athula. He was the first person to start cave excavation after P. E. P. Deraniyagala. The excavated material contained mainly stone tools, bone artefacts and food remains. The significant finding of this excavation was the fragments of skulls belonging to Balangoda man. Among the food materials were some snails, bony remains of small mammals and shells of Kekuna (*Canarium zeylanicum*) seeds.

In 1972, the human skeletons from Balangoda Bellanbedipalassa were studied by S.U. Deraniyagala and J. Kennedy studied their environment and physical structure. In 1980, Kennedy compiled the chronology and Paleo-environment of early human settlements. Until quite recently, none of the researches on Sri Lanka's Stone Age had been

conducted within an explicit theoretical and methodological framework. S.U. Deraniyagala built a new theoretical framework for the prehistoric studies of Sri Lanka. He constructed a chronology of Palaeo-environment and technology for Pleistocene coastal sediments of Sri Lanka (Deraniyagala 1984; 1986). Kennedy *et al.* (1986) analyzed the whole human skeletal remains from Batadomba Lena and Belilena caves and summarized the anthropological features. During 1986-1987, W. Wijayapala (Director General/ Department of Archaeology) studied the Fa Hien Cave excavation at Bulathsinhala, and he was able to discover the earliest fossilized human remains to date from Sri Lanka. In 1995, Katupotha studied the Pleistocene shell bed of southeast coastal zone of Sri Lanka and evaluated its evolutionary and biological significance.

In 1990 and 1992, Kelum Nalinda (= K. Manamendra-Arachchi) described the fossil evidence of *Hexaprotodon sinhaleyus* from Elapata, south of Ratnapura and *Geomyda trijuga sinhaleyus* from Muvagama, Balahapura near Ratnapura. The first tiger subfossil was described from Sri Lanka by Manamendra-Arachchi et al., (2005) based on Kuruvita Batadomaba Lena excavation.

In 2002, Hawkey, analyzed the teeth of the prehistoric populations and recent human races within Sri Lanka and India. Using dental evidence, Hawkey discussed the microevolution of early populations from India and Sri Lanka. In 1999, fossilized bones of Rhinoceros were discovered from Lunugala near Passara. These fossils were dated to 80000 BP, and this was the first attempt to absolutely date the age of extinct fauna of Sri Lanka (Liyanarachchi, 1999,Deraniyagala, 2002). In 1999, T. R. Premathilaka started palaeo-botanical studies based on fossilized pollen from Horton Plains National Park. This work helped to understand the Late Quaternary vegetation and climate of Horton Plains, and provide evidence for the plant domestication in Sri Lanka (Premathilake, *et al.*, 1999 and Premathilake, 1999; 2000). Gunatilake (2000) predicted the palaeo-climate of Sri Lanka by using sea level changes., Another Hippopotamus (*Hexaprotodon sinhaleyus*) fossil was discovered from Central Province of Sri Lanka in 2002 (Weerawardena, *et al.*, 2002.

The 19th century palaeobiodiversity research in Sri Lanka with respect to lithic and anthropological research, was conducted entirely by foreigners. It commenced with the British who were either mineral surveyors or surveyors in general. The first contribution was made by E.E.Green and J.Pole who collected stone tools from the Maskeliya, Nawalapitiya and Peradeniya regions. The Swedish explorers Sarasin and Sarasin studied the ethnography and physical anthropology of the Veddahs. They took with them more than 100 skeletons from the island which are now deposited in the Basel Museum in Switzerland. In 1908 Seligman studied the ethnographic survey of the Veddahs in the lowlands. Several others also studied stone tools and formulated new systems of classification and conducted excavation in both the wet zone and the dry zone. In 1915 Wayland studied the Red Earth (Iranamadu formation) in the northern region. He also classified the peneplains.

It was only after P.E.P Deraniyagala became the head of the National Museum in 1939 that a Sri Lankan researcher commenced to contribute towards palaeobiodiversity research in Sri Lanka. Deraniyagala excavated many caves and conducted explorations throughout the entire island. He was the discoverer of fossils from Jurassic to Holocene periods. He unearthed many human skeletons and other bioartefacts and reconstructed the palaeoenvironment in Sri Lanka. Deraniyagala's contribution towards the furtherance of the knowledge in Sri Lankan history and archaeology stands unmatched todate. Subsequently, his son, Dr. S.U.Deraniyagala, investigated and conducted excavations in many districts of Sri Lanka. His findings were included in his PhD thesis which later came out as a book on the Prehistory of Sri Lanka. It contains an ecological perspective to the prehistory of Sri Lanka. Thereafter, major contributions were made by a few Sri Lankans such as Dr Wijepala, Prof S. Bandaranayake, Dr.Mohan Abeyratne, Prof. Raj Somadeva, Prof A.M.G Adikari, Prof.J Katupotha, Dr Nimal Perera. Dr T.R, Premathilake and Kelum Manamendra - Arachchi.

2.12 The need to conserve palaeobiodiversity

The need for an action plan on Paleobiodiversity:

Despite the fact that Archaeology and Environmental Sciences merge into and overlap one another, these subjects have been separately dealt with in Sri Lanka primarily due to the fact that the respective Government departments come under separate Ministries. Taking this in to consideration the Action Plan has been formulated to bring together all institutions concerned in to the unifying action of conservation and sustainable use of the Palaeobiodiversity in Sri Lanka.

3.0 Principles, goals and broad objectives

The optimum level of conservation of any resource will depend on how well the overall landscape is managed with a minimal loss. In respect of Palaeobiodiversity, it is very important to consider conservation aspects of the landscape in its entirety. The needs of the people and their activities must be reconciled with the maintenance of Palaeobiodiversity. The management of fossil sites, prehistoric sites and other sites of palaeobiodiversity related artefacts should be on the same planning framework as the development activities like sacred area development, infrastructure development, industrial development, agrarian and agriculture projects etc. There is no simple prescription on how this could be done.

3.1 The principles related to palaeobiodiversity conservation management.

(1) Each form of fossil, sub fossils, biofacts is unique; each played a distinctive role in the web of life during the era of their dwelling and warrants respect and consideration by mankind. Without conserving the fossils and preserving the evolved species, the attempts at the maintenance and the understanding of the present web of life would be unrealistic.

(2) Conservation of palaeobiodiversity should be a common concern for all citizens, and the country has a stake in, and a sovereign right, to the sustainable use of its fossil resources and other resources for the benefit of the nation.

(3) Palaeobiodiversity conservation is an investment that yields substantial benefits to it trustees; ensuring benefits to local communities which will encourage and foster sustainable use of this invaluable resource.

(4) Costs and benefits of Palaobiodiversity conservation should be shared on a basis that is fair and equitable.

(5) The best long-term economic use of palaeobiodiversity is that which will maintain the ecological and cultural values of the landscape.

(6) That both *in situ* conservation and *ex situ* preservation of biodiversity are key tools in management of Palaebiodiversity conservation should be recognized.

(7) All sectors that influence Palaeobiodiversity should help to plan its conservation.

(8) Palaeo-resources cannot be sustainably managed exclusively by the communities or the government. There should be an integrated management regime as a part of a larger political and economic framework.

(9) Palaeobiodiversity conservation can be sustained if public awareness and concern are substantially increased and policy makers have access to reliable information upon which to base policy decisions.

3.2 The goal of palaeobiodiversity conservation

Since the subject of Palaeobiodiversity has come into prominence and importance recently, the information available on the global concerns related to the subject is minimal. As a result, the common platform of sustainable development has been selected/applied/used to formulate our goal.

The overall national goal of Palaeobiodiversity conservation, therefore, is to conserve the Palaobiodiversity of Sri Lanka, while fostering its sustainable use for the benefits of the present and future generations.

3.3 The broad objectives

In order to achieve the national goal of Palaeobiodiversity conservation the following broad objectives are set out;

(1) To build the capacity and develop programmes to gain a better understanding of the overall component of the country's Palaeobiodiversity in a holistic manner.

(2) To identify adverse impacts on the different components of Palaobiodiversity and take action to mitigate such impacts to avert potential adverse impacts.

(3) To built the capacity and develop programmes to enhance the conservation status of Palaeobiodiversity sites that are in demand for development and under threat due to excessive use.

(4) To manage Palaeobio-resources in a manner that will conserve Palaobiodiversity while enhancing the use of the resources within sustainable limits

(5) To enhance public awareness on Palaobiodiversity and encourage public participation in its conservation.

(6) To integrate institutional mandates to conserve and manage palaeobiodiversity resources and to streamline the relevant legal aspects.

4.0 Palaeobiodiversity Conservation - Proposal for Action

4.1 *In situ* conservation

In situ conservation ensures the on-site preservation of palaeobiodiversity within the country, so that it can be used sustainably where appropriate but without the development programmes pursued by the different sectors causing serious or irreversible damages to it. Identified sites of palaeobiodiversity are distributed among the major ecosystems of Sri Lanka and the geological eras. However, many of these sites have not been listed. Lack of information on undocumented palaeobiodiversity sites prevails.

At present 15% of total land area of the country is protected for wildlife and another 10% declared under the Forest Department. Some Palaeobiodiversity sites are still situated outside the protected areas. Unfortunately, there are no protected areas declared for the sole purpose of conservation of fossils in Sri Lanka.

When considering the ecosystem approach, it is easy for the different institutions involved to demarcate the specific areas under their respective purviews. But, in matters considering the sites situated in an area that is not under the purview of either the Forest Department, Department of Wildlife Conservation or Coast Conservation Department, it is necessary for the Department of Archaeology to take legislative action. Many of the fossilised remains have been destroyed due to human intervention. Various development projects have either displaced fossilised remains and biofacts or put up constructions over areas containing them without allowing room for preliminary study. When a series of sites of palaeobiodiversity importance exist adjacent to each other all should be declared under a single unit of conservation as it is not practical to gazette each site individually.

The management of Palaeobiodiversity resources is unique and the inclusion of those management practices into the management plans of forest and wildlife is rarely implemented.

The programmes related to archaeological sites have mostly been used for the purpose of tourism and the available management plans for those sites have focused only on conservation of archaeological aspects and neglected biodiversity . The ultimate result is the degradation of the biological environment of the sites eg. giving priority to the archaeological importance of bat inhabited caves ignoring the biodiversity. Mining permits are given without prior investigation of the palaeobiodiversity importance of the particular area.

Recommendations

(1) Identify and declare potential paleobiodiveristy sites under the National Environmental Act, Archaeology Act or any other Act deemed appropriate for the preservation of the sites. There is an urgent need to list and gazette the palaeobiodiversity sites and provide them with protected status.

(2) Provide the required inputs for the preparation of management plans for the protected areas which have one or more Palaeobiodiversity sites, to include Palaeobiodiversity conservation.

(3) Declare and establish of conservation zones of paleobiodiversity

(4) Carry out Archaeological Impact Assessments (AIA) simultaneously with Environment Impact Assessments (EIA) processes when development projects are carried out.

(5) Develop site specific management plans for paleobiodiversity sites to minimise degradation of the biological environment. The plans could include more or less all aspects including cultural, religious, artistic, geological, biodiversity etc.

(6) Conduct a preliminary survey of the palaeobiodiversity of the area when mining permits are given. If the mining area contains evidence of palaeobiodiversity, a representative area should be marked and set aside for preservation and research. Regulations to this effect should be incorporated in the TOR of the GSMB and other respective institutions.
(7) Generate incentives for the communities to provide information on palaeobiodiversity sites.

(8) Establish a mechanism and develop the capacity in the Department of Customs to handle issues such as export of fossils and biofacts/ artefacts.

4.2 *Ex situ* conservation

Ex situ conservation comprises of collection, handling and management (including research) of fossils, sub fossils, artefacts, biofacts or germplasm, and ensuring their storage, characterisation/evaluation, documentation and dissemination of information to users, while simultaneously emphasising the need to ensure that such steps do not threaten ecosystems and in situ populations of species.

The National Museum and the Archaeological Department are the main repositories of fossils and other artefacts of the prehistoric period. There are some small collections of fossils that have been maintained at the regional museums, universities and research institutes. However, there is a lack of capacity and facilities in the repositories to carry out *ex-situ* activities. Systematic collection of fossils and artefacts have not yet been established and therefore, many fossils collected from gem-pits in Rathnapura district have been destroyed when deposited in an ad-hoc manner. Private collections of fossils, biofacts, artefacts, biofacts can be found, especially in the Rathnapura area, despite the fact that the keeping of fossils, biofacts, artefacts, biofacts as a private property is prohibited by law. Furthermore, the importance of Palaeobiodiversity of a region has not been sufficiently highlighted in established Archaeological Museums.

Recommendations

(1) Formulate and implement a national policy instrument for the ex situ conservation of fossils and prehistoric artefacts.

(2) Construct proper mechanisms to collect, deposit, maintain and document palaeobiodiversity artefacts within the relevant institutions.

(3) Develop competent civil-society entities (i.e Grama Sevakas under the purview of the regional officers of the Dept of Archaeology) to provide the relevant human resources and enlist financial assistance from private sector stakeholders in order to carry out *ex-situ* conservation activities.

(4) Strengthen the capacity and scope in the National Museum and the Department of Archaeology to conduct ex situ conservation activities.

(5) Establish and maintain a directory of all privately and institutionally held collections.

(6) Highlight the Palaeobiodiversity importance of a region in regional Museums.

(7) Establish of fossil/ biofacts/ artefacts/ exchange programmes with foreign museums and other reputed and suitable repositories to upgrade fossil repositories in Sri Lanka.

4.3 Sustainable use and benefit sharing

In order to conserve a site it is important to use it sustainably so that its benefits are shared. The resource, therefore, needs to be utilised in a manner that assures its availability to the future generations.

The conservation of Palaeobiodiversity envisages a transition from a system of protecting the elements of Palaeo-

biodiversity (e.g. faunal and floral fossils and related artefacts, fossil micro habitats and landscapes) to a one which includes providing economic incentives/benefits, while ensuring the benefits are equitably shared between the stakeholders and the public in general. It is necessary therefore that the demands for the utilization of Palaeobiological resources be balanced against the public concern for their sustainable use within a framework of ethical principles.

The programmes related to archaeological sites have mostly been used for mass scale tourism purposes and the available management plans for those sites have focused only on the conservation of archaeological aspects and have mostly neglected biodiversity aspects. The ultimate result is a degraded biological and palaeo environment of the sites due to unsustainable use of biological diversity and fossil resources.

Recommendations

(1) Prepare site specific paleobiodiversity tourism guidelines for all sites including those outside the protected areas.

(2) Preserve a representative area when permits are issued to mine palaeobiodiversity sensitive areas.

(3) Prepare specially designed programmes for the collection and better utilization of the fossil/artefacts/ biofacts resources found from gem-pits with the collaboration of the Research Institute of Gem and Jewellery Authority.

(4) Discourage, or limit through regulation, the excavation of fossil resources which are more susceptible to decay when exposed to the air unless conducted in a scientific manner.

(5) Institute a regulatory regime for the development of palaeobiodiversity tourism in palaeobiodiversity sites to restrict the number of visitors to fragile ecosystems with palaeobiodiversity resources.

(6) Promote and monitor site-specific sustainable tourism guidelines.

4.4 Education, Awareness and Training

Education, awareness and training are instruments that ensure conservation and sustainable utilisation of palaeobiodiversity. They are also tools that bridge the knowledge gap and interests of relevant stakeholders and the public at large on the importance of conservation of palaeobiodiversity resources. Efforts to conserve cannot succeed without the understanding and support of the general public. Education is a long-term process of developing an individual's capacities and way of thinking. Formal and informal education and training programmes could be developed in order to create awareness on the necessity of conservation.

Understanding the diverse needs of the people, their differing perceptions, knowledge, attitudes, interests and values is necessary in order to achieve the goals of conservation. Social contexts need to be understood.

The Advisory Committee on Palaeobiodiversity under the Ministry of Environment is the pioneer in promoting and developing the aspects of Palaeobiodiversity in Sri Lanka. Since the subject or concept of Palaeobiodiversity is novel to Sri Lanka in particular and the world in general, and also because it is not a pure science, the fields of education, training and awareness necessary for a holistic approach to the Palaeobiodiversity have not been properly established. At present, the aspects of palaeobiodiversity are addressed separately under various subjects: biological sciences, geology, history, geography etc.

Recommendations

(1) Revise the existing relevant curricula of formal education system at all levels to ensure all aspects of Palaeobiodiversity are covered with special emphasis on its conservation and sustainable use.

(2) Promote awareness and provide required training in respect of the subject to relevant stake holders and personnel in Government institutions.

(3) Develop and conduct separate certificate or diploma courses on Palaeobiodiversity in appropriate universities with a wider enrolment opportunity for people of various education levels.

(4) Develop field oriented on- the- job training programmes on Palaeobiodiversity tourism, especially for the operators/employees in the tourism industry

(5) Make available the material in the form of printed and electronic media to the general public.

(6) Construct and conduct programmes in order to popularise the subject and create awareness on conservation.

(7) Create awareness of the importance of artefacts among those in the mining industry to enable them to recognise and notify appropriate authorities of the discovery of such items when mining near conservation zones.

(8) Ensure that the palaeobiodiversity sites contain information in the form of hoardings, notices etc. in order to highlight the palaeobiodiversity importance of each site.

(9) Document all important Palaeobiodiversity sites and publish a handbook on Palaeobio-tourism guidelines.

(10) Construct a database of information pertaining to palaeobbiodiversity.

4.5 Palaeobiodiversity Information Management

The management of palaeobiodiversity resources, including its conservation and sustainable use, needs not only scientific information but also cultural archaeological and socio-economic information. Most of the information on Palaeobiodiversity is scattered under various pure sciences. It is necessary to collect, categorise, generate and systematically organize Palaeobiodiversity related data and information which transcends conventional sectors.

A sizeable volume of Palaeobiodiversity related information has been collected by both the governmental and non governmental groups as well as individuals which has resulted in some information not been made available to the relevant authorities. Most of the information is stored in its raw form in institutional libraries. The flow of information is also inadequate, mainly due to the lack of mutual trust and understanding between the providers and the users of information.

Recommendations

(1) Establish a separate Palaeobiodiversity Information Management Section (PIMS) within the Biodiversity Secretariat of the Ministry of Environment

(2) Formulate a National Policy for Palaeobiodiversity Information Management.
(3) Establish a system to support the establishment and/ or recognition of legal rights and interests in respect of Sri Lanka's genetic and biological material.

(4) Develop a scheme to provide monitory and non-monetary incentives to those who provide information on artefacts and deposits to enable research studies of the sites

(5) Establishment of the palaeobiodiversity information management tools and mechanisms: databases, Clearing House Mechanisms, web sites, directories and compendiums.

4.6 Research

The role of research is multi faceted which is necessary in order to document the status, preservation, restoration, sustainable use, reduce/ mitigate impacts due to exploitation, reduce/ mitigate impacts related to development and

valuation of palaeobiodiversity.

Since the subject of Palaeobiodiversity is still new to the country, the current research on Palaeobiodiversity does not add up to the level of research that is necessary to support an effective programme for the conservation and sustainable use of Palaeobiodiversity. Research programmes to address the subject of Palaeobiodiversity holistically, should therefore be promoted.

Although, the subject of archaeology was mainstreamed in the research and education sector, it has focused more or less on cultural aspects neglecting its biological aspects. New technologies like fossil pollen studies and carbon dating have been used in Sri Lanka very rarely, due to the lack of knowledge, equipment and financial resources. The institutional coordination for Palaeobidiversity research is extremely poor and research capacity of respective institutes is not up to the required level.

Furthermore, there is an absence of the identification of research priority areas and a lack of an institutional framework to coordinate applied and practical research work on palaeobiodiversity and to monitor research carried out according to accepted ethics.

Recommendations

(1) Identify research priorities, with emphasis on fossils, and prepare long term research agenda for Palaeobiodiversity and mainstream it into the relevant institutional mandates

(2) Formulate an appropriate institutional framework in order to coordinate applied and practical research areas.

(3) Develop a partnership and participation programme of Government, non Government and private sector for Palaeobiodiversity research to create funds and share benefits arising out from the outcome of research.

(4) Implement research ethics needed.

(5) Formulate a monitoring mechanism in order to monitor the research being conducted.

(6) Enhance the capacity of the National Museum, Department of Archaeology, Central Cultural Fund and other relevant institutions in the techniques of authentication and preservation.

(7) Enhance the capacity of relevant institutions for funding, training, equipment purchase. This issue could be addressed through implementation of management plans with a holistic approach to archaeological and current biodiversity.

(8) Assess the present gap in the knowledge of paleobiodiversity. The concept of paleobiodiversity should be mainstreamed into the regular program to obtain funds to bridge the gap. Research to assess the loss of biodiversity should be initiated.

(9) Identify the aspects of traditional knowledge in paleobiodiversity..

(10) Construct a database on palaeobiodiversity and update it regularly by the focal point institution.

(11) Develop a mechanism to update registries in the National Museum and the Department of Archaeology.

(12) Hold a National Symposium of Palaeobiodiversity annually and publish the proceedings

4.7 Policy and legal measure

The mere existence of policy and legal framework does not ensure that conservation objectives are met with.

The policy instruments of biodiversity, archaeology, culture and other relevant subject areas were used more or less to formulate this action plan since the subject of Palaeobiodiversity is new to Sri Lanka as well as to the world.

Since the subject of archaeology developed after the origin of humans, it is very difficult to apply the policy instruments for Palaeobiodiversity. Development of a National Policy on Conservation and Sustainable Use of Palaeobiodiversity is a priority and the establishment of an integrated policy approach is a basic requirement to address palaeobiodiversity in a holistic manner. No institution with a mandate exists to handle issues and provide legal directives for the issues arising from paleobiodiversity. At the highest level there has to be an over-arching policy framework, which must be strengthened with a legal framework.

Recommendations

(1) Incorporate a mandate in the Department of Archaeology to take legal measures for related issues.
(2) Amend the Archaeology Act to include the protection of fossils (especially Jurassic and Miocene) and to gazette representative areas for protection.

(3) Carry out a review of the action plan and related legal policies every five years with an initial review in the third year of implementation of PBAP in order to increase the efficacy of the implementation process concerning specific conservation processes and new issues.

(4) Ensure that the jurisdiction overlaps are not contradictory.

(5) Establish a comprehensive legal system or amend the existing legal framework to address palaeobiodiversity issues.

4.8 Institutional support

Resource constraints in institutions play a major role in either retarding or terminating the action necessary for the conservation of Palaeobiodiversity. No new institutions need to be established since existing Institutions are adequate to handle situations if proper mechanisms are established.

According to the present administrative system in Sri Lanka, all aspects of archaeology and biodiversity are administered by institutes of different sectors and there are no institutes or coordination mechanisms to address palaeobiodiversity specifically and in its entirety. No coordinated initiatives have been established in order to integrate palaeobiodiversity concerns into sectorial, institutional and provincial programmes. Certain institutional mandates do not cover aspects of palaeobiodiversity that had occurred before the advent of man

Recommendations

(1) Establish a joint coordination committee consisting of relevant stakeholders to coordinate specific areas of work. Prepare the National Action Plan for conservation and sustainable use of Palaeobiodiversity with the participation of all stakeholders and establish a joint implementation mechanism as one of the solutions for the issue. Appointment of a National Palaeobiodiversity Advisory Committee is recommended to screen issues and direct them to the relevant institutions.

(2) Upgrade the Advisory Committee to 'National' level.

(3) Incorporate Miocene and Jurassic areas (incorporation of the terms 'fossil' and 'sub fossil') into the archaeological act.

(4) Reconstitute a palaeobiodiversity network comprising middle level officers in implementing agencies and central agencies, to facilitate the Biodiversity Secretariat and other implementing agencies to obtain necessary information whenever required for implementation of PBAP.

(5) Provide constant feed back when handling various issues. Integrate institutions by a network to share information.

(6) Ensure that relevant members of the Palaeobiodiversity Advisory Committee are represented in all other committees that have been established in the relevant Government sector institutions.

(7) Prepare a Strategic Implementation Programme (SIP) and formulate a Strategic Coordinating and Monitoring mechanism through a high level task force which is necessary for a coordinated initiative to integrate palaeobiodiversity conservation concerns into sectoral, institutional and provincial programmes and set up a strategic coordinating and monitoring mechanism within the BDS for effective implementation of the SIP.

5.0 Action Plan and Budget

The Action Plan for the conservation and sustainable use of Palaeobiodiversity is considered as the culmination of a comprehensive assessment of issues arising in the field of palaeobiodiversity. Recommendations made by relevant stakeholders at a colloquium to review and assess the draft is included in the Action Plan. However, it should be further reviewed by the relevant institutions in terms of the availability of human and financial resources for the future. In many actions, the responsible institutions are apparently those belonging to the Archaeological Department. However, a joint implementation strategy by the focal coordinating body (the Ministry of Environment) is recommended to bring synergy between the relevant institutions. The total time-frame is given as five years (2014 to 2019) but, an attempt should be made to plan and initiate as many actions as possible during the year 1 and proceed to achieve goals through a definite time frame.

A tentative budget has been prepared for the implementation of the action Plan. Funds for implementation have to be obtained by relevant institutions.

Action plan for the conservation and sustainable use of Palaeobiodiversity

Yr = Time frame (Number of years)

Classified Action	Responsible Institution	Yr	1	2	3	4	5	Total Rs. Million
Identification of palaeobiodiversity sites, demarcation and declaration.	FD, DWC, DoA, Universities, PGIAR, MoE&RE	5	10.0	10.0	12.0	15.0	15.0	**62**
Publication of material and conduct awareness programmes to introduce the subject	MoE&RE, Universities,DoA, PGIAR	5	10.0	10.0	12.0	15.0	15.0	**62**
Incorporation of palaeobiodiversity as a subject within the curriculum	Universities, PGIAR, FD, DWC	3	1.5	1.0	1.0			**3.5**
Promotion of research in identified fields (especially fossils) to reduce gaps	Universities, PGIAR, NSF, MoE&RE, DWC, FD	5	5.0	7.5	10.0	10.0	10.0	**42.5**
Establishment of a National Palaeobiodiversity Advisory Group	MoE&RE	3	0.05	0.05	0.05			**0.15**
Preparation,implementation of Management plans, guidelines and ethics for identified palaeobiodiversity sites for tourism.	Ministry of Tourism, CCF, DoA, MoE&RE, FD, DWC,PGIAR	5	5.0	10.0	15.0	15.0	20.0	**65**
Gazetting & legal measures to be taken to protect palaeotourism sites	DoA, FD, DWC, MoERE, CEA	5	5	5	6	8	8	**32**
Promotion of palaeobiodiversity tourism	Tourist Board, Ministry of Tourism,tour operators,CCF, DoA, MoERE PGIAR	5	2	5	5	10	10	**32**

Classified Action	Responsible Institution	Yr	1	2	3	4	5	Total Rs. Million
Establishment of databases and their maintenance	National Museum, PGIAR, NSF, MoE&RE, DWC, FD, DoA	5	5.0	2.0	2.0	2.0	2.0	**13**
Mechanism to collect, deposit and maintain fossils, biofacts, artefacts, sub fossil collections	National Museum, PGIAR, DoA	5	3.0	3.0	3.5	3.5	4.0	**17**
Formulation of a legal system and policies to address issues arising from palaeobiodiversity	DoA, MoE&RE, GSMB, FD, DWC, CCF, CCD	3	0.5	0.5	0.5			**1.5**
Preparation of site specific management plans	DoA, MoE&RE, CEA, CCF, FD,DWC, CCD, GSMB	5	2.0	2.0	3.0	5.0	5.0	**17**
Training of personnel	FD, DWLC, GSMB,MoE&RE	5	1.0	1.0	1.0	1.0	1.0	**5**
Establishment of a research unit with equipment for dating etc	GSMB, PGIAR	5	25	20	20	20	20	**105**
Promote marine palaeobiodiversity	MoE&RE, CCF, DoA, Maritime University, NARA, Navy	5	1.0	1.0	1.0	1.0	1.0	**5**
Mapping	DoA, GSMB, FD, DWC	5	1.0	1.5	1.5	2.0	2.0	**8**
TOTAL			**77.5**	**79.55**	**93.55**	**107.5**	**113**	**471.05**

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Appendix 1: Provisional list of the Palaeobiodiversity Sites in Sri Lanka.
(Compiled by Kelum Manamendra-Arachchi and Hasula Wickemasinghe)

Location	District	Dating	Type	Ownership	Artefacts
Adande vala, Kuruvita	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Akuragoda near Tissamaharama			Sacrificial altar		
Akurala	Galle	Lower strata 6200BP, 7100BP, 6720 BP, 6850 BP,4550 BP	Open air habitation		No artefacts
Alavala Pothgul lena	Gampaha	(Mesolithic)	Cave		Human remains, faunal remains, botanical remains, stone tools, geometric microliths, bone tools, ornaments, *Panthera tigris*
Alige kumbura,	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Alu-lena Attanagoda	Kegalle	Lower strata 9700BP	Cave	DoA	faunal remains, botanical remains, stone tools, bone tools
Alutbombuwa (Wilpattu NP)			Cist burial		pottery
Ampalauva, Kuruvita	Ratnapura	Pleistocene	Gem pit		*Rhinoceros kagavena*
Anaikoddai	jaffna	Megalithic	Extended burial		Inhumated skeletons, bowl signet ring, megalithic graffiti symbols, early brahmi symbols
Angomuwa, Track 6, Rajangane		750- 400BC	Burial site		Cist burials
Andigama	Kurunegala	Jurassic			Jurasic plant fossils
Anuradhapura citadel (ASW 2)	Anuradhapura	Iron Age	Pit Burial		Iron arrow head, copper alloy wire, rubbing stone, pottery cups,
Anuradhapura citadel, Gedige	Anuradhapura	Lower strata 5850BP	Open air habitation	DoA	Mesolithic artefacts
Anuradhapura Gedige	Anuradhapura		Habitation Site		Potsherds,beads of semi precious stones, objects of iron,copper, bronze, animal bones, rice husk, post firing graffiti symbols, brahmi symbols
Anuradhapura Gedige (AG-85)	Anuradhapura	Lower strata 5040BP	Open air habitation	DoA	Mesolithic geometric microliths
Arabokka area			Shell midden, Open Habitation		
Aranwala	Galle	Lower strata 6300BP, 2350 BP, 2320 BP	Open air habitation		No artefacts

Location	District	Dating	Type	Ownership	Artefacts
Arnakallu Site 30	Puttalam	Lower strata 3058BP	Open air habitation		*Arca granosa*
Aruwakkalu quarry	Puttalam	Miocene	Quarry		Miocene vertebrate and invertebrate fossils, palaeolithic artefacts,
Asswedduma, Kuruvita	Ratnapura	Pleistocene	Gem pit		*Hexaprotodon sinhaleyus*
Asvaduma, Adandevala	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Atey Gammane (off Ottappuva), rajangane			Cist Burial		750- 400BC
Badaamuva, Karangoda	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Bagure					
Balahapuva, Muvagama	Ratnapura	Pleistocene	Gem pit		*Melanochelys trijuga sinhaleya*
Bambaragala	Ratnapura				Faunal remains, pottery,quartz, *Acavus*
Bandara- Bogavala, Dodampe	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Bandarawela	Bandarawela		Open air habitation		Mesolithic stone tools
Bandattara	Southern province		Terracotta cist burial		
Batadomba-lena Cave	Ratnapura	Lower strata 37,000BP	Cave	DoA	Human remains, faunal remains, botanical remains, stone tools, geometric microliths, bone tools, ornaments, *Panthera tigris*
Batathota lena	Ratnapura		Cave		Mesolithic stone tools
Beli galge at Bambaraktuva	Ratnapura		Cave		Quartz flakes, Acavus, chert, bone points, bones, aquatic snails, microliths, pitted pebbles
Beli-lena Cave, Kitulgala	Kegalle	Lower strata 31,000BP	Cave	DoA	Human remains, faunal remains, botanical remains, stone tools, geometric microliths bone tools, ornaments
Beli-lena Athula	Kegalle	Lower strata 7900 BP	Cave	DoA	Pitted pebbles,hammer stones,grind stones,microliths, quartz chips,bone objects, faunal remains, botanical remains, human remains
Bellan-bandi Palassa	Ratnapura	Lower strata 12,750 BP	Open air habitation	DoA, DWC	faunal remains, botanical remains, stone tools, bone tools, ornaments
Beravadeniya, Mahingoda, Eheliyagoda	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Bokirideniya, Karangoda	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus, Hexaprotodon sinhaleyus*

Location	District	Dating	Type	Ownership	Artefacts
Bokirideniya, Karangoda, Haldola	Ratnapura	Pleistocene	Gem pit		*Hexaprotodon sinhaleyus*
Caudulla stream, Medirigiriya, Hingurakgoda	Polonnaruwa	Pleistocene	Gem pit		*Gona sinhalaya*
Deniya kumbura, Panamure near walawe river	Ratnapura	Pleistocene	Gem pit		*Bubalus bubalis migona*
Diwul Wewa			Cist burial		100 cists, iron plough-coulter
Dorawaka lena	Kegalle	7300 BP	Cave	DoA	Stone tools, pottery, few faunal remains & Floral remains
Dunvattavaturana,-Dodampe	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Ellavala river	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Ellekumbura, Haldola	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Embilipitiya	Ratnapura		Open air habitat		Geometric microliths, Balangoda points
Erukamam	Batticoloa		burial		'cinereal urn' associated with a brick structure
Near Erukamam	Batticoloa		'stone sar-cophagus'		Tiles
Fa Hien cave	Kalutara	Lower strata 40,000 BP	Cave	DoA	Human remains, faunal remains, botanical remains, stone tools, geometric microliths bone tools, ornaments, *Panthera tigris*
Galadandemandiya, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Gal-Atara	Kegalle		Cist burial		Pots, bones, charcoal, iron weapons, metal ornaments
Galpottevela, Kuttapitiya, Pelmadulla	Ratnapura	Pleistocene	Gem pit		*Rusa unicolor*
Getadombe, Kitulpe	Ratnapura	Pleistocene	Gem pit		*Hexaprotodon sinhaleyus*
Gonapitiya, Kuruvita	Ratnapura	Pleistocene	Gem pit		*Melanochelys trijuga sinhaleya*
Gonapitiya, Kuruvita	Ratnapura	Pleistocene	Gem pit		*Sus sinhaleyus*
Goraka gaha deniya, gonapitiya	Ratnapura	Pleistocene	Gem pit		*Hystrix sivalensis sinhaleyus, Bos gaurus sinhaleyus, Hexaprotodon sinhaleyus*
Gorok gaha deniya, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Bos gaurus sinhaleyus*
Gurugal-hinna	Anuradhapura		Cist burial		Pottery, bronze articles
Haldamulla	Ratnapura	3700 BP	Burial ground		Geometric microliths, pottery, clay burials, balangoda points
Haldola Kumbura	Ratnapura	Pleistocene	Gem pit		*Lissemys punctata sinhaleyus*

Location	District	Dating	Type	Ownership	Artefacts
Hamagodana					Burnt clay, quartz, grinding stone, pottery, stone tool, (chert), charcoal,shells
Hangamu ganga	Ratnapura	Pleistocene	Gem pit		*Bos gaurus sinhaleyus*
Haweniwela	Matale		Burial Site		Megalithic burial site, pottery, beads, copper object, Orthostats
Henagahapugala Site 57	Hambantota	Lower strata 3370BP	Open air habitation	DoA, DWC	Mesolithic habitation, *Meretrix casta*
Hikkaduwa	Galle	Lower strata 5780BP, 3460 BP	Open air habitation		No artefacts
Hirikumbura	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Horaliyedda, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Horaliyedda, Kuruvita	Ratnapura	Pleistocene	Gem pit		*Melanochelys trijuga sinhaleya, Hexaprotodon sinhaleyus*
Horton Plains	Nuwara Eliya	17,000 - 3,000 BP	Open iar habitation	DWC	Geometric microliths, ancient pollen
Hulavalikumbura, Adandevela	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Hulavalkumbura, Edandevala	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Hungama, Miniethiliya	Hambantota	Lower strata 5000 BP	Shell midden, open air habitation		Human remains, faunal remains, stone tools
Huruluela, Katurana, Kurugam modara, Dompe	Ratnapura	Pleistocene	Gem pit		*Rhinoceros sinhaleyus,*
Ibbankatuwa	Matale	2400 BP	Megalithic burial cite	DoA	Potsherds,'early' brahmi inscriptions, cist burials
Ihala minuvandeniya, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Rhinoceros sinhaleyus, Cuon javanicus sinhaleyus*
Indivinna, Northern flank of Karagan Lewaya					
Jaffna	Jaffna	6 -16mil			Lower Palaeolithic stone artefacts
Jahinge Angiliya Kumbura, Radalla, karangoda	Ratnapura	Pleistocene	Gem pit		*Homo sinhaleyus, Hexaprotodon sinhaleyus*
Kadiraveli	Batticoloa		Cist burial		
Kegalle			Rock shelter		Polished unpitted pebbles
Kalamatiya					Grinding stones, burnt bones, bones, charcoal, shells
Kalametiya Lagoon	Hambantota	Lower strata 6660BP, 3870 BP	Open air habitation	DWC	No artefacts

Location	District	Dating	Type	Ownership	Artefacts
Kantarodai	Jaffna	Megalithic	Burial site	DoA	Pottery,coins, chank,remains of iron, gold, copper, non brahmi graffitti
Kanukatiya, Demala poruva, Karangoda	Ratnapura	Pleistocene	Gem pit		*Elephas sp,Rhinoceros sp, Hexaprotodon sinhaleyus*
Kanuketiya, Demalaporuva	Ratnapura	Pleistocene	Gem pit		*Hexaprotodon sinhaleyus*
Karagan Lewaya	Hambantota	Lower strata 3375BP	Open air habitation	SALT	No artefacts
Karainagar	Jaffna	Megalithic	burial		Pottery, shark bone, iron slag
Karamban Kulam (Wilpattu NP)			Urn burial		
Karapincha	Ratnapura	Pleistocene	Open air habitation		Pleistocene fossils
Karmarangapitiya	Ratnapura	Pleistocene	Gem pit		*Elephas hysudricus sinhaleyus*
Ketala ovita, Ellawala	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Koggala	Galle	Lower strata 6290BP	Open air habitation		No artefacts
Koholan ela, Palmadulla	Ratnapura	Pleistocene	Gem pit		*Elephas hysudricus sinhaleyus*
Kok-ebe	Anuradhapura		Cist burial		200 cists, pre-christian brahmi inscriptions
Kollan Kanatta (S of Kudirimalai)	Mannar	Megalithic	Open air site		Faunal remains, chank, pottery
Kuderamalai	Mannar		Open air site		Stone tools
Kuruvita	Ratnapura	Pleistocene	Gem pit		*Elephas namadicus sinhaleyus, Elephas maximus sinhaleyus, Hexaprotodon sinhaleyus*
Kuruvita, Hiriliedda, Thalavitiya	Ratnapura	Pleistocene	Gem pit		*Rhinoceros kagavena*
Landegeovita, Rilhena, Palmadulla	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Lunugala, Adavatta	Moneragala	80,000BP	River		*Rhinoceros sinhaleyus*
Machchagama			Cist burial		Part of the Megalithic complex associated with the Kala Oya, 100 burials, pottery, bone,
Madakumbura, ethoya	Ratnapura	Pleistocene	Gem pit		*Lissemys punctata sinhaleyus*
Mahalenama			Sacrificial alter		
Makevita near Biyagama	Colombo		Pit burial		Pots, tray bowls, pottery,
Malikolaniye Valigatte					Pottery, bone, grinding stones, quartz debitage
Mallapitiya, Karangoda	Ratnapura	Pleistocene	Gem pit		*Hexaprotodon sinhaleyus*

Location	District	Dating	Type	Ownership	Artefacts
Mamaduwa (Vavuniya)		Megalithic	Cist Burial and cairn circle		Pottery, human remains, (due to development activities the only known cairn circle no longer exists), early brahmi inscriptions
Manda galge					
Manel lena gavaragiriya	Ratnapura		Cave		Mesolithic stone tools
Mantai (Tirukketishvaram)		Megalithic	Extended burial		Ceramic ware, chank, beads, ornaments, metal ware, tiles, glass ware, faunal remains, coins
Matiwaladeniya, Pohorabava, Ellawala	Ratnapura	Pleistocene	Gem pit		Choppers, *Hexaprotodon sinhaleyus*
Matota (MA-82)	Puttalam	Lower strata 3800 BP	Open air habitation	DoA	Geometric microliths, faunal remains
Mavin-Kumbura, Pohorabava	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Meddekumbura, Kosgoda	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus, Rhinoceros kagavena*
Migahagoda, Palmadulla	Ratnapura	Pleistocene	Gem pit		*Elephas hysudricus sinhaleyus*
Millagahadeniya, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Hystrix sivalensis sinhaleyus, Bos gaurus sinhaleyus, Hexaprotodon sinhaleyus*
Millavitiya, Karangoda	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Mimavaladeniya, Gonapitiya,Kuruvita	Ratnapura	Pleistocene	Gem pit		*Muva sinhaleya*
Minihagalkanda	Hambantota		Open air habitat	DWC	Miocene vertebrate and invertebrate fossils, palaeolithic artefacts,
Modaragan Oya			Open air habitation		Neolithic quartz mortar
Moragala kumbura, Eheliyagoda	Ratnapura	Pleistocene	Gem pit		*Rhinoceros kagavena*
Moragala, Kandangamuva, Eheliyagoda	Ratnapura	Pleistocene	Gem pit		*Hexaprotodon sinhaleyus*
Moragalyayage kumbura, Eheliyagoda	Ratnapura	Pleistocene	Gem pit		*Rhinoceros sp. Hexaprotodon sinhaleyus, Elephas maximus sinhaleyus*
Mukkarugoda	Ratnapura		Burial site		Medium pot containing smaller pots with human or animal bones
Muvagama,	Ratnapura	Pleistocene	Gem pit		*Sus sinhaleyus*
Nagoda	Ratnapura	Pleistocene	Gem pit		*Elephas namadicus sinhaleyus, Elephas maximus sinhaleyus, Hexaprotodon sinhaleyus*

Location	District	Dating	Type	Ownership	Artefacts
Naranvatta, Karmarangapitiiya, pelmadulla	Ratnapura	Pleistocene	Gem pit		*Rhinoceros sinhaleyus, Elephas maximus sinhaleyus*
Nika vava	North central province				Pitted pebbles, chank shells,
Nikawelamulla	Kegalle		Cist burial		pottery, clay burials,
Nilgala	Moneragala	Pleistocene	Prehistoric cave site	DWC, DoA	Faunal remains, microliths, geometric microliths, human remains
Niri alli ganga,	Ratnapura	Pleistocene	Gem pit		*Bos gaurus sinhaleyus*
Okanda					
Padavigampola	Kegalle		'dolmen'		
Pahala vela, Galadande mandiya, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Panthera leo sinhaleyus, Hexaprotodon sinhaleyus, Elephas maximus sinhaleyus*
Pahalameepitiwela, Getahaththa	Ratnapura	Pleistocene	Gem pit		*Rhinoceros kagavena*
Pallama	Kurunegala	Jurassic	river		Jurasic plant fossils
Pallemalala	Hambantota	Lower strata 5000 BP	Shell midden, open air habitation		Human remains, faunal remains, stone tools
Pallikudawa	Hambantota	Lower strata 6300BP	Open air habitation		No artefacts
Pan vila, Adande vala	Ratnapura	Pleistocene	Gem pit		*Panthera leo sinhaleyus, Rhinoceros sp, Hexaprotodon s inhaleyus, Elephas maximus sinhaleyus, Elephas hysudricus sinhaleyus Rhinoceros sinhaleyus,*
Pan vila, Dodampe	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Pan vila, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Panvila, Kuruvita	Ratnapura	Pleistocene	Gem pit		*Bos gaurus sinhaleyus*
Paramaiya Kumbura	Ratnapura	Pleistocene	Open air habitation		Pleistocene fossils, *Elephas maximus sinhaleyus*
Parei Kumbura, Nagoda	Ratnapura	Pleistocene	Gem pit		*Elephas hysudricus sinhaleyus*
Pathirajawela Site 50	Hambantota	Lower strata 5260 BP	Open air habitation	DoA, DWC	Stone tools, *Meretrix casta*
Pin-wewa / Gal-sohon- Kanatta near Yapahuwa		150 BC	Cist burial		Pots, calcined and uncalcined human bones, pottery, iron, copper objects, flakes of mica
Pomparippu	Puttalam	Megalithic	Urn burial		8000 burials Ceramics, pottery, human remains, faunal remains, implements of copper, iron, bronze, stone,, beads,mica
Potana near Sigiriya	Central	Lower strata 6000 BP	Cave		Human remains, faunal remains, ornaments, stone tools, bone tools
Puduwakattu near Tiriyay			Urn burial		bones

Location	District	Dating	Type	Ownership	Artefacts
Rabewa near YanOya			Cist burial		Forms part of a complex, surrounded by early brahmi inscription sites
Radalla, Pothgulkanda	Ratnapura	Pleistocene	Gem pit		*Hexaprotodon sinhaleyus, Elephas maximus sinhaleyus*
Raigamovita, Veraniyagoda	Ratnapura	Pleistocene	Gem pit		*Elephas maximus sinhaleyus*
Ranchamadama	Ratnapura	3360 BP	Burial ground		Geometric microliths, pottery, clay burials
Ravana Ella	Badulla	Mesolithic	Cave	DWC, DoA	Stone tools, Human remains, Faunal remains, bone artefacts
Samanala -Wewa reservoir			Open air habitation	FD, Irrigation Dept	Pitted pebbles, anvils
Sandanamkulama Ittkattiya near malwatu Oya		750- 400BC	Burial site		Cist Burial
Sannasgamuva, Pelmadulla	Ratnapura	Pleistocene	Gem pit		*Sus sinhaleyus*
Sirinandanapura, tanamalwila			Rock pool		Animal bones and fossils (now destroyed)
Siyabalagaswewa		750- 400BC	Burial site		Cist Burial
Tabbova	Puttalam	Jurassic	Surface fossil site	DWC, rrigation Dept.	Jurassic plant fossils & *Acanthodes* fish fossil
Tammenna-godella	Anuradhapura		Cist burial		
Tekkam (Wilpattu NP)		Megalithic	Urn burial	DWC	Not yet excavated. May be similar to Pomparippu
Thunhiriyavila, Gonapitiya	Ratnapura	Pleistocene	Gem pit		*Crocodylus* sp
Tun hiriya vila	Ratnapura	Pleistocene	Open air habitation		Pleistocene fossils
Uda Malala	Hambantota	Lower strata 5330BP & 4520BP	Open air habitation	DWC	No artefacts
Udupiyan galge, Ukgal Kaltota	Ratnapura	Mesolithic	Cave		Pitted pebbles, Pitted anvil cum grind stone, Bone tools, stone tools, faunal remains,
Uru Palauva	Ratnapura	Pleistocene	Open air habitation		Pleistocene fossils
Urupalava yaya, Nugehena, Gonapitiya	Ratnapura	Pleistocene	Gem pit		Choppers,
Ussangoda (Welipatanwila)	Hambantota		Open air habitation	DWC, DoA	Middle Palaeolithic stone tools
Valandure,Kuruvita	Ratnapura	Pleistocene	Open air habitation		Pleistocene fossils
Vilachchiya		750- 400BC	Burial site		Cist Burial
Wilpattu National Park	Puttalam, Anuradhapura		Open air habitation	DWC	Stone artefacts, pottery
Yak giri lena, Matugama			Rock shelter		Pitted pebbles, marine shells,

Appendix: 2 (a) Provisional List of Jurassic Fossils of Flora and Fauna

Compiled by : Hasula Wickremasinghe

Flora	Species	Tabbova	Andigama
Pteridophyta	*Cladophlebis zeylanica* Sitholey	+	
	Cladophlebis reversa (Feist.) Seward and Holtum	+	
	Cladophlebis denticulate (Brogn.)Seward and Holtum	+	
	Cladophlebis cf. browniana Jacob	+	
	Cladophlebis sp.		+
	Sphenopteris hymenophylloides (Brogn)	+	
	Sphenopteris wadiai		
	Fern like fragments	+	
Cycadophyta	*Taeniopteris spatulata* McClelland	+	
	Nilssonia schaumburgensis	+	
	Anomozamites (nilssonia) sp.	+	
	Nilssonia fissa	+	
	Ptillophyllum sp.	+	
	Otozamites sp.	+	
Coniferales	*Elatocladus plana* (Feist.) Seward and Sahni		+
	Elatocladus sp.	+	
	Araucarites cutchensis (Feist.) Seward and Holtum	+	
	Brachyphyllum mamillare (Brogn.)Seward and Holtum	+	
	Desmiophyllum (?Podozamites) sp.	+	
Petrified wood	*Araucarites* sp.	+	
Fauna			
Acanthodidae	*Acanthodus* Agassiz 1833	+	

Despite the fact that it has been mentioned that Jurassic fossils have been found at Pallama, no records are present of the species found there.

The Scientific names used here have been adapted from publication. Nomenclatural changes have taken place for a few generic and species names.

Appendix 2(b) Provisional List of Jurassic Spores

Compiled by : Hasula Wickremasinghe

List of spores and pollen classified according to Naumova's classification. The spores are classified according to the sculpturing of the exine. These were all found in the carbonaceous shale of Andigama of the Jurassic period

Spore Group	Possible species	Comments
Triletes: Azonotriletes (i) Leiotriletes Naum.	a)Phlebopteris hirsute b)Triquitrites deltoids c)Granulati-sporites d)Granulati-sporites concavus e)Microspore of a heterosporous lycopod	Common in the Andigama shale
(ii) Chomotriletes Naum.	Could belong to Genus *Cyathia*	Common in the Andigama shale (this type has also been recorded from the Surma series of Lower Miocene age in Assam)
(iii) Acanthotriletes Naum.		
(iv) Lophotriletes Naum		Similar fossil spores have been recorded from the Barail series (Lower Olgocene) of Assam
(v) Camptotriletes Naum.		Only one spore of this type has been found in the Andigama shale
(vi) Dictyotrilites Naum.	One spore type resembles *Lycopodium scariosum*	Six distinct types can be found
(vii)		Does not fit into any sub -group
Triletes: Zonotriletes Walts (viii)Euryzonotriletes Naum.		
Monoletes Ibr. (ix)Azonomonoletes Luber.	Some may be of pteridophytic nature	
Irremales Naum (x) Aletes Ibr.		Fairly common in the shale

Pollen group	Possible species	Comments
Trilobata Naum (xi) Dolichotrilistrium Naum.		
(xii) Brachytrilistrium Naum.		Similar pollen ypes have been described from the Tertiary rocks of Assam
Saccata Naum. (xiii) Oedemosaccus Naum	Coniferous pollen probably belonging to Pityosporites	Common in both Upper and Lower Gondwana rocks of India.
(xiv) Coniferous pollen with 3 bladders	Resembles the 3 winged pollen of Podocarpineae	Described from the Rajmahal hills, Behar.

Appendix 3: Provisional List of Miocene fossils discovered in Sri Lanka

Compiled by W.L.D.P.T. Sampath de A. Goonatilake (04 June 2008)

Invertebrates		
Phylum: Porifera **Class: Hyalospongiae** Order: Amphidiscophora Family: Pheronematidae	*Pheronema minihagali* Deraniyagala, 1960 Type in Colombo museum	Locality: Minihagal kanda
Phylum: Coelenterata		
Class: Anthosoa Order: Seleratinic Family: Turbinoliidae	*Flabellum sp.*	Locality: Minihagal kanda
Family: Astraeidae	*Solenastrea sp.*	Locality: Minihagal kanda
Phylum: Mollusca		
Class: Gastropoda	*Strombus minihasgali* Deraniyagala, 1960	Locality: Minihagal kanda
Class: Pelecypoda	*Chlamys sp.*	Locality: Minihagal kanda
	Spondylus waylandi Davies	Locality: Minihagal kanda
Class: Lamellibranchia	*Placenta miocenica* (Suess)	Locality: Jaffna Note: relative to living P.placenta (Linne)
	Ostera vesperetina Conrad syn: *O. vireleti* Deshayes	Locality: Jaffna
	Ostea peguensis Noetling	Locality: unknown
	Arca granosa Linne	Locality: Arnakallu
Phylum: Arthropoda **Class: Crustacea** Order: Decapoda	*Oxystomata*	Locality: Unknown
Family: Leucosidae	*Leucosia unidentata* lankae	Locality: Arnakallu
Phylum: Echinodermata **Class: Echinoidea** Order: Cidaroida Family: Cidaridae	*Minicidaris minihasgali* Deraniyagala, 1960 Type in Colombo Museum	Locality: Minihagal kanda
Order: Centrechinoida Suborder: Camarodonta Family: Strongylocentrotidae	*Strongylocentrotus minihasgali* Deraniyagala, 1960 Type in Colombo Museum	Locality: Minihagal kanda
Suborder: Clypeastereida	*Clypeaster annandalei caviventer* Deraniyagala, 1960 Type in Colombo Museum	Locality: Minihagal kanda
	Clypeaster sp.	Locality: Minihagal kanda
	Laganum sp	Locality: Minihagal kanda
Order: Spatangoida Family: Lovenidae	*Lovenia minihagalai* Deraniyagala, 1960 Type in Colombo Museum	Locality: Minihagal kanda
Phylum: Protozoa **Class: Gymnomyxa** Order: Foraminifera	*Taberina malabarica* (Carter) Type in Colombo Museum Now identified as *Pseudotaberina malabarica* Ranjeev Epa *et al.*, 2011	Locality: Keerimalai to Jaffna Locality: Aruwakkalu

Vertebrates		
Phylum: Chordata **Class: Chondrichthes** Order: Lamniformes Family: Laminidae	*Isurus glaucus* (Muller et Henle)	Locality: Arnakallu
	Isurus sp.	Locality: Arnakallu
Order: Hybodontiformes Family: Hybodontidae	*Miosynechodus mora* Deraniyagala 1969	Locality: Arnakallu
Order: Carcharhiniformes Family: Carcharhinidae	*Galeocerdo cuvier* (Peron et le Sueur 1822)	Locality: Arnakallu
	Glyphis minor Agassiz, 1843	Locality: Arnakallu
Family: Galeolaminidae	*Galeolamna gangatica* (Muller et Henle 1841)	Locality: Arnakallu
	Galeolamna brachyura (Gunther)	Locality: Arnakallu
Family: Hemigaleidae	*Hemipristis serra* Agassiz, 1843	Locality: Arnakallu
Order: Myliobatiformes Family: Myliobatidae	*Myliobatis sinhaleyus* Deraniyagala, 1937	Locality: Arnakallu
	Aetobatus sinhaleyus Deraniyagala, 1937	Locality: Arnakallu
Order: Rajiformes Family: Trygonidae	*Trygon sinhaleyus* Deraniyagala, 1969	Locality: Arnakallu
Class: Osteichthyes Order: Tetradontiformes Family: Diodontidae	*Diodon sinhaleyus* Deraniyagala, 1937	Locality: Arnakallu
Order: Perciformes Family: Sapridae	*Chrysophrys miolankae* Deraniyagala, 1969	Locality: Arnakallu
Family: Labridae	*Labrodon sinhaleyus* Deraniyagala, 1937	Locality: Arnakallu
	Labrodon angustidentatus Deraniyagala, 1937	Locality: Arnakallu
Family: Scaridae	*Callyodon sp.*	Locality: Arnakallu
Class: Reptilia Order: Testudinata Family: Emydidae	*Geoemyda striata* Deraniyagala, 1969	Locality: Arnakallu
Family: Testudinidae	*Miotestudo ibba* Deraniyagala, 1967	Locality: Arnakallu
Family: Chelonidae	*Miocaretta lankae* Deraniyagala, 1967	Locality: Arnakallu
Class: Mammalia Order: Sirenia Family: Dugonidae	*Miodugong brevicranius* Deraniyagala, 1969	Locality: Arnakallu
Order: Cetacea Family: Delphinidae	*Miotursiop mulla* Deraniyagala, 1969	Locality: Arnakallu
	Mioceta bigelowi Deraniyagala, 1967	Locality: Arnakallu
	Mioceta magna Deraniyagala, 1967	Locality: Arnakallu

Appendix 4(a) : Provisional List of Pleistocene fossil fauna of Sri Lanka

Species	Type and paratype Localities ?
Order Decapoda Suborder Macrura Family Callianassidae *Callianassa sp.* Deraniyagala, 1938	Kutchavalli
Order Decapoda Suborder Brachyura Family Portunidae *Podophthalmus vigil* Fabricius, 1830	Kutchavalli
Order Decapoda Suborder Brachyura *Scylla serrata* Forskal	Kutchavalli
Order Decapoda Suborder Brachyura *Charybdis* (Goniosoma) sinhaleyus Deraniyagala, 1938	Kutchavalli
Order Decapoda Suborder Brachyura Family Ocypodidae *Macrophthalmus latreillei* Desmarset, 1823	Kutchavalli, Matti Aru
Class: Gastropoda *Placenta placenta* (Linne)	Nadugala – Hakmana, Attudava- Matara
Class: Gastropoda Family: Melaniidae *Paludomus loricata* Reeve 1840	Karavita- Ratnapura, Ellavala, Kosgoda, Karangoda
Class: Gastropoda Family: Helicidae *Acavus sp.*	Kosgoda- Ratnapura
Class: Reptilia Order: Testudinata Family: Emydidae *Geoemyda trijuga sinhaleya* Deraniyagala, 1953	Horeliyadda, Gonapitiya, Kuruvita; Balahapuva, Muvagama near Ratnapura.
Class: Reptilia Order: Testudinata Family: Trionychidae *Trionyx punctata sinhaleya* Deraniyagala, 1953	Mada kumbura, Haldola Kumbura- Ratnapura
Class: Reptilia Order: Crocodylia Family: Crocodylidae *Crocodylus sinhaleyus*	Tunhiriya vila, Gonapitiya, Kuruvita
Class: Mammalia Order: Primates Family: Homonidae *Homopithecus sinhaleyus* Deraniyagala, 1960	Balahapuva near the Kalu River (Ratnapura); Lindagava kumbura, Muvagama;
Class: Mammalia Order: Primates Family: Homonidae *Homo sinhaleyus* Deraniyagala, 1957	Jahinge Angiliya kumbura, Radalla, Karangoda near ratnapura
Class: Mammalia Order: Primates Family: Homonidae *Homo sapiens balangodensis* Deraniyagala, 1945	Ravanalla; Bellan bendi Pelessa;

Species	Type and paratype Localities
Class: Mammalia Order: Rodentia Family: Hystricidae *Hystrix sivalensis sinhaleyus* Deraniyagala, 1951	Millagahadeniya, Gonapitiya
Class: Mammalia Order: Carnivora Family: Canidae Cuon *javanicus* sinhaleyus	Ihala minuvandeniya, Gonapitiya, Kuruvita
Class: Mammalia Order: Carnivora Family: Felidae *Leo leo sinhaleyus* Deraniyagala, 1937	Pan vila, Adande vala, Kuruvita; Pahale vela, Galadande mandiya, Gonapitiya, Kuruvita; Linda gava kumbura, Muvagama
Class: Mammalia Order: Cetacea Family: Delphinidae *Globicephala macrorhyncha* Gray, 1846	Colombo
Class: Mammalia Order: Proboscidea Family: Elephantidae *Hypselephas hysudricus sinhaleyus* Deraniyagala,1942	Panvila, Adandevala,Kuruvita; Kamarangapitiya; Miga-hagoda,Palmadulla;Parei kumbura, Nagoda
Class: Mammalia Order: Proboscidea Family: Elephantidae *Palaeoloxodon namadicus sinhaleyus* Deraniyagala	Kuruvita; Nagoda
Class: Mammalia Order: Proboscidea Family: Elephantidae *Elephas maximus sinhaleyus* Deraniyagala, 1937	Asvaduma, adande vala, Kuruvita; Paramaiye kumbura, Kuruvita; Pan vila, Gonapitiya; Nagoda; Hiri kumbura, Ratnapura; Bathambure vela, Talavitiya; Allege kumbura, Haldola; Beravadeniya, Mahingoda, Ahaliyagoda; Ellavala river;Karangoda; Palmadulla; Dodampe; Radella; Phorabhava
Class: Mammalia Order: Perissodactyla Family: Rhinocerotidae *Rhinoceros sinhaleyus* Deraniyagala, 1936	Naranvatta, Karmarangapitiya, Palmadulla; Hurulle Ela at Katurana, Dompe; Panvila, Edandevala, Kuruvita; Ihala Minuvandeniya, Gonapitiya, Kuruvita; Kuttapiti-ya
Class: Mammalia Order: Perissodactyla Family: Rhinocerotidae *Rhinoceros kagavena* Deraniyagala	Hiriliyadda, Talavitiya; Mativala deniya, Pohorabhava; Moragala Kumbura, ahaliyagoda; Pahala meepitiwela, Gatahetta; Madde Kumbura, Kosgoda, Kuruvita; Am-palauva, Kuruvita
Class: Mammalia Order: Artiodactyla *Sus sinhaleyus* Deraniyagala, 1947	Gonapitiya, Kuruvita; Sannasgame, Palmadulla
Class: Mammalia Order: Artiodactyla Family: Hippopotamidae *Hexaprotodon sinhaleyus* Deraniyagala, 1936	Kuruvita; Haldola; Gonapitiya; Asvadduma; Bokirideniya, Karangoda; Gatadombe, Kitulpe; Kanukatiya, Demalapo-ruva; Tunhiriya vila; Moragala, Kandangamuva; Nagoda; Ellavala; Pohorabava; Kurundu ovita; Demala Poruva, Karangoda; Galinna kumbura, Ahaliyagoda
Class: Mammalia Order: Artiodactyla Family: Cervidae *Muva sinhaleya* Deraniyagala	Mimavaladeniya, Gonapitiya, Kuruvita

Species	Type and paratype Localities
Class: Mammalia Order: Artiodactyla Family: Cervidae *Rusa unicolor unicolor* Kerr, 1792	Horeliyadda; mallavitiya, Karangoda; Iriyagahaliyadda, Gonapitiya; Rilhena, Palmadulla; Galpothevela, Kutta-pitiya, Palmadulla; Baddama,Haldola
Class: Mammalia Order: Artiodactyla Family: Cervidae *Axis axis ceylonensis* Fischer, 1829	Valikumbura, Pohhorabhava; Ambala; Balangoda
Class: Mammalia Order: Artiodactyla Family: Bovidae *Bibos gaurus sinhaleyus* Deraniyagala, 1951	Gorakgaha deniya, Gonapitiya; Pan vila, kuruvita, Pan liyadda; Alapata; Thotapitiyage vatta, Pahalagama, Ellavala
Class: Mammalia Order: Artiodactyla Family: Bovidae *Gona sinhaleya* Deraniyagala	Madirigiriya near Hingurakgoda
Class: Mammalia Order: Artiodactyla Family: Bovidae *Bubalus bubalis migona* Deraniyagala, 1953	Deniya kumbura, Panamure;

Compiled by : Hasula Wickremasinghe

Appendix 4(b) : Provisional list of fossil plants that were found during the Pleistocene

Compiled by : Hasula Wickremasinghe

Species	Location
Alsophila zeylanica	Ratnapura gem sands
Bambusa vulgaris Schrad	Ratnapura gem sands
Ochlandra stridula Thwaites	Ratnapura gem sands
Onchosperma fasciculate Thwaites	Ratnapura gem sands
Caryota urens Linne	Ratnapura gem sands
Elaeocarpus subvillosus Arn	Ratnapura gem sands
Myristica dactyloides Caertn.	Ratnapura gem sands
Canarium zeylanicum Bl.	Ratnapura gem sands
Coscinium fenestratum Colebr.	Ratnapura gem sands
Wrightia flavidorosea Trim.	Ratnapura gem sands
Myrtaceae	Ellawala, Ratnapura
Strobilanthes	Ellawala, Ratnapura
Moraceae	Ellawala, Ratnapura
Sapindaceae	Ellawala, Ratnapura
Anarcadiaceae	Ellawala, Ratnapura
Rutaceae	Ellawala, Ratnapura
Graminae	Ellawala, Ratnapura
Cyperaceae	Ellawala, Ratnapura
Geraniceae	Ellawala, Ratnapura
Impatiens	Ellawala, Ratnapura
Caryophyllaceae	Ellawala, Ratnapura
Labitatae	Ellawala, Ratnapura
Adiantum	Ellawala, Ratnapura
Polypodiaceae	Ellawala, Ratnapura
Polypodium	Ellawala, Ratnapura
Pteris	Ellawala, Ratnapura
Mesua	Palmadulla
Lagerstroemia speciosa	Balahapuva
Cyathea	Ratnapura
Artocarpous	Ratnapura

Appendix 5: Provisional list of rock art found in Sri Lanka

Compiled by : Hasula Wickremasinghe

Name of Cave	District	Province	Discoverer & Year	Subject of Pictograph
Budunnehela			Dissanayake, J. B. (2001)	These human beings, deer, tusker and elephant are specific. Also, beehives, hungotu, hoop, arrow and several other unidentified illustrations, human beings
Bambaragastalava Cave	Ampara	Eastern	Deraniyagala, P.E.P, 1957	Unidentified animal figures
Ganegama	Ampara	Eastern	P.E.P Deraniyagala, 1957	Elephant, crocodile, crawling animal, Brahmi script
Gonagolla	Ampara	Eastern	L.K. Karunaratne,	Stag, hunter, deer, stag and deer juveniles
Hulanuge	Ampara	Eastern	Roland Silva,	Humans, elephants
Malayadi Kanda	Ampara	Eastern	Register of ancient monuments	Veddah paintings
Pihilegoda -galge	Ampara	Eastern	C.G.Seligman & B.Z. Seligman, 1911	Men, women, animals, maludema, leopard, monitor lizard, bow & arrow
Rajagal kanda	Ampara	Eastern	C.E Godakumbura, 1961	unidentified
Umagekanda	Ampara	Eastern	Gamini G Punchihewa, 1982	Man, symbols
Samangala	Ampara	Eastern	Medananda, Ellawala (2003)	pangolin, a deer, either a jackal or a dog and also '*hangotu*'
Piyangala	Ampara	Eastern	Kappagoda, Priyatha & Gunawardana, Indika (2005).	a group of humans (a family?) a deer and geometric shapes.
Panama Wewa	Ampara	Eastern	Manatunge, Seevali (2005).	geometric symbols and few human figures
Nella	Ampara	Eastern		human figures, deer, '*hangotu*' beehives and geometric shapes
Walagampura	Ampara	Eastern		Human, deer, elephant, '*hangotu*' (deer skin receptacle for honey), beehive and unidentified figures
Hennanigala	Ampara	Eastern	R. L. Spittle (1924)	human figures, animal figures and geometric shapes
Neelagiri Kanda	Ampara	Eastern	Chinthaka Wijetunga, 2012	Deer, tortoise like animals and geometric shapes
Vettambugala cave	Ampara		Raj Somadeva, 2012	Animal figures, geometric designs, elephants

Name of Cave	District	Province	Discoverer & Year	Subject of Pictograph
Andiyagala	Anuradhapura	North Central	John Still, 1910	Human, sun, Iguana?
Billawa	Anuradhapura	North Central	John Still,1910	Human, sambur, peacock, unidentified symbols
Komarika Cave	Anuradhapura	North Central	P.E.P Deraniyagala, 1951	Elephant, human, either a sambur doe, jackal or dog
Tantrimale	Anuradhapura	North Central	John Still, 1910	Sun, human, animals, birds, bear, child, leopard, iguana?, moon
Punchikiriamma-galge	Badulla	Uva	C.G.Seligman & B.Z. Seligman, 1911	Elephant, humans,
Arangodagala	Batticoloa	Eastern	HC.P.Bell, 1904	Man, woman, monkey, deer, lotus of sun, centi-pede or leaf,bow & arrow, geometrical patterns, flowers
Gamakande-galge	Batticoloa	Eastern	C.G.Seligman & B.Z. Seligman, 1911	"hangout or maludema" (a vessel for collecting honey)
Kandurupokuna	Batticoloa	Eastern	P.E.P Deraniyagala, 1958	Elephant, unidentified animals
Kiripokuna	Batticoloa	Eastern	P.E.P Deraniyagala, 1951	Elephant
Kudumbigala	Batticoloa	Eastern	A.T.Rambukwella, 1963	humans
Lenama	Batticoloa	Eastern	S.J.Kadirgamer, 1963	Elephants, pigs, bears, birds, men
Mahalenama eliya	Batticoloa	Eastern	P.E.P Deraniyagala, 1958	Drawings, inscriptions
Pulukunawa kanda	Batticoloa	Eastern	Chinthaka Wijethunga, 2012	two human figures, deer, elephant, dog, hangotu, beehive and geometric shapes
Havala Eliya	Hambanthota	Southern	Register of ancient monuments	Veddah art
Magulmaha Viharaya (Sithulpavva)- Yala National Park	Hambanthota	Southern	Kulasinghe, Jayalath and Bandara, T. M. C., 2003	Hand impressions
Dorawaka (Ethgale galge)	Kegalle	Central	G.F.R. Browning, 1919	Elephant and calf, unin-dentiified figurines
Dorawaka kanda	Kegalle	Central	P.E.P.Deraniyagala, 1951	Elephant, unidentified herbivore
Urakanda	Kegalle	Central	W.H.Wijepala,	Unidentifiable symbols
Urakanda (07.11.988N, 080.24.531E)	Kegalle		Jayampath Senanayake & U.R.Rammungo-da,2010	Human forms, Siripathula, triangular engravings,

Name of Cave	District	Province	Discoverer & Year	Subject of Pictograph
Habbeli Kanda	Kurunegala	North Western	Dept Archaeology	human figures, animals (pangolin , deer clearly visible) and geometric shapes.
Alu-galge	Moneragala	Uva	Rev. Dharmasiri of Kotte raja maha Viharaya	Human, leopard, peacock, wheel-like symbol
Manda-galge	Moneragala	Uva	P.E.P Deraniyagala, 1951	Elephants, symbols,humans
Navagala	Moneragala	Uva	Frederick Lewis, 1914	Lion/ tiger
Ussagala near Bibile	Moneragala		Senarath Wickremasingha, 2001	Human,animal, geometric shapes, natural objects, unidentified objects (vedda)
Wettambugala	Moneragala	Uva	Shimada, Hided and Sirisoma, M. H., 1999	Tusker, elephant, Deer, human on an elephant, beehive and '*hungotu*'
Lihiniyagala	Nuwara Eliya	Central	Mahinda Karunarathna,2007	Human figures
Lihiniyagala	Nuwara Eliya	Central	Dissanayake, Senerath (1997).	human beings, animals and geometric shapes
Dimbulagala	Polonnaruwa	North Central	W.S.Karunaratne, 1967	Human, square
Konatte-goda-gala	Polonnaruwa	North Central	HC.P.Bell, 1904	Veddah 'ash pictures'
Budugala	Ratnapura	Sabaragamuwa	L.A.Adithiya, 1971	Lion,human faces, swastika, trident
Kondagala	Ratnapura		Raj Somadeva, 2012	Lines, linear diagrams
Kongarayan-kulum	Vavuniya	Northern	M.H.Sirisoma	Humans, animal figurines, inscriptions