Global Veterinaria 22 (1): 19-29, 2020
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2020.19.29

Origin and Zoogeography of the Order Proboscidea

[1]*Mosissa Geleta Erena and* [2]*Abebe Getahun*

[1]Department of Biology, Wollega University, Nekemte, Ethiopia
[2]Addis Ababa University, Department of Zoological Sciences, Addis Ababa, Ethiopia

Abstract: Proboscidean are groups of mammals that includes elephants and their extinct relatives. Among the several species of Proboscidean once existed in this world, only *Loxodonta africana* and *Elephas maximus* exist in Africa and Asia, respectively. The aims of this review paper were to evaluate the distribution patterns of elephants since their origin across the globe and to analyse conservation activities practiced ever for elephants. It also aims to suggest more on researches, conservation and management activities of elephant species beyond a paper work. The order Proboscidae was originated in Africa during the late Paleocene Epoch, about 60 million years ago. They subsequently spread to Eurasia via Arabian plate and Indian during the Early Miocene. The favourite habitats of the primitive Eocene Proboscidean have been the shores of the Tethys Ocean from where they dispersed out of Africa following several land bridges. The Horn of Africa is presumed to have been the first migration corridor which allowed the Proboscidean to reach Eurasian. The most probable route of dispersal from African to Eurasian were Morocco-Iberia, Tunisia-Sicily-Italy, Suez isthmus and routes from north-east Africa through the Arabian Peninsula. During the middle Miocene, Proboscidean crossed Beringia from Eurasian into North America and spread rapidly through South America. Currently, relic elephant species, *Loxodonta africana* and *Elephas maximus,* were limited to 37 African and 13 Asian countries, respectively. The survival of these species is affected by disease, demographic factors, habitat loss and fragmentation, human-elephant conflicts, drought and poaching for ivory and meat. Poaching elephants is increasing due to the high demand of ivory. Poor economic development in developing countries is the driving factor for poaching elephant. Political instability, poor governance of protected areas and weak enforcement of wildlife laws at national and international level negatively influenced conservation activities of the relic elephants. Despite the allocation of huge fund to save elephant species, the works done to date have not yet gone beyond paper work. In the future, much efforts than before should be invested to ensure the sustainable conservation and management of elephant species because threatening factors are getting worse than ever.

Key words: Distribution · Elephants · *Elephas maximus* · *Loxodonta africana* · Proboscidea

INTRODUCTION

Proboscidea are group of animals that includes the living elephants and their fossil relatives. They are ungulate dating to the late Palaeocene of northeast Africa and spread to all continents except Australia and Antarctica. Proboscideans are the oldest surviving and most speciose mammalian groups to have inhabited Africa. The term Proboscidea was coined by Carl D. Illiger in 1811 by their most unique organ called the proboscis or trunk. Proboscidea come from two Greek words, the *Pro* which is to mean 'before' and *boscis* as 'Mouth'. However, the suffix-*idea* is used for ranks in the taxonomy of the order Mammals and interpreted as 'Appearance' or 'Kind' [1].

The order Proboscidea includes a vast array of Proboscideans ranging from the dog-sized *Phosphatherium escuilliei* that lived in northwest Africa about 60 million years ago, the glorious woolly mammoth, *Mammuthus primigenius*, that lived in northern latitudes of Eurasia and North America from about 2 million years until it became extinct less than 4000 years ago. Among the several species of the order Proboscidea once existed in this world, only two species and about 6 subspecies

Corresponding Author: Mosissa Geleta Erena, Department of Biology, Wollega University, Nekemte, Ethiopia.

exist to date. The living African (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) are the only two survivors of a widespread radiation of the order Proboscidea. The African elephants are represented by the savanna elephants (*Loxodonta africana africana)* and the forest elephants (*Loxodonta a. cyclotis*). But their sub-Saharan distribution is increasingly fragmented and threatened [2].

Genetic study on L. africana and E. maximus has provided new insight to the taxonomic classification at the subspecies level. Preliminary genetic studies have indicated two subspecies of African elephants, namely the savanna elephants (L. a. africana) and the forest elephants (*L. a. cyclotis*). However, reexamination of the anatomical and genetic evidence has assured the two subspecies into species categories as *Loxodonta cyclotis* and *L. africana* [3, 4]. In addition, the existence of third African subspecies, West African elephant, inhabiting both forest and savannas has also been postulated [5]. The savanna elephant resides in the savanna and grassy plains of east and South Africa but the forest elephants inhabit forested regions of central and western Africa [6]. The Asian elephants have four recognized subspecies. These include, the Sri Lankan subspecies (E. m. maximus), the mainland subspecies (E. m. indicus), the Borneo subspecies (E. m. borneensis) and the Sumatran subspecies (E. m. sumatranus). This has revealed that the taxonomy of elephant in general may further diversify in the future as genetic and phylogenic research indicates additional subspecies.

Elephants play an important role as 'keystone' and 'umbrella' species in maintaining biodiversity of an ecosystem [7]. As they require large habitat, their conservation ensures the conservation of other species that coexist in the habitat. Elephants modify the environment in a positive as well as negative ways. In some cases, the reduction of woody vegetation has been beneficial in opening up tsetse fly infested woodland and transform bushland to grassland for livestock. Studies have shown that elephants have a great ecological importance as agents of seed dispersal [8]. Elephants are considered as 'flagship' species in Asia as it is associated with the social and cultural aspects of people. It is a species of great economic importance as it attracts tourist into the country. The elephants are categorized as threatened species category. The Asian elephant is categorized as an endangered species in the Red List of the World Conservation Union, whereas the African elephant is categorized as vulnerable [9]. Studying the ecology and biology of elephants are a concern of many scholars since their origin. The efforts made to study all about the ecology, biology and behaviour of elephants from fossil record and extant species has brought an insignificant development on the conservation of elephants. This is because the population number, distribution and ranges of elephant species is declining than ever. The reduction in the historical ranges and number of relic elephant have stimulated to review and track the biogeographic distribution of elephants since their origin. The aim of this review paper is, therefore, to summarize the former and current distributional ranges and factors that affect the distribution of the order Proboscidae at global level. This review also describes the different conservation approaches ever practiced to conserve the order Proboscidae. Moreover, the review aims to document the current ranges of elephants, key causes for their historical range contractions and the current conservation measures implemented to sustain the relic elephants in the future. This would help to design the future conservation and management plan of the species.

MATERIAL AND METHODS

We obtained information by reviewing both published and unpublished literature. To achieve the overall objectives of this review, any published and unpublished works were used regardless of their time of publication. Before the collection of all necessary documents, an outline for searching literature review sources was set along with key leading questions. Accordingly, all the necessary information that exactly fit with the objectives and questions set for the review were extracted. Information gathered from different sources were analysed by text analysis method. The following questions were used to direct literature document assembly and synthesis in this review.

- What forced Proboscidean to distribute away from their center of origin?
- What are the current threats to the conservation and management of the relic elephant species?
- What conservation measures should be implemented to sustain the relic elephant species?

RESULTS AND DISCUSSION

Origin of Proboscidea: There were many hypotheses about the center of Proboscidean origin. Many findings had asserted the center of origin for the order Proboscidea. For instance, during early to middle Eocene,

a fox like creature called *Eritherium* was discovered from Morocco. In addition, *Moeritherium* was discovered in Fayum basin of Egypt. It was a pig-sized and hippo-like creature that lived in freshwater and or marshy habitats before 30-35 million years. However, an African origin of Proboscidean were seriously challenged when *Anthracobunids* discovered from older Eocene rocks in the northwestern India [10]. After many debates and examinations, the African origin of Proboscidean was reasserted with the discovery of *Numidotherium* in the early Eocene in Algeria. Moreover, the discovery of *Phosphatherium,* in the late Paleocene, from Morocco strengthened the African origin of Proboscidean. Yet, by the end of the Pleistocene, all Proboscidean had become extinct except two genera: *Elephas* and *Loxodonta* [7]. Many research findings indicated that Proboscidean had evolved in the Old World and successively migrated to the New World because of human induced environmental factors. The existence of remnant elephant species in the Old World like Africa has confirmed that the current relic elephants better adapted to their ancestral center of origin than colonized ranges across the globe.

Since the late Paleocene Epoch, the order Proboscidean showed a spectacular radiation until the end of the Pleistocene Epoch [10]. Proboscidean undergone three major events of radiation [3]. The earliest Proboscideans such as *Anthracobunids*, *Moeritheres* and *Deinotheres* had evolved first during the Eocene and Oligocene. The second occurred during the latest Oligocene and Miocene which comprises the evolution of *Gomphotheres* and *Stegodontids* and the third occurred during the latest Miocene to the Pleistocene which includes the evolution of *Elephantidae*. Proboscidean in the first radiation were mostly browsers, whereas those in the second and third radiations were grazers [11]. The initial radiation of *Elephantimorpha* (*Mammutidae* and *Elephantidae*) that replaced the ancient *Elephantiformes* (*Phiomidae* and *Paleomastodontidae*) was centered in Africa. During this period, these Proboscideans also expanded out of Africa reaching all continents except Australia and Antarctica [12]. The widespread distribution of Proboscideans was probably related to their large body size. Elephants require large geographical ranges because they are proficient to travel long distances to search resources. In addition, some *Elephantimorph* species (*Mammoths* and *Mastodons*) were clearly well adapted to live in cold climates and environmental flexibility [13]. Though the size of Proboscidean helped them for diversification across the globe, they had not well adapted to their colonized ranges.

Dispersal routes of Proboscidean: Proboscidean are originated in Africa during the Paleocene [10] and subsequently spread to Eurasia via Arabian plate and Indian during the Early Miocene [14]. The favourite habitats of the primitive Eocene Proboscidean were the shores of the Tethys Ocean [3] from where they dispersed out of Africa following several land bridges [15]. The Horn of Africa is presumed to have been the first migration corridor which allowed the Proboscidean to reach the Saudi Arabian Peninsula during late Oligocene to early Miocene and, thereafter Pakistan (Fig. 1) [16]. Early Miocene was known as the major faunal exchange between Africa and Eurasia which was mostly called Proboscidean Datum Event. Proboscidean that have been assumed to disperse from Africa include *Hemimastodon*, *Gomphotherium*, *Zygolophodon, Choerolophodon, Platybelodon*, *Mammuthus* and *Deinotherium*. During the late Oligocene and early Miocene, Africa was separated from Eurasia and India by the Tethy Ocean through which they disperse out of Africa during glaciations [16]. The most probable areas of dispersal between African plate and Eurasian plate across the Tethy Ocean were Morocco-Iberia, Tunisia-Sicily-Italy, Suez isthmus and routes from north-east Africa through the Arabian Peninsula. For migration of Proboscidean, these routes need not necessarily possess full bridges. However, chains of islands and formation of glaciations are adequate for dispersal. These chains are called Alpine chains which are formed by a great uplift of land between Africa and Eurasia. Another dispersal route of Proboscidean has occurred via Indian plate while tectonics slowly drove Africa and India closer to Eurasia. Tectonic land movement resulted in abrupt lowering of sea level and produced land connection between these areas. Since then, a general lowering of sea level during the late Middle Miocene due to the formation of glacial resulted in repeated dispersal [17].

The availability of land connection was a prerequisite for dispersal, but not the real factor that controls migration of Proboscidean. Since Proboscidean are very large, they are less sensitive to temperature but climatic change affected the environment to limit dispersal of Proboscidean. Environmental changes resulted in different feeding specialization which further forced them to disperse from areas they inhabited. Proboscideans of African dispersed towards Western Europe due to varied modes of feeding specialization. The first dispersed Proboscidean were browsers which had low crowned cheek teeth, thick enamel and short molars [19]. They were forced to disperse to Europe due to changes in tropical

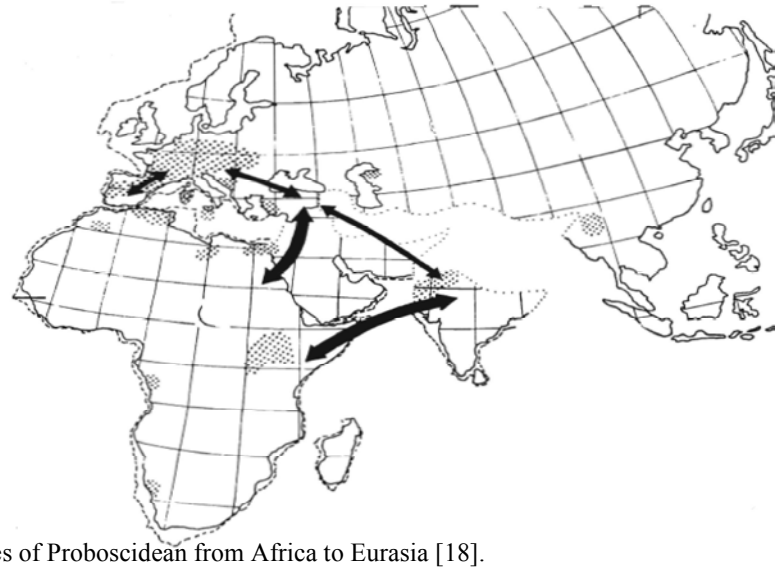

Fig. 1: Dispersal routes of Proboscidean from Africa to Eurasia [18].

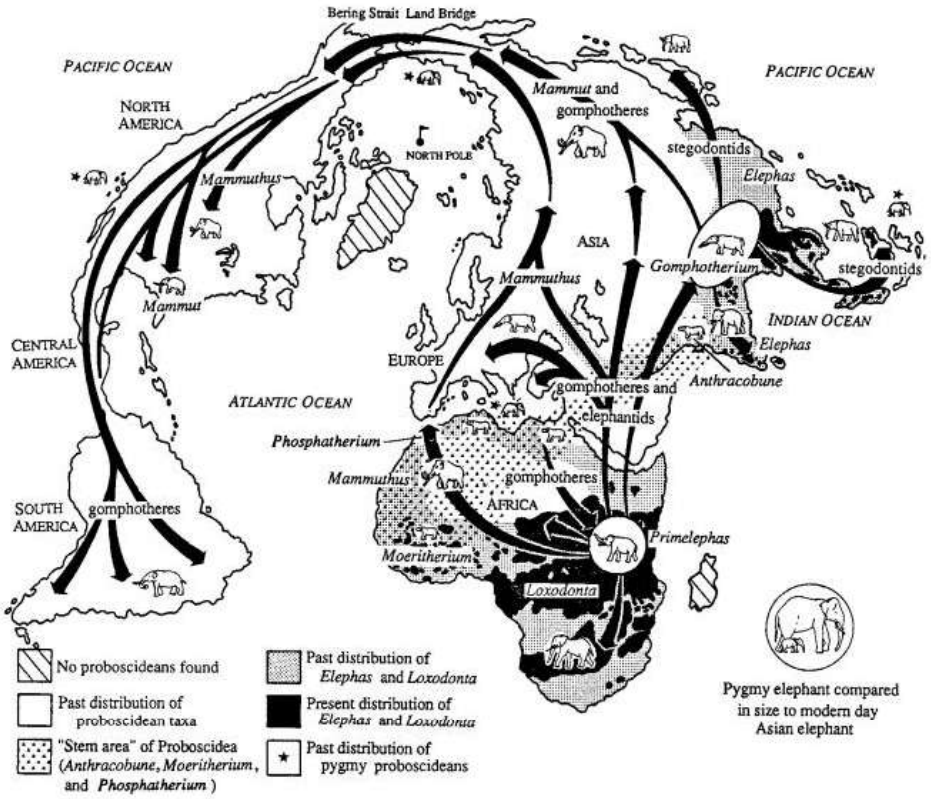

Fig. 2: Reconstructed dispersal routes and distribution pattern of Proboscidean across the world [21].

vegetation. But the remaining Proboscidean were adapted to graze and have evolved high crown cheek teeth with compressed cusps and elongated molars. It is this adaptation that allowed these Proboscideans to enter Europe later during the severe climate change in the tropics. The earlier dispersal occurs when Europe had a warmer and less seasonal climate than today, whereas the later dispersal occurred at moments of fundamental global climatic changes when open landscapes increased in Europe [20]. The reconstructed dispersal routes and global distribution of Proboscidean is shown in Figure 2.

During the middle Miocene, Proboscidean crossed Beringia into North America and spread rapidly through the continent [22]. They first appeared in Central America during the Late Miocene and persisted there until their extinction, at the end of Pleistocene. Fossils of Proboscidean from Central America are assigned to four genera: *Gomphotherium, Cuvieronius, Mammut and Mammuthus* [23]. *Gomphotheres* dispersed from North America to Central America about nine million years ago. However, there is no evidence that showed their dispersal into South America. Besides, there were no recorded fossil of *Gomphotherium* in South America as the Miocene Panamanian seaway was a barrier to Proboscidean dispersal [19]. However, during the Late Pliocene, *Cuvieronius* arose from a *Gomphothere* in North America and dispersed southward through Central America to South America because the Panama way joins North and South America. *Mammut* has a single Central American record during the Late Pleistocene. Neither *Mammuthus* nor *Mammut* was recorded in South America. During the late Cenozoic, Central America has served as a pathway for the Proboscidean migration. All South American Proboscidean includes *Cuvieronius* and its descendants such as *Notiomastodon*, *Stegomastodon* and *Haplomastodon* [23].

Distributions of Proboscidean: The oldest Proboscidea were known from Africa at least 60 million years ago and migrated into Eurasia where fossils are known from Arabia, Pakistan, France, Portugal, Japan, Indonesia, Philippines and from western Asia and Africa. The elephants that developed in Africa and Asia were distributed into Western Europe and Northern America during the glaciations. During Miocene, the Proboscidean such as *Gomphotherium* migrated to North America via Bering Bridge [24]. The *Mammuths* and *Mammut* evolved from *Gomphotherium* and survived and disappeared from North America about 10,000 years ago. *Mammoths* and *mammut* were widespread in Europe, north Asia, North America and Central Mexico, but they never dispersed into South America. However, three genera such as *Cuvieronius*, *Haplomastodon* and *Stegomastodon* migrated into South America where they survived and extinct [25]. In addition to the mainland masses, Proboscidean was distributed in several islands such as Mediterranean islands, Asian islands (Java, Sumatra and Borneo), island of Sardinia and other islands. With the exception of Australia, Antarctica and some islands, fossil Proboscidean have been found in every continent [7].

Loxodonta and *Elephas* are the only two genera left as the sole inheritors of African and Asian elephants, respectively. During the Pleistocene, *Loxodonta* were reserved to live in the moist forests of Central Africa due to loss of vegetation and dominance of grass and woodland in other parts of Africa. To the contrary, *Elephas* roamed over the drier and grassland regions which were far more extensive in the continent [24]. The traits of *Loxodonta* that suited for a life of browsing in forest may have favoured their dispersal out of the moist forest into the expanding woodlands. The late Pleistocene climatic and habitat conditions granted *Loxodonta* a selective advantage over *Elephas*, thereby enabling it to become the sole Proboscidean inhabitant of the African continent. However, it is not known how and why *Elephas* disappeared from Africa. The modern Asian elephant was derived during the later Pleistocene from *E. hysudricus* found in the Siwaliks of the Indian subcontinent [7].

The current distribution of elephants is markedly reduced compared to the past. Currently, *Loxodonta* remains restricted to Africa (Fig. 3A), whereas *Elephas* is found in Asia (Fig. 3B) [25]. Both the African and Asian elephants have a wide range of attributes which give them the ability to survive and thrive in mild to extreme environmental conditions [6]. For instance, the anatomical and physiological adaptations of Proboscidean were as diverse as the spread of habitats they occupied [7]. However, there is no detail evidence why *Loxodonta* remained in Africa and *Elephas* dispersed into Asia. Currently, elephants are present in 50 countries at global level. The Asian elephant (*E. maximus*) is found in 13 countries across South and Southeast Asia out of which India holds over 50% of the global population. African elephant (*L. africana*) is found in 37 countries distributed over eastern, southern, central and western Africa [7].

Factors That Affect Distributions of Proboscidean

Continental Drift: Proboscidean have colonized different continents except Australia, Antarctica and some islands. This is because the great evolutionary radiations of most terrestrial vertebrates occurred after the breakup of Pangaea and Panthalassa. Similarly, Proboscidean had evolved in the late Paleocene, after the separation of Antarctica and Australia. Gondwanaland separated into its different land plates about 180 million years ago. During the mid-Cretaceous (About 100 million years ago), Australia and New Zealand rifted from Antarctica. Much farther to the south, New Zealand retained a

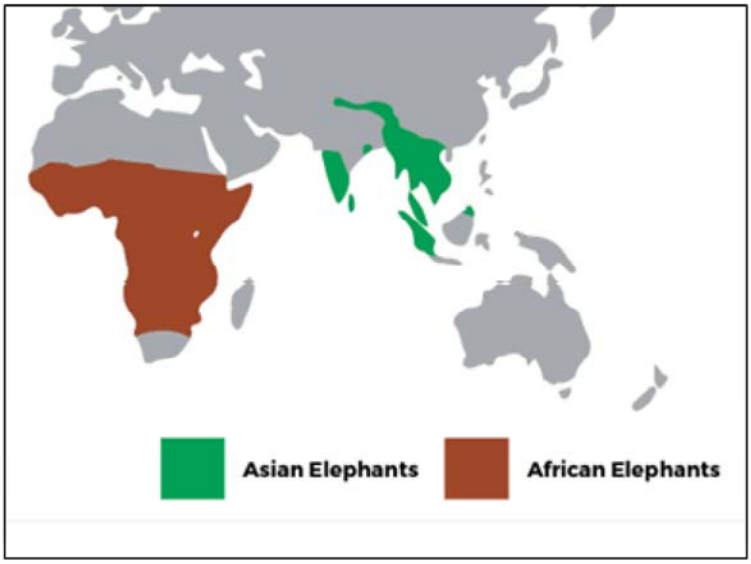

Fig. 3: Current distribution of *Loxodonta* in Africa and *Elephas* species in Asia [26].

connection to Antarctica about 90 million years ago. However, Antarctica broke away completely from Australia and New Zealand about 80 million years ago. Though most islands and some continents were colonized by Proboscidean via chains of land bridges, the distance of the two continents and other islands becomes a barrier for distribution of Proboscidean [27].

Habitat and feeding specialization: *Mammuthus* (*Elephantidae*) and *Mammut* (*Mammutidae*) had been recorded in Florida and Honduras during the Pleistocene and expected to cross the Panamanian land bridge, but they did not reach South America [28]. The reasons may be associated to the diet and habitat preferences of these genera's. *Mastodons* (*Mammut*) have relatively low-crowned molars with cusps arrayed in widely spaced lophs. This dental morphology led to the recognition of mastodons as browsers. *Mammoths (Mammuthus*) have high-crowned molars with closely spaced enamel lophs coated with cement which identifies them as grazers. They had been gradually adapted to became grazers as grasses dominate their habitat. Both *Mammuthus* and *Mammut* have adapted to the North American habitats and climate. Thus, they have never preferred to disperse into South America [29].

Temporal Barriers at Land Corridors: Land corridors or bridges are not constant, but periodically changed based on land movement. For instance, the ancestor of *Sinomastodonplus, Cuvieronius* and *Stegomastodon* had been dispersed from Europe to North America via Beringia during the latest Miocene and early Pliocene. However, at the end of the Pliocene, an increased sea-level resulted in a new vicariant event and split North America from Asia [14]. Thus, *Sinomastodon* evolved in isolation in Asia and recorded only in Early Pliocene in sediments of China. In addition, *Mammuthus* and *Mammut* had been confined to North America for about nine million years (Up to their extinction) because the narrow Panamanian way acts as barrier though it was not a complete barrier to the southward dispersal of North American Proboscidean [20].

Survival of Proboscideans on Islands: Proboscidean are the largest mammalian species that survived on mainland and islands. The distribution of Proboscidean from Africa to Europe, Asia, North, South America and different islands bears witness to their ability to traverse diverse terrain and habitats. Proboscidean colonized Mediterranean islands more than others because they are closer to the mainland mass. According to Masseti [30] it is commonly assumed that elephants reached the Mediterranean islands from the mainland by temporary land-bridges that originated as a result of the lowering of the sea level during the Ice Age. For instance, they inhabited the western Mediterranean islands (Malta, Sicily and Sardinia) and the eastern Mediterranean islands (Cyprus, Crete and several Aegean islands) during the Quaternary period. They colonized Mediterranean islands through temporary land bridges except Cyprus which was

colonized without land bridge. Thus, the only way that elephants could arrive on this island was by swimming across the sea. The distance from the mainland mass and the small depth of ocean favours active swimming of Proboscidean into islands. The depth of sea decreased during glacial period and allows movement of elephants to islands. *Mammoth* reached Crete island due to the lowering of sea level in the Early Pleistocene. Proboscidean also colonize island by the aid of humans to cross the water body [31]. Today about 1,500 genetically distinct populations of elephants live in the northeast corner of Borneo, a Southeast Asian island shared by Indonesia, Malaysia and Brunei. The Bornean elephant (*E. m. borneensis*) has recently been confirmed as a separate taxon. They are also called pygmy elephants because of their dwarf nature [31]. They are the world's most endangered member of Proboscidae. The origin of the Bornean elephant remains unclear. But they might have been colonized during Pleistocene when the sea level was much lower than it is today or introduced by man more recently from Java island where elephants occurred until 1850. Currently, pygmy elephants are threatened by habitat fragmentation and increasing conflicts with humans. The island has made elephants to become dwarf [31]. The island distance to the mainland, its food resources, intraspecific and interspecific competition are the main factors that impacted island elephants to become dwarf. In addition, it was assumed that there is an evolved gene that encodes environmental stress to reduce body size. Several Mediterranean islands have shown such dwarf Proboscidean. Fossil remains of dwarf elephants have been found on the Mediterranean islands [32].

Extinct Proboscidean: Most of the Proboscidean evolved in this world have gone to extinction. Specially, the Late Pleistocene extinction of Proboscidean was part of the global mega-fauna extinction that is often attributed to overkill by hunters and climate change at the end of the last glacial age [33, 34]. It is believed that the probability of large mammal extinction increases exponentially with reduction in geographic range. In addition, the size of mammalian home range is a direct function of its body size. As large ungulate, Proboscidean would have required large geographic ranges. However, the geographic range of Proboscidean during the late Quaternary was very less compared to the extant species [20]. This and other factors have resulted in the extinction of Proboscidean in most parts of the continents. Habitat destruction, climate and environmental change were other contributing factors for the extinction of Proboscidean. The possible explanation for their disappearance may be attributed to the inability of the order to evolve quickly to environmental changes. This is because, the more they have specialized a particular habitat, the more likely they will become extinct in periods of dramatic climate and environmental changes [25]. During the Early and Middle Miocene, Proboscidean diverged into two based on their feeding specialization, as browsers and grazers. Feeding specialization in Proboscidean resulted in nutritional stress when some plants disappeared during Pliocene and Pleistocene due to environmental changes. In addition, the synergetic effect of severe climate change and habitat loss leads Proboscideans to further extinction. The extinction of Proboscidean is generally correlated with the disappearance of certain Pleistocene habitat types such as open boreal forest, parkland and savanna [35] and interspecific competition, specialization and long generation time [6]. Humans have destructed habitats by land clearing and the use of fire was the causes for Holocene extinction on islands [36].

Current threats to Proboscidean: There are several threatening factors that affect the survival of extant Proboscidean. These include: disease, demographic factors, habitat loss and fragmentation, institutional weakness in enforcement of laws, poaching and ivory trade. Poaching elephants is increasing due to the high demand of ivory. Poor economic development in developing countries is the driving factor of poaching elephant for meat and ivory. As opposed to the African elephant, only male Asian elephants bear tusks, which have so far helped Asia's elephants avoid the catastrophic poaching rates seen currently in Africa [37]. In addition, elephants are hunted for meat and hides. Particularly, China and Thailand are the two major end use markets of ivory at global level. Even if the current rate of poaching is slowed, habitat loss and fragmentation is continued to threaten the future of elephant populations across African and Asian countries. Habitat disturbance and barriers to movements of elephants in search of water and forage are also critical threats [38]. Elephants are also threatened by rapid human population growth and agricultural expansions which leads to human-elephant conflicts. Weak political structures and conflicts at national and international level can also negatively influence conservation activities of elephants. All these factors not act independently, but intertwined in affecting the survival of elephant populations [7].

Ongoing Conservation Approaches: Elephants are protected in the wild under CITES (Convention on International Trade in Endangered Species). Asian elephants are identified as endangered, whereas as the African once are identified as vulnerable. However, the African Elephant Specialist Group has designed a number of continent-wide, national and regional elephant conservation action plans. The main conservation and management actions underway to sustain elephant species are as follows.

Translocation: Elephant populations are reduced due to habitat destruction and fragmentations, poaching, poor breeding potentials and demographic stochastacity. This may lead them to inbreeding depression. Such populations have no hope of future survival as they have long generation time and low fecundity. When populations are declined due to various factors, they are translocated to other suitable habitats where there are elephant populations below the carrying capacity.

Habitats Conservation: Elephant populations have faced increasing threats from habitat loss and conflict with humans. Protecting habitats for elephants is critical to the survival of the species. Today, only a fraction of their historic ranges remains protected [7]. Protected habitats should provide sufficient space for the movement of elephants because they need large home range. In protected elephant ranges, priority is given to the requirements of elephants, but compatible human activities such as sustainable timber harvesting, livestock grazing and controlled logging allowed. For instance, controlled logging is very important since regrowth and secondary vegetation is an excellent source of food for elephants [39]. There are three major habitat attributes that have to be considered for the conservation of elephant populations. These are habitat size, integrity and quality of habitats. The minimum viable habitat size is related to the minimum viable population and the carrying capacity of the habitat. Large habitat size is used to conserve elephants based up on their minimum viable population size [40]. The population size of elephants should not exceed the carrying capacity of the habitat. Maintaining the integrity of the overall landscape for an elephant population should be the most important consideration for long-term conservation. Large and adjacent landscapes would ensure seasonal or temporal movement for habitat utilization. Even if the size of a population is reduced, a large landscape would facilitate rapid recovery when favorable conditions return. When habitats are threatened with fragmentation, a system of corridors is one practical way to ensure connectivity for elephant movement. Though it is difficult to generalize the quality of habitats required by elephants, secondary forests and surface water free of pollution are recommended for conservation. All these have to be considered into planning to make elephant conservation compatible with biodiversity conservation.

Mitigation of Human-elephant Conflicts: Human-elephant conflict is one factor that threatens elephants in human dominated range of elephants. Elephant movement can be controlled by using barriers. Reserves should be designed for elephants so that the stimulus to move elsewhere is minimized. However, human-elephant conflict cannot be totally eliminated. Hence, the goal of management should thus be to control and minimize conflict [7]. This can be done by preventing elephants from entering settlements, crop fields and elephant population management. Ditches and electric fences are the two commonly used barriers to keep elephants away from agricultural land. Trenches have been relatively ineffective in higher rainfall areas because it might be destroyed by rapid soil erosion. The high-voltage electrified fence is the most widely used barrier in the two continents. The electric fence makes a strong shock and frightens elephants, but does not cause death or damage [40].

Regulations and Management of Populations: Management of large population through culling has been the issue of debate in managing elephants. The decline of poaching and better protection of elephants in some countries revives the debate over culling. In areas of high elephant density, many tree species are damaged at rates that exceeded their regenerating capacities thereby converting woodlands into grasslands [24]. Thus, landscapes are changed in many parts of elephant ranges, threatening the future existence of these ecosystems. Thus, management through culling of elephants would help maintain a high rate of animal productivity and ensure the persistence of other biological elements in the landscape [24, 41]. To the contrary, the counter arguments to culling elephants have been equally strong. Ethical arguments reinforced the anti-culling attitude. Killing a highly intelligent, sensitive and social animal and in such large numbers, was morally disgusting. Elephants that were targeted during culls seemed to transmit the distress of the event to other elephants in the area before being killed. The opponents proposed other methods of

management such as birth control, abortion of fetus and vaccination against fertilization which further created problems on elephants. Hence, large populations of elephant can be controlled by human through habitat managements such as creating artificial waterholes and corridors.

Control of Poaching and Illegal Trade in Ivory: Poaching for ivory and other products has posed a major threat to the survival of elephants. Poaching can be controlled both through law enforcement and regulation of trade on their products. For the existing laws to conserve wildlife in general and elephants in particular, need to be fully enforced. Enforcing laws for conservation of elephant is valuable because it simultaneously protects the habitats of vast ranges of species sympatric with elephants.

Establishment of Corridors: Where the establishment of large protected areas is impossible for elephant conservation, forest corridors are maintained to facilitate migration between forest patches. Land use planning also considers the establishment of migration routes. Maintenance of migration corridors minimizes conflict between elephants and people. In addition, it prevents the isolation of herds of elephants

Implication for Future Conservation of Elephant Species: A vast array of researches had been conducted on the origin, taxonomy, ecology, reproduction and behavioural activities of the extinct and extant species of the order Proboscidea. Many legislative, regulatory and institutional policies had been designed by governmental and non-governmental organizations to conserve elephant species across the globe. Moreover, huge amounts of money have been assigned yearly for research, conservation and management of elephant species across the globe. However, the outcomes of most of these funds remains a paper work. In the future, much efforts than before should be invested to ensure the sustainable conservation and management of elephant species because threatening factors for the species are getting worse than ever. The main threats for the survival of elephant species are poaching and ivory trade, habitat loss and fragmentation, human-elephant conflicts, demographic factors and other anthropogenic factors. These all factors synergistically interact with the slow generation rate of elephants and made conservation and recovery of elephant population highly problematic. In order to curb these scenarios and secure the future conservation and management of elephant species, the following actions need to be ensured and realized beyond the paper work. These include the development and strengthening of harmonized legislative, regulatory and institutional frame work, ban poaching and trade of elephant products on the market, improve technical capacity in conservation and management, improve law enforcement and human-elephant conflict mitigation strategies, improve knowledge of elephant population and their habitats, improve connectivity between fragmented populations, elephant population and their habitats should be continuously monitored so as to design effective conservation and management measures. Many elephant ranges are assumed to lie outside protected areas. Hence, the existing elephant habitat should be managed, rehabilitated and or more protected parks and reserves should be established. Human-elephant conflict is also a crucial issue that needs special attention in order to strengthen community support for the conservation and management of this relic and magnificent animal. The conservation status and threatening factors for both African and Asian elephants vary across different countries. Therefore, different conservation and management strategies should be seriously implemented to the ground level, as per the problems identified, in different countries and or continents. However, if the current scenarios of elephant conservation crisis are continued, it would not be long to hear news about the extinction of elephant species for good.

REFERENCES

1. Shoshani, J., 2002. Proboscidea (Elephants). Encyclopedia of life sciences. John Wiley and Sons, Ltd. www.els.net, pp: 1-16.
2. Kingdon, J., 1997. The Kingdon Field Guide to African Mammals. Academic Press, pp: 464.
3. Shoshani, J. and P. Tassy, 1996. Summary, conclusions and a glimpse into the future. In: The Proboscidea: Evolution and Palaeoecology of Elephants and their Relatives (Eds. J. Shoshani and P. Tassy), pp: 335-348.
4. Todd, N.E., 2006. Trends in proboscidean diversity in the African Cenozoic. Journal of Mammalian Evolution, 13: 1-10.
5. Eggert, L., C.A. Rasner and D.S. Woodruff, 2002. Evaluation and phylogeography of the African elephants inferred from mitochondria DNA sequence and microsatellites markers. Proceedings of the royal society of London, pp: 269.

6. Shoshani, J. and J.F. Eisenberg, 1982. Elephas maximus. Mammalian species. 182: 1-8.
7. Sukumar, R., 2003. The living elephants: Evolutionary ecology, behavior and conservation. Oxford University Press, pp: 478.
8. Kortlandt, A., 1984. Vegetation research and the "bulldozer" herbivores of tropical Africa. In: Tropical rain-forest: The leeds symposium, (Eds. Chadwick, A. C. and S. L., Sutton) pp: 205-226.
9. Perera, B.M., 2009. The Human-Elephant Conflict: A Review of Current Status and Mitigation Methods. Gajaha, 30: 41-52.
10. Gheerbrant, E., 2009. Paleocene emergence of elephant relatives and the rapid radiation of African ungulates. Proceedings of the National Academy of Sciences of the United States of America, 106: 10717-10721.
11. Maglio, V.J., 1973. Origin and evolution of the elephantidae. Transactions of the American Philosophical Society, New Series, 63: 1-149.
12. Prado, J.L. and M.T. Alberdi, 2008. A cladistics analysis among trilophodont gomphotheres (Mammalia, Proboscidea) with special attention to the South American genera. Palaeontology, 51: 903-915.
13. Sanchez-Chillon, B., J.L. Prado and M.T. Alberdi, 2004. Feeding ecology, dispersal and extinction of South American Pleistocene gomphotheres (Gomphotheriidae, Proboscidea). Paleobiology, 30: 146-161.
14. Tassy, P., 1996. The earliest gomphotheres. In: The Proboscidea: Evolution and palaeoecology of elephants and their relatives (Eds. Shoshani J. and P. Tassy), pp: 89-91.
15. Madden, C.T. and J.A. van Couvering, 1976. The Proboscidean datum event: Early Miocene migration from Africa. Geological Society of America, abstracts with programs.
16. Shoshani, J. and P. Tassy, 2013. Order Proboscidea-Elephants. In: Mammals of Africa, (EdS. Kingdon J., D. Happold, T. Butynski, M. Hoffmann, J. Happold Kalina), pp: 173-176.
17. Haq, B.U., J. Hardenbol and P.R. Vail, 1987. Chronology of Fluctuating Sea Levels Since the Triassic. Science, 235: 1156-1166.
18. Coryndo, S.C. and R.J.G. Savage, 1992. The origin and affinity of African mammal's faunas. Special paper in Paleontology, 12: 121-135.
19. Van derMade, J. and A.V. Mazo, 2003. Proboscidean dispersals from Africa towards Western Europe. In: Advances in Mammoth Research (Proceedings of the Second International Mammoth Conference, pp. 437-452, (Eds., Reumer, J. W., F. J., DeVos and Mol, D. Rotterdam.
20. Pickford, M. and J. Morales, 1994. Biostratigraphy and palaeobiogeography of East Africa and the Iberian Peninsula-Palaeogeography, Paleoclimatology. Palaeoecology, 112: 297-322.
21. Shoshani, J., 1998. Understanding Proboscidean evolution: a formidable task. TREE, 13: 480-487.
22. Prothero, D.R., E.B. Davis and S.S.B. Hopkins, 2008. Magnetic stratigraphy of the Massacre Lake Beds (late Hemingfordian, Miocene), northwest Nevada and the age of the "Proboscidean datum" in North America. New Mexico Museum of Natural History and Science Bulletin, 44: 239-246.
23. Lucas, S.G. and G.E. Alvarado, 2010. Fossil Proboscidea from the upper Cenozoic of Central America: taxonomy, evolutionary and Paleobiogeographic significance. Revista Geológica de América Central, 42: 9-42.
24. Wylie, D., 2008. Elephant. Reaction Books Ltd, China, pp: 208.
25. Hynaes, J., 1999. Mammoth, Mastodont and Elephants: Biology, behaviour and Fossil records. Cambridge University Press, pp: 413.
26. https://seethewild.org/elephant-threats/)
27. Brown, J.H. and M.B. Lomolino, 1998. Biogeography, 2n ed. Sinauer Associate Inc. USA, pp: 691.
28. Koch, P.L., K.A. Hoppe and S.D. Webb, 1998. The isotopic ecology of late Pleistocene mammals in North America, Part 1, Florida. Chemical Geology, 152: 119-138.
29. Webb, S.D., J. Dunbar and L. Newsom, 1992. Mastodon digesta from North Florida. Florida Geological Survey Special Publication, 10: 1-59.
30. Masseti, N., 1994. On the Pleistocene occurrence of Elephas (Palaeoloxodon antiquus) in the Tuscan Archipelago, Northern Tyrrhenian Sea (Italy). Hystni, (n.s.), pp: 101-105.
31. Roach, J., 2008. "Extinct" Pygmy Elephants Found Living on Borneo. National Geographic News. Accessed on January, 2015.
32. Prothero, D.R. and P.C. Sereno, 1982. Allometry and Paleoecology of Medial Miocene Dwarf Rhinoceroses from the Texas Gulf Coastal Plain. Paleobiology, 8: 16-30.

33. Surovell, T., N. Waguespack and P.J. Brantingham, 2005. Global archaeological evidence for Proboscidean overkill. Proceedings of the National Academy of Sciences of the United States of America, 102: 6231-6236.
34. Koch, P.L. and A.D. Barnosky, 2006. Late Quaternary extinctions: State of the debate. Annual Review of Ecology, Evolution and Systematics, 37: 215-250.
35. Graham, R.W., 2001. Late Quaternary biogeography and extinction of Proboscideans in North America. The World of Elephants, International Congress. 707-709. Accessed on April, 2015.
36. Burney, D.A., L.P. Burney, L.R. Godfrey, W.L. Jungers and S.M Goodman, 2004. A chronology for late prehistoric Madagascar. Journal of Human Evolution, 47: 25-63.
37. Van Aarde, R.J., T.P. Jackson and S.M. Ferreira, 2006. Conservation science and elephant management in southern Africa. South African Journal of Sciences, 102: 385-388.
38. Unep, Cites, Iucn and Traffic, 2013. Elephants in the dust: The African elephant crisis. A Rapid Response Assessment. United Nations Environment Programme. Birkeland Trykkeri AS, Norway.
39. Fernando, P., P. Leimgruber, T. Prasad and J. Pastorini, 2012. Problem-Elephant Translocation: Translocating the Problem and the Elephant? PLOS ONE, 7: 1-9.
40. IUCN, WCS, WWF and USA Fishery and Wildlife Service's 2005. Central African elephant conservation Strategy, pp: 41.
41. Gillson, L., R.J. Ladle and M.B. Araujo, 1995. Baselines, patterns and process. In: Conservation Biogeography, (Eds., Ladle, R.J. and R.J. Whittaker), pp: 31-44.