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Reconsidering the Palaeo-Environmental Reconstruction of the Wet Zone of Sri Lanka: A Zooarchaeological Perspective

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Abstract**—**Bones, teeth, and shells have been acknowledged over the last two centuries as evidence of chronology, Palaeo-environment, and human activity. Faunal traces are valid evidence of past situations because they have properties that have not changed over long periods. Sri Lanka has been known as an Island, which has a diverse variety of prehistoric occupation among ecological zones. Defining the Paleoecology of the past societies has been an archaeological thought developed in the 1960s. It is mainly concerned with the reconstruction from available geological and biological evidence of past biota, populations, communities, landscapes, environments, and ecosystems. This early and persistent human fossil, technical, and cultural florescence, as well as a collection of well-preserved tropical-forest rock shelters with associated 'on-site ' Palaeoenvironmental records, makes Sri Lanka a central and unusual case study to determine the extent and strength of early human tropical forest encounters. Excavations carried out in prehistoric caves in the low country wet zone has shown that in the last 50,000 years, the temperature in the lowland rainforests has not exceeded 5 degrees. Based on *Semnopithecus Priam* (Gray Langur) remains unearthed from wet zone prehistoric caves, it has been argued periods of momentous climate changes during the Last Glacial Maximum (LGM) and Terminal Pleistocene/Early Holocene boundary, with a recognizable preference for semi-open 'Intermediate' rainforest or edges. Continuous genus *Acavus* and *Oligospira* occupation along with uninterrupted horizontal pervasive of *Canarium* sp. ('kekuna' nut) have proven that temperatures in the lowland rain forests have not changed by at least 5 °C over the last 50,000 years. Site catchment or territorial analysis cannot be any longer defensible, due to time-distance based factors as well as optimal foraging theory failed as a consequence of prehistoric people were aware of the decrease in cost-benefit ratio and located sites, and generally played out a settlement strategy that minimized the ratio of energy expended to energy produced.

Keywords**—**Palaeo-environment, palaeo-ecology, palaeo-climate, prehistory, zooarchaeology.

I. Introduction

SRI Lanka has been well known since ancient times for its great natural beauty. A significant commodity of the country is a rich and diverse flora. This tiny, 65,610 square kilometer island has more than 3,500 native flowering plant species. More than a quarter of these species are deemed unique to the country. Today Sri Lanka is regarded as one of South Asia's most diversified regions [1]. The pear-shaped island of Sri Lanka is situated some 48 km off the southern tip of India, between 6 and 10 degrees north of the equator. Within this extent, Sri Lanka has been experiencing various ecologies ranging within extreme to moist [2]. The main island of Sri Lanka's island country, also known as Sri Lanka, is a South Asian island in the Indian Ocean, southeast of the Indian subcontinent, strategically situated near major sea lanes in the Indian Ocean [3]. Sri Lanka's climate includes equatorial monsoons: the northeast monsoon (December to March), and the southwest monsoon (June to October). Its topography is mostly low, flat to rolling plain, with mountains in the south-central interior [4].

Sri Lanka has two major epochs where fossils of multicellular organisms are found, and fossilized deposits representing one phase. Among them are Jurassic fossils found in northwestern Sri Lanka such as Tabbowa [5]-[7], Adigama, and Pallama [8]. The fossils found here are mainly limited to plants [9]. The fossils, which are commonly referred to as ferns (non-flowering), are found here [10]. Besides, several fossils of fish have also been reported by [11]. As per literature cited from [12] located in the Anakallu area of northwestern Sri Lanka, the Jaffna peninsula, and the southeastern Minihagalkanda region [13], fossils belong to the Miocene period [14]. Miocene fossils in Sri Lanka are almost entirely marine fossils [15]-[17]. There are also fish, turtles, star tortoises, dolphins, whales, sea pigs, and vertebrates [18]-[21]. Fossils of marine predators, shells, and gastropods [10], [14], [15] are also found. Pleistocene is the last of the fossil phases in Sri Lanka [13], [22]-[24]. Most of the mammals that lived there are now extinct, but there are also mammals that persist from the Pleistocene to the Holocene [23], [25].

II. Methodology

Palaeo-environmental reconstruction typically involves the analysis of abiotic and biotic evidence. Abiotic evidence includes geomorphic, sedimentologic, and stratigraphical attributes and biotic evidence consists of plant and animal remains as well as of other living things. When using vertebrate remains to reconstruct palaeo-environments, several factors have been considered. Specifically, most large mammals have broad habitat tolerance and consequently, they are less reliable indicators of environmental reconstruction [26]. By contrast, small mammals, such as rodents are more ecologically restricted and therefore more valuable for environmental reconstruction [27]. Among invertebrates, insects and mollusks are ideal for palaeo-environmental reconstruction, have helped reconstruct environmental conditions for the periods of human occupation [28], [29]. Mollusks occur in a variety of depositional settings,

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including loess; caves and rockshelters; stream, lake, and spring sediments and marine environments [30]. The above rational conditions were analyzed with the following published data.

The purpose of this study was to be conscious of the positioning of Gray Langur's (*Semnopithecus priam*) existence in Sri Lankan Wet zone prehistoric caves within the ecological reconstructed paradigm while considering additional indicator species' 50,000 years of uninterrupted continuation. Therefore, this research fundamentally based on published data [2], [31], [32] and unpublished data. Target caves can be listed up in chronological framework, its Fahien Lena, Batadombalena, and Kithulgala Beli Lena respectively; stationed deep in the heart of the wet zone. Detailed excavation profile of Batadombalena is achieved from Dr. Nimal Perera's "Prehistoric Sri Lanka: Late Pleistocene Rockshelters and an open sir site" published in 2010 [2], while most of the unpublished data of faunal remains from excavations carried out in Batadombalena, Kithulgala Beli Lena, Fahien Lena, Balangoda Kuragala, Alavala Pothgul Lena, Pothana and Aligala and Bellanbendipelessa came from second author's personal research experiences of not less than 30 years. First author's Zooarchaeological preliminary investigations initiated at the Postgraduate Institute of Archaeology, University of Kelaniya, furthermore two individual bone sessions were carried out at Field Museum, Chicago, and National Museum of Natural History, France. Zooarchaeological theoretical base was entrenched from Cambridge Manual of Zooarcheology, Cambridge Manual of Teeth, Cambridge Manual of Vertebrate Taphonomy.

Material method reference lists are guided by Prehistoric Sri Lanka [2] and Checklist of Alavala Cave excavation [33]. But above all, "Prehistory of Sri Lanka; An Ecological Perspective (1992)" [39] by Prof. Siran Deraniyagala, is used as a guide for the advancement of intellectual knowledge of Sri Lanka's prehistory. The theoretical zooarchaeological basis for this research paper was established through the Ecological Approach to the Prehistory of Sri Lanka, which is discussed here. Selected references of present faunal environmental conditions are illustrated through reference under [34], [35] (*Lyriocephalus scutatus*); and references under [36]-[38] (*Acavidae* and *Oligospira*).

III. Wet Zone and Prehistoric Archaeology

Sri Lanka has the best-recorded prehistoric sequences in South Asia, as synthesized in S.U Deraniyagala's "The Prehistory of Sri Lanka: an Ecological Perspective" [39]. Reference [39] documented the evidence for the first habitation over 125,000 years ago, and the current state of knowledge on a swathe of the open-air sites and rock shelters between the late Pleistocene and the late Holocene [2].

Sri Lanka is divided into three wide precipitation and vegetation zones which are guided by climate. The 'Wet Zone' receives an annual rainfall between 2200 and 4800 mm and is home to wet deciduous and tropical evergreen rainforest [40], while the 'Intermediate Zone' receives 1700-2200 mm and supports moist tropical deciduous and intermediate semi-evergreen rainforest [40]-[43]. While most of the rain in the Wet Zone falls between May and October, there is no real dry season as a result of the southwest monsoon. Conversely, the Island's northern dry zone experiences frequent drought cycles between May and September [43]. Tropical wet evergreen forest dominates in the lowlands in the Wet Zone, and submontane and montane evergreen forests predominate in the highlands [41], [42].

Wet zone forests of Sri Lanka anchorage more than 60% of the indigenous fauna, and the high proportion of endemism can be seen in the southwest lowland forests where almost 90% of the endemic vertebrates are concentrated [44]-[46]. The wet lowlands of Sri Lanka, lying less than 900 m asl, occupy the west and south-western parts of the Island. Prehistoric sites are ubiquitous in this zone and offer the density of information that would enable a fine-resolution analysis of forager adaptations in both temporal and spatial terms [2], [39]. Also, all of Sri Lanka's major rock shelter sites located in the wet zone, including, Dorawaka Lena near Warakapola, excavated in 1991 by Wijepala (1997) [2], with suggestions of Neolithic cultural remains. Alternatively, Nimal Perera has discovered 9 rockshelters [2] in Gampaha district during the excavation of Early Historic clay cist graves. Alavala has reportedly yield shreds of evidence of human reliance on the wet zone [37], [47]. According to [39], this zone includes many open-air prehistoric sites. Tun Modara on Vak-Oya, west of the Labugama Reservoir, has yielded pitted hammer pebbles and nut-stones in alluvial slit throughout some 3 km [2].

As stated by [39], the Rathnapura Gravels have occasionally yielded quartz and chert artifacts of a nondescript chopper industry termed the Rathnapura Industry [48]-[50]. These gravels also contain a fauna, the Rathnapura Fauna [50]-[52], which includes extinct forms, notably two palaeoloxodont elephants [25], two rhinoceros, lion [53]-[55] and hippopotamus [12], [23].

IV. Major Prehistoric Rockshelter Sites

Caves and rockshelters occur extensively in the Rathnapura, Kegalle and Kaluthara districts of Wet zone. Fahien-lena in Kaluthara District is one of the largest rockshelters and was excavated by over several seasons between 1986 and 1988 by Wijepala [31] yielding seven dates on charcoal ranging from c. 40,000 to 5400 cal BP [2]. Batadomba-lena near Kuruwita is another sumptuous rockshelter in the lowland wet zone, which is well dated and extremely rich archaeological record of the late Pleistocene age, capitulated a consistence series of 10 radiocarbon dates ranging on c. 38,000 to 13,000 cal BP. [2], [39]. Kithulgala Beli-lena is an eminently habitable rockshelter in Kegalle District. It was first excavated by Deraniyagala in 1963, after S.U. Deraniyagala and Wijepala by 1978-79-83 and 1986 respectively and recently by Wedage in 2017 [2], [31], [39], [43].

In conformity with Nimal Perera's excavation session (2005) at Batadombalena has yielded a colossal archaeological assemblage, including abundant organic remains, from terminal Pleistocene [2]. As will become evident, the majority of identifiable faunal material from Batadombalena is found of mammalian remains [2], [56]. According to [39], the land mammals of Sri Lanka comprise some 39 genres and 109 subspecies, which reflects the island's environmental diversity. While mammalian remains are certainly important to reconstructing the palaeo-diet and palaeo-environment, the board habitat range of mammals make their use in a matter of interpretation [57]-[62].

V. Acavus and Oligospira as Bio Indicators

Many factors have demonstrated that the rainforest cover of Sri Lanka's wet zone has remained unchanged for the last 50,000 years [10], [63]. The stratification of Batadomba-Lena is translucent. Seven distinct cultural layers have been identified from the earth to the present [2], [39]. On the testimony of the last excavation carried out by Perera in 2005, the seven main layers have been identified up to 125 sub-layers [2]. The deposits are around 38,000 years old [2], [31], [32], [57], [62].

Perera [2] acknowledged that Deraniyagala affirms that very large quantities of gastropods, predominately *Acavus* and the *Oligospira*, were found in main excavations of the 1980s [56], [62]. The number of identified fragments from layer 7 is much greater than from layers 4 to 6, along the lines of excavations from 2005 [2]. Family Acavidae is very sensitive to climatic variations and therefore, it can be used as a bio indicator to describe the fluctuations of Palaeo-climatic nature and present day [10], [65]. Therefore, Acavus identifications, continuously found in seven layers, with wide vertical spreads, which led us there , would certainly be no grounds to suspect environmental change in the environs of Batadomba-Lena [2], [10].

In a zoological perspective, *Acavidae* in the superfamily *Acavoidea* [66] is a taxonomic family of air-breathing land snails, terrestrial pulmonate gastropod mollusks. Genus Acavus by Linnaeus (1758) fundamentally restricted to the wet zone, including the lower regions of the focal massif, up to in excess of 600 m heights [36]-[38]. One *Acavus* species is also present at Ritigala [10], a patch of moist woodland inside the north-central dry zone in 600 m altitude. Sri Lanka's south-western moist sector (annual precipitation extra than 2500 mm) was once included with the aid of evergreen rain forest, however now the final patches of foremost wooded area are being severely fragmented [36].

From prehistoric times, *Acavidae* has survived and adapted to the terrestrial life in the wet environment. From the optimal fossils found in every excavation in Batadombalena cave, sub fossils of Acavidae have been reported as a dominant position [64]. Occupation of Acavidae species in different soil strata showed that the members of the Acavidae were ceaselessly lived in each Batadombalena region of the Palaeo age [64], [65].

The Kithulgala Beli-Lena invertebrate faunal assemblage presents a similar range and distribution of freshwater and arboreal/terrestrial taxa to that seen in other cave sites in southwest Sri Lankan rainforest environments, particularly Batadomba-Lena rockshelter [32]. Therefore, the abundance of layers of many of the above caves, including the snails and the Batadombalena, which are highly sensitive to the rainforest environment, is a piece of important evidence that the wet zone rainforest coverage has persisted for at least the last 50,000 years. At the wet zone archeological sites of Batadomba-Lena [62], [64] and Beli-Lena Kitulgala [32], [67] consecutively, the presence of rainforest land snails dated to the LGM and terminal Pleistocene may seem to confirm the late Pleistocene preservation of rainforest stands in the vicinity of these sites. Prehistoric excavations in the wet zone caves have proven that temperatures in the lowland rain forests have not changed by at least 5 °C over the last 50,000 years [68].

VI. Mammalian Dominance of Unearthed Fauna

The mammalian dominance of the Batadomba-Lena faunal assemblage is comprised of 80-93% of the total by Number of Identified Species (NISP) [2]. Monkey's dominance of the mammalian assemblages is entrenched [2], and the importance of giant squirrels, palm civets, and mongoose as secondary prey is also clear [2], [62]. Similarly, arboreal and semi-arboreal primate and other small mammalian species make up the majority of fauna at Batadomba-Lena and Fahien-Lena [31] during the Late Pleistocene [2], [64], while evidence for *Canarium* sp. nut exploitation further supports the persistence of tropical forest in the Sri Lankan wet zone [61], [31], [32].

Reference [61] has declared that despite potential fluctuations in the extent and productivity of Sri Lankan tropical forests associated with these climatic changes, late Pleistocene human foragers maintained a reliance on the intermediate rainforest and tropical forest edge [61], [62]. They made up two groups for their stable isotope analysis purposes, whereas the first group, predominantly made up of semi-arboreal and ground-dwelling forest mammals including porcupine (*Hystrix indica*), giant squirrel (*Ratufa macroura*), mouse deer (*Moschiola meminna*), and two monkey species (*Macaca sinica* and *Semnopithecus entellus priam*) is representative of modern intermediate rainforest fauna, *Elephas* sp., cervids, suids, and hare (*Lepus nigricollis*) [61].

In the direction of unavoidable facts, all of the above mentioned evidenced caves relied on the center of the wet zone (Fig. 1). If those caves were on the fringes as they dispute, dry zone animals should be reflected through strata of wet zone caves. When taking Batadombalena alone, the entire 7 layers have yielded an uninterrupted occupation of Acavus sp. and *Canerium zeylanicum* [2], a plant that grows in the middle of the rainforest [10], [56], [61], [62].

VII. Pollen Studies at Central Highlands

Pollen analysis has also been used to identify episodes of regional bioclimatic change that may have favored or deterred human occupation at an archaeological site or brought about cultural transitions. Palynology research carried out in Horton Plains [69], [70] has built up for the region in the last 24,000 years (late Pleistocene and Holocene), with rain forests that have greatly altered the climate of our country [69]-[71]. Subsequently, Premathilake and Risberg [69] constructed a series of climatic fluctuations, for the period from around

20,000 years ago to present [69], [70], [2].

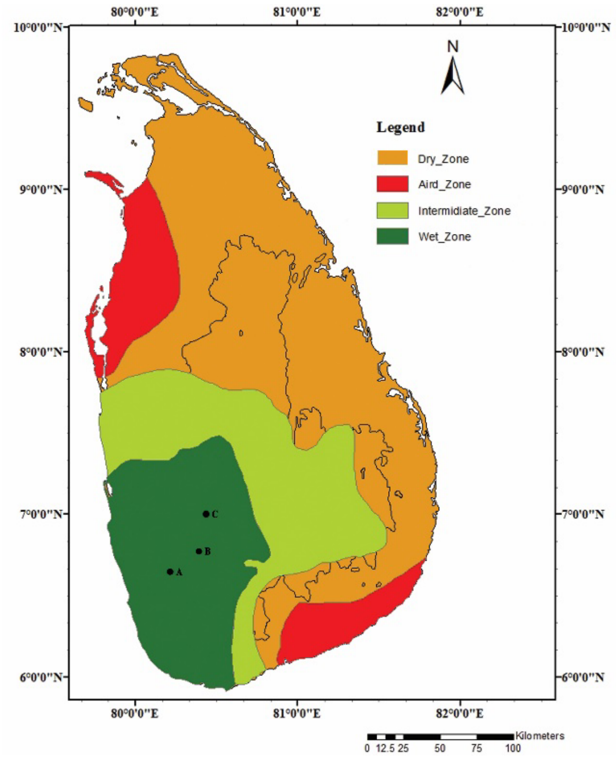

Fig. 1 Map of Sri Lanka showing the location of A- Fahien Lena, B- Batadomba-Lena C- Kitulgala Beli-Lena and the island's vegetation zones [41], [42]

Pollen data indicated that the transition was marked by a dramatic increase in moisture [70]. It should be further investigated whether the changes in the environmental conditions in the upper montane forest zone during the last 24,000 years presented by Premathilake and Risberg are common to the whole of Sri Lanka or to the whole montane zone in particular [10], [70]-[72]. Considering the extent to which the above-mentioned environmental conditions, based only on a limited sample taken from the Horton Plains above 2000 m above sea level, should be considered as a substitute for the southwestern rainforest zone extending from sea level to 1500 m above sea level. As per [69], if the dry conditions prevailing in the high mountain region are directly affected by lowland rainforests, some species that prefer dry climates in Sri Lanka's dry zone or intertidal zone may invade the wet zone. The best example of this is Semnopithecus *priam.* It is a primate species that prefers dry climates [34]. If the dry climatic conditions prevailing in the high mountain range are affected by the lowland wet zone, the dry zone could invade the lowland wet zone. As a result, species that are resistant to dry conditions should migrate into the wet zone. If they had entered the wet zone, the prehistoric man would have hunted them and brought them to the cave, just like other animals[1]. In further explanations, there's no explanation can be found that why they did not carry back entire those animals, while larger animals are carried back entirely. But in the low-lying wetlands, prehistoric human habitats such as the Fahian Lena, Batadomba Lena, Beli Lena, Alu Lena, Dorawaka Lena and Pothgul Lena, have not been found in areas where animals can withstand dry environmental conditions such as *Semnopithecus vetulus* [10].

VIII. Economic Substantial of *Semnopithecus Priam* and *Axis Axis Ceylonensis*

Very recent publication [32] has documented both *cercopithecines* (macaque) and *colobines* (langurs) were identified in the assemblage based on teeth and certain post-cranial elements. They "confidently" identified 74 specimens representing *Macaca sinica* and 35 were identified as coming from langurs [32]. In the terms of Zoology, there are two subspecies, *Semnopithecus priam priam* in India [73], and *Semnopithecus priam thersites* from Sri Lanka [36], [74], [75]. They can be found at Polonnaruwa [77], [78], Dambulla [79], Sigiriya [10], also Yala National Park, Tissamaharama and Hambanthota [76]. According to [76] and [80], the gray langur is very fond of the dry zone, it also lives in the inter-zone boundaries. But they were never tend to found in the wet tropical rainforests, gray langurs are found throughout the well-wooded areas of the country's dry zone from south of Jaffna in the north to the shores of the extreme southern coast [81]. The gray langur is an excellent Indicator of animal species to measure dry environmental conditions [10], [82].

The fossilized deer (*Axis axis Ceylonensis*) remains found in the intertidal and dry zones of a gem mine from Ratnapura belong to the Pleistocene period [12]. Deraniyagala complemented that the fossilized deer may have lived in the Ratnapura region during the dry season in the Pleistocene. Nevertheless, he has not commented on the period of the Pleistocene [12], [22]. Moreover, teeth and bones of the genus *Axis* have been found in the lowland wet zone caves [2], [39], [82]. Manamendra-Arachchi [82] holds his opinion that these bones maybe belongs to Hog deer[2] [83] (*Axis porcinus*). Because the Hog deer, currently living in low-lying lowland rainforests such as Matugama, Kalutara, and Galle [84], [85], may have lived in the lowland forests during the Late Pleistocene and Holocene. This is further confirmed by the discovery of the remains of the Hog deer in Alavala Pothgul cave-Gampaha District, which dates back 14,000 to 8,000 years [33]. The spotted deer (*Axis axis*) may have lived in the wet zone around Ratnapura during the dry season that preceded it.

[1] Optimal Foraging theory- Large animal's kills at the site; they carry only meat to the camp while small animals are carried back entirely.

[2] Keelart n 1852 defined the Hog Deer as a taxon precise to Sri Lanka and referred to as t Axis oryzus. Pocock (1943) synonymized this taxon as a subspecies underneath *Axis porcinus* Zimmermann, 1780 [84]. It become notion that the Hog Deer was delivered to Sri Lanka. However, it has now not been documented in literature, while every made of trade and alien species added into Sri Lanka changed into documented. None of it suggests that the Hog Deer became brought to Sri Lanka. Incidentally there may be a report of the Hog Deer being exported to Australia from Sri Lanka [101]. It is counted as a few of the smallest deer species inside the international and also seemed as certainly one of the maximum primitive species of deer.

IX. *Lyriocephalus scutatus*: A Wet Environment Essentialist

The remains of animals living in the rainforest ecosystem are almost entirely present in the wet zone caves where the stratosphere has been deposited for more than 40,000 years [31], [32], [56], [61], [64]. It is worthwhile to take a look at several other aspects of this model, which show that lowland wetland rainforest coverage persisted during the last 50,000 years. Suitable for the propagation of the *Lyriocephalus scutatus* (genus *Lyriocephalus)* [35], which lives in the southwestern rainforest mantle of elevation 1650 m above sea level [86]. It is the largest agamid endemic to Sri Lanka and lives in dense wet zone forests, [87] widespread in the wet lowlands and the mid-hills, from 25 m up to elevation of 1650 m [86], [88]. Several localities are known, such as Ratnapura, Udawatta Kele Sanctuary [88], Gannoruwa, Gammaduwa, Hanthana, Mathugama, Knuckles Mountain Range, Adam's Peak, Gampola, Kandy and Sinharaja Rain Forest [86], [87]. This species was not found in sweltering sunny sites [88].

A wet environment is essential for the survival of the hump-nosed lizard [44]. But this lizard species is capable of migrating from the southwest to the dry zone [86]-[90]. This species of lizard has been observed in the Riverine forests on the banks of the Walawe River in the village of Kinchigune in Balangoda Place, Ratnapura District [82]. The village of Kinchigune (6.6898° N, 80.7806° E), near Pambahinna, though situated in an inter-region, has a very dry climate. Correspondingly Karunarathna & Amarasinghe [86] recorded among 109 individuals 86.2% (n = 94) recorded from wet zone while 13.8 % (n = 15) from intermediate zone. They were able to sustain record one individual at Lunugala for the first time from Badulla district [86]. This manifests the rainforest's lizard that can travel to the dry zone through the riverine forests and survive there. Even in the dry zone, the cover of wet and humid air in the riverine forests may have caused these creatures to some degree of the wet forest patch. Rainforest inhabitants can survive at certain times in wet zones under dry zone conditions. The tree snails of the Genus Acavus are living in rain forests but they live in the Riverine forests in the village of Kinchigune [82]. Therefore, it is clear that the snail is also capable of living in the same environment commensurate by a hump-nosed lizard. These two examples show that some species of rainforest can survive in the dry zone under appropriate environmental conditions and more precisely we can consider this species as mainly lowland species but sporadically submontane species [86].

According to Premathilake and Risberg [69]-[72], if the dry conditions of the last 24,000 years in the high mountain region had affected the lowland rainforest, they would have fallen during that period. That is to say, the dry zone environment may have invaded the wet zone. In such a situation, rain forest inhabitants are confined to areas with minimal facilities for their survival. The prevalence of the hump-nosed lizard suggests that the forests and animals were largely confined to the riverine areas. In the wild, the creatures were able to overcome the dry or arid conditions of life, and it was under these conditions that the creatures could not remain permanently tortured. Then, until the dawning of the wet and rainy season, these rainforest creatures may live in the confined areas of the swamp and re-emerge as the cliffs of the rainforest. Dry conditions across the wet zone have returned to the dry zone. Based on the foregoing, it is clear that the organisms continued to exist during the last 50,000 years of the low country wet zone. The prehistoric cave excavations in the Wet Zone confirm the existence of these creatures in terms of animal remains. If the dry and dry conditions aforementioned by Premathilake and Risberg invaded the wet zones, there would have to be a decline in the population. However, if we consider only the Batadomba-Lena, there is no sign of rain forest degradation among all its layers [2], [39]. If there was a dry or arid season in the wet zone, the prehistoric man would have little chance of getting wet zone animals here. But when we consider the population of all the seven layers of Batadombalena, it does not appear that there is a decrease in the population [2], [62]-[65].

X. Recent Advancements

In Sri Lanka and South India, the research results of the DNA of freshwater crab, freshwater shrimp, freshwater fish, caecilian (footless amphibians), reptiles, and shrimp frogs are very important. Indian and Sri Lankan land relations that date back to the Pleistocene period have been lost on several occasions over 500,000 years [91]-[94]. However, these animals have not migrated between the two countries during this period. This may have been due to some obstacles in northern Sri Lanka and the South Indian region. Genetic research in these animals has confirmed this paradigm [82]. However, over the last 10,000 years, Sri Lanka and India have become independent [91]-[94]. Genetic factors of modern organisms have revealed important information on wetland rainforest cover. The following invertebrate and vertebrate groups living in the rainforests of Sri Lanka and South India were used for this genetic research published in 2004. Research using mitochondrial DNA based on Genus *Puntias,* Genus *Ichthyophis,* Genus *Pseudophilautus,* Genus *Uropeltidae* groups shows that the ancestors of these animals came to Sri Lanka from India more than 53 million years ago [95]. Almost all of the above species are sensitive to rainforests, and they continue to live in the wet zone rainforests of the Southwest until today [33], [95]. This reaffirms that in the last 50,000 years, there have been no expansive fluctuations of rainforest temperature.

XI. Discussion

The results of from [31], [32], [60]-[62], brandish that Sri Lankan human foragers relied primarily on rainforest resources [64] from at least c. 48,000 years ago [31], through times of earth shattering atmosphere changes during the LGM and Terminal Pleistocene/Early Holocene limit, with a conspicuous inclination for partially opened Intermediate Extremes [58], [60]-[62]. This direct information alongside the archaeological record for continuous occupation, relative technological stability [61], ostensibly specialized subsistence

[56], human burial [96], and the intensity of symbolic materials already established for the Wet Zone rockshelters, provides strong evidence for Late Pleistocene human rainforest occupation in Sri Lanka [2], [39], [64].

Recent findings on [32] are a bit controversial, as they have "confidently" stated that 35 remains of Genus Semnopithecus have been recorded from Excavations carried out in Kithulgala Beli-Lena in 2017. Also, there are two subspecies, *Semnopithecus priam priam* in India [73], and *Semnopithecus priam thersites* from Sri Lanka [34], [74]. If not fallacious when Wedage et al. mentioned "langurs (*Semnopithecus*/*Trachypithecus*[3]), we believe they were talking about preceding species from genus *Semnopithecus.*

There are no historical records of *S. priam* in the lowland wet zone of Sri Lanka, indeed their ecology, locomotor anatomy, and social organization are adapted to dry-zone forests far removed from the southwest rainforests. The three species are not sympatric in the wet zone area of Sri Lankan lowland prehistoric caves as [31], [32] stated in the precedent publication [31], [32].

Back in 2019 [31] mentioned in supplementary note 2 (p. 12), "the *cercepithecoid* specimens in the assemblage were differentiated based on the morphology of certain dental and skeletal elements. Of the 4,188 cercopithecid bone fragments recorded in the site, 318 specimens (7.6%) were identified to species, with *M. sinica* (49.4%) being more common than *T. vetulus* 13 (34.6%) and *S. priam* (16%)" in Fahien Lena; a cave was then as now in the center of the wet zone separated from the dry zone by distance, climate, and a mountain barrier. It is therefore highly unlikely that the remains found for *Semnopithecus* belonged to *S. priam thersites*; the Hanuman or gray langur, instead all such langur remains were of the highly arboreal purple-faced langur, *S. vetulus vetulus*. Notwithstanding *Semnopithecus priam* would be considered as an alien species without a proper context of existence.

Secondly, [31] signifies the toque macaques (*Macaca sinica*) were found more frequently in the middens than remains of the langur. That brings up the interesting question of the human hunting strategy. In numerical terms alone the purple-faced langur (*Semnopithecus vetulus*) far outnumbers the macaques (*Macaca sinica*) in density in the habitat. There may be two explanations for the greater prevalence of macaques in the midden. First, the langur is highly arboreal and therefore more difficult to hunt despite their greater numbers and frequency of encounters with hunters. Conversely, if macaques then as now were easily attracted to the food supply of the cave dwellers, their discarded vegetable matter for example, it would be consistent with them being more easily taken as prey, perhaps even baited with food and trapped. The leaf-eating langurs are less easily baited than the generalist macaque [77], [97], [99].

In obedience to optimal foraging theory, along with additional subjects such as "Prey Size", "Patch Residence Time", "Patch Quality and Competitors", "Search Strategies", "Risk Aversive Behavior" and foraging practices subject to "Food Limitation", it is logically impossible for a human to be hunted by similar small animals and neglect a few kilos, whereas considering Batadomba cave [2], [62]-[64], Beli Lena [32], Alulena and Pothgul Lena [33], it is evident that rodents belonging to the genus *Rattus*, *Calotes* and *Lyriocephalus* species have also been eaten by prehistoric people. If situations are true to "Killed and processed at the site" of [31], [32], there must be a research gap of "why prehistoric people abandoned species like Spotted deer (*Axis axis ceylonensis*); which is easier to hunt and much meat content (25-75 Kg) and hunted Gray Langurs which is a small amount of flesh (10-20 Kg) in the body?" Since *Homo sapiens* are more cognitive species, they would be conquered through the optimal relationship between costs and benefits of different subsistence activities. If there were some trade or friendly relationship between inter-climatic zones, then there must be a crystal clear appearance of other dry zone species such as spotted deer, among strata of wet zone caves. It is not evidenced yet.

Contrarily, [98] has enumerated responses to potential predators and suggested that spotted deer and gray langur responded to each other's alarm behavior. Spotted deer made aware of langur caution more as often as possible than the other way around. Hostile collaborations between the two species were seen in 5.8% of affiliations, predominately directed from gray langurs to spotted deers [98]. On account of this behavior, gray langurs will often sit next to herds of the spotted deer. Through the medium of this "mutualism"; the symbiotic relationship in which both neither is harmed, suggests that they spend considerable time in each other's company, which is commonly perceptible. In such a spot, when hunting outdoors in open grasslands of dry zone, both species would have caught the eye of Prehistoric man.

Supplementarily, Site Catchment Analysis (SCA) can be used in a potential way of monitoring Gray Langur's Presence. SCA was first elucidated by Claudio Vita-Finzi and Eric Higgs in 1970, [99] to refer to the scanning of archaeological sites in alliance to their environmental backdrops. Ethnographic observation has revealed that foragers rarely walk more than 10 km or 2 hours from their base to procure resources [100]. It is further assumed that prehistoric people were aware of the decrease in cost-benefit ratio and located sites, moved their locations, and generally played out a settlement strategy that minimized the ratio of energy expanded to energy produced.

[3] This issue of identifying the langur species from teeth and bone fragments has been considered as an early opportunity to mislead between species. Researchers should be aware also of the correct langur taxonomy. Both the gray (GL) and purple-faced langur (PFL) of Sri Lanka share the same genus *Semnopithecus*; they are distinguished as *S. priam and S. vetulus* species, respectively. The taxonomy of these langurs was updated some years ago: There are no Trachypithecus n Sri Lanka. The GL occurs as one subspecies *S. priam thersites* distributed throughout the dryzone whereas the PFL occurs as four subspecies n wet-zone habitats: *S. v. vetulus* n the southwestern rainforest south of the Kalu Ganga, *S. v. nestor* also n the southwestern rainforest but north of the Kalu Ganga (Colombo environs), *S. v. monticola* n the wet zone highlands and *S. v. philbrickii* confined to the relatively moist forest habitats found n the dry zone – as n riverine forests along the banks of permanent water bodies such tanks and perennial rivers. n other words, we expect to find PFL n dry zone habitats but no GL n the wet zone.

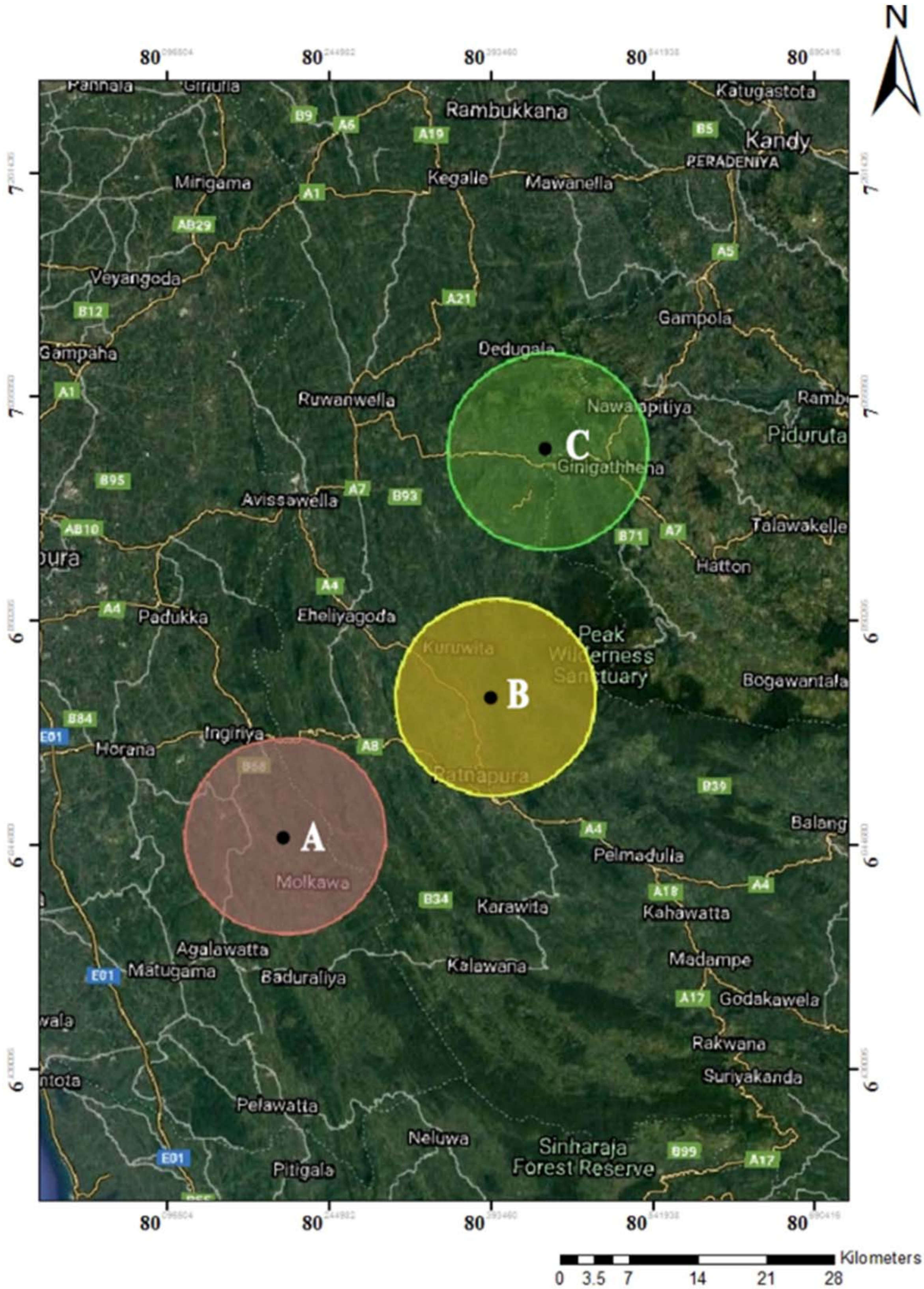

Fig. 2 Map showing the Daily Exploitation Radius of 10 km as per [99] Note that A- Fahien Lena, B- Batadomba-Lena C- Kithulgala Beli-lena could not reach Dry zone or even Fringes of present dry zone within a 10 km or 2 hours of walking

Within consideration of antecedent time-distance factors, people from ancient wet zone could not reach dry zone by 10 km of daily exploitation radius (Fig. 2). There will be more than 100 km from the each wet zone cave to reach at a point where a Gray Langur can be seen at first. But this whole paradigm was created from Kung Bushman of Kalahari Desert, there's a critique when applying this module to wet zone lowland rainforests. Therefore, Chisholm in 1968 [100] observed some "exceptional" cases; for an example, the inhabitants near water bodies or rainforest dwellers, may not want to walk 10 km for a day to procure their resources as they already filled with subsistence resources. In contrast to that, all three identified Paludomus species of the Pleuroceridae family from Batadomba-Lena [2] require clean, freely flowing freshwater-conditions expected to prevail in the hydrological systems adjacent to the rockshelter under undisturbed rainforest canopy [62]. Therefore, people inhabited this area must experience animals that came to the water facility. Scholars [62] tested both bulk and sequential stable carbon and oxygen isotope analysis to human and faunal tooth enamel from the sites of Batadomba-Lena, Fa Hien-lena, and Balangoda Kuragala; they have dignified stable carbon and oxygen isotopes result from *M. sinica* drinking from open, evaporative water sources on the ground; which is occupying space up to 49% of excavated faunal materials [56], [64]. So, its halcyon that, people from Batadomba-lena, Fahien-lena may not have to walk 10 km far to hunt or gather food.

Identically [32] suggests that there was either a trade of gray langurs with wet zone human inhabitants or that Gray Langurs inhabited the wet zone fringes [32]. The former requires a cogent explanation of why a resident forager of the dry zone would transport, over a considerable length in time, distance and geophysical obstacles, a dead or live gray langur trophy to his wet zone counterparts in trade regularly. If not, there were drastic climatic changes that drew Gray Langur into the wet zone of Sri Lanka. There is no evidence for the latter, we have examined every possible archeological way in above. More researches need to be done for further confirmation.

Site Territorial Analysis is a lately developed version of SCA, considering inwards from the surrounding landscape to the archeological site. In this concept, a site can have different catchments and its own SET's (Site Exploitation Territories) and satellite SET with an effort to extend the economic catchment of the residential base. But as there is no evidence of satellite camps around specified wet zone caves yet, this concept is also disenfranchised.

From all appearances, the emergence *of Semnopithecus priam* from prehistoric contexts is controversial. All the assumptions that can be made to support that idea is considered as above, but could not be justified. Suitable rational theories (Optimal Foraging Theory, SCA, STA) in archaeology have been considered, there was no push for it. However, further study opportunities need to be expanded.

XII. Conclusion

The nature of past environments has long been a fundamental question in archaeology, and therefore many attempts have been made to use faunal remains from archeological contexts to provide palaeoenvironmental reconstructions. Such attempts have met with mixed success, because the relationship between animals and environmental conditions is very complex. Moreover, using a specific species or species characteristic to reconstruct palaeo-environmental specifies, such as past climate conditions can be very difficult. Fahien-lena, Batadomba-lena, Kithulgala Beli Lena preserve evidence for the presence of *H. sapiens* foragers in the rainforest of southern Sri Lanka from ca. 48,000 cal BP onwards to the end of the Pleistocene. Reference [56] indicates the presence of Wet Zone closed rainforest and more open and intermediate rainforest based on stable carbon and oxygen isotope analysis and [68] constructed a series of climatic fluctuations, for the period from around 20,000 years ago to present whereas [69] has determined there there are no such fluctuations of Temperature even by 5 ° for last 28,000 years (now 38,000 ybp).

Tenacious Zooarchaeological materials have yielded uninterrupted rainforest occupation through the last LGM without suspension. Spatial horizontal distribution of Acavus and Oligospira from Batadombalena, Presence of Kekuna seeds (*Canarium zeylanicum*), and Ceylon breadfruit (*Artocarpus nobilis*) confirmed Deraniyagala and Kennedy in 1989 [68] .

Three cercopithecoid species are currently present in the Island: the cercopithecine *Macaca sinica* (toque macaque), the colobines *Semnopithecus vetulus* (purple-faced langur), and *Semnopithecus priam* (tufted gray langur). References [31] and [32] confidently documented that gray langur (*Semnopithecus Priam*) bones have been found within wet zone prehistoric caves. Without the availability of morphologic or morphometric data or analysis of gray langur bones, the relevant point should be re-examined along with more zoological and ecological indexes.

Optimal foraging theory, SCA or Site Territorial Analysis along with SETs could not explain the positioning of gray langur bones in wet zone prehistoric caves. Reference [32] suspects that the hunter-gatherers that were hunting in the dry zone or that gray langurs were at one point present in the fringes of the wet zone region. This would be more parsimonious since this is supported by the presence of other materials in the cave that could have been sourced elsewhere or other dry zone materials should appear among contexts. Alongside the predominantly arboreal character of the vertebrate fauna in layer 6 in Batadomba-Lena [64], the snail representation suggests that rainforest refugia persevered in the environs of the site even during the driest period of the Late Pleistocene.

The gray langur interpretation is inconsistent with what we know of the nature of these species and seems to indicate a species misidentification. We would look forward to new data, i.e., a credible reference base for morphological distinctions between gray langur and purple faced langur teeth to resolve this matter. The issue of resolving the species of tooth fragments requires that have a substantial sample of teeth from the different species as a baseline of comparison and should clarify the degree of variation and overlap in tooth morphology of both species and establish if and to what degree tooth morphologies of the two species differ.

XIII. Future Directions

This research focuses primarily on biotic factors uncovered from excavations carried out prehistoric caves in wet zone of Sri Lanka. Priority has been given to animal remains rather than plant materials. To further clarify the veracity of the above hypothesis, research opportunities based on abiotic factors (geomorphic, sedimentologic, and stratigraphic indicators) need to be expanded. Geochemical analyses like stable isotope composition of sediments, soil organic matter, soil nodules, and carbonates could be used as more advanced methods for the further clarifications.

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