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GAJAH is the official journal of the Asian Elephant Specialist Group (AsESG) of the Species Survival Commission (SSC) of the World Conservation Union (IUCN). The journal is intended as a medium for communication by members of the AsESG of important issues that concern the conservation and management of the Asian Elephant (*Elephas maximus*) both in the wild and in captivity. GAJAH welcomes communications and research papers on all aspects of the Asian elephant. GAJAH is aimed at professionals, biologists and academics carrying out research on Asian elephant, government and non-government organizations involved in its conservation, and interested members of the general public. All articles published in GAJAH are deemed to reflect the individual views of the authors and not the official points of view, either of the Asian Elephant Specialist Group (AsESG) or the Species Survival Commission (SSC). GAJAH is a non-profit publication that is supported by financial assistance from the U.S. Fish and Wildlife Service.

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Journal of the Asian Elephant Specialist Group (Number 24, 2006)

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Conservation News

Sri Lanka

Re-introduction of the insurance scheme for mahouts

The Diyawadana Nilame of the Sacred Temple of the Tooth (The Dalada Maligawa, Kandy), Neelanga Dela Bandara plans to re-introduce the insurance scheme for mahouts following an unfortunate incident of a mahout named Mr. M. Piyasena killed by his elephant while he attempted to give it a wash He was 59-year old father of four children. According to an eye witness, the elephant concerned was boisterous for a while forcing Piyasena to use the goad to control it. The elephant became so furious that he took the goad and broke it in two, before turning on the mahout. This was the second incident of elephants in captivity killing their mahouts within two months. In the past two years, more than six mahouts have been killed by enraged elephants in Kandy alone.

Source: The Sunday Times (Sri Lanka) November 6, (2005).

USA

Sanctuary receives Excellence Award

Riddle's Elephant & Wildlife Sanctuary has become the first recipient of the Institution of Excellence Award given by the Elephant Managers Association (EMA), which is a non-profit organization of professional elephant handlers, administrators, veterinarians, researchers and elephant enthusiasts. The award was handed out in the Fall of 2005 during the EMA annual conference hosted by the Portand Zoo in Oregon. The award was granted "for contributions to elephant training, research and care performed with professionalism, integrity and passion". The Sanctuary is operated by an Arkansas non-profit organization dedicated to preserving both Asia and Africa elephants. It offers permanent refuge to any elephant in need. The facility provides training and education in elephant management and conservation and conducts scientific study in the health and physiology of elephants.

Source: Log Cabin Democrat, December 24, (2005).

Workshop on Ultrasound and Veterinary Procedures

The 9th Ultrasound and Veterinary Procedures Workshop for Wildlife Veterinarians was hosted by the Riddle's Elephant & Wildlife Sanctuary in May 2005 at Greenbrier, Arkansas. World renowned elephant veterinarian Dr. Dennis Schmitt, assisted by the sanctuary staff, taught the course. Veterinarians from international elephant facilities (Canada, USA and Sri Lanka) attended the course and shared experiences.

Source: Pachyderm Periodical, 15: 3 (2005).

Elephant program at the Smithsonian Institution's National Zoological Park

Elephants in North American Zoos number approximately less than 275 among 70 or so widely dispersed cities. AZA institutions attract over 150 million visitors, more than all professional sports combined. American Zoos have a unique ability to focus and educate these visitors on the critical conservation issues of this century. Within North America itself, there is tremendous need to establish breeding bull groups as management strategies to dramatically increase the captive population and improve genetic diversity. Captive elephants are not breeding fast enough to keep up with natural mortality. The Smithsonian Institution National Zoological Park can change all this now and make a critical leadership step. It plans to proceed with an ambitious plan to renovate its present elephant exhibit. The new facility will take up an 8-acre parcel of land at the Zoo, with approximately 3 acres of ground space for a group comprising 8 Asian elephants. In addition, the Zoo plans to expand its capability to conduct Asian elephant research and propagation by eventually developing a facility at its Front Royal campus – a 3,200 acre parcel of land that constitutes the Zoo's Conservation & Research Center.

Source: Smithsonian Institution National Zoological Park (2006).

Cambodia

Community participation in elephant conservation in Cambodia

As wild elephant habitat is eroded by the spread of cultivation and over exploitation of forest resources, wild elephants resort to feeding on crops. In this context, the resolution of human-elephant conflict to prevent death or injury on both sides, is no less important than the conservation of elephant habitat. A recent survey of Cambodian rural communities indicates that the work of Fauna & Flora International (FFI)'s Human-Elephant Conflict (HEC) teams is already changing attitudes to Asian elephants. Community leaders interviewed by Tuy Sureivathana, one of FFI's local counterparts in Cambodia's Ministry of Environment, revealed that villagers no longer retaliate against elephants that raid their crops or damage their property. FFI team has been instrumental in dissuading people from using spring traps and even poison against the elephants. The mitigation of the HEC is a vital element of FFI's Asian Elephant Conservation Programme, which also works to prevent poaching, protect habitats and gather crucial scientific data.

Source: FFI Update 2 (2005).

Kenya

Elephant translocation

The elephant population in the Tsavo National Park in the 1960s numbered 40,000. However, poaching for ivory has since reduced the numbers to less than 7,000. In August 2005, the Kenya Wildlife Service (KWS) began rounding up 400 of the 700 elephants in Shimba Hills and moving them to Tsavo East, a much bigger park in southern Kenya with the hope of repopulating the national park. Family groups were selected for translocation by marksmen in helicopters who fired tranquilizer darts at their targets, before loading the elephants into a giant steel crate for the 300 km journey. KWS hopes to track the relocated elephants using GPS collars, fitted to the matriarchs who led each family. The operation will cost the KWS about $ 3 million, and is welcomed by the villagers near Shimba Hills who complain that elephants regularly stray from the park and raid their crops. A previous attempt in 1996 to translocate about 30 bull elephants from Shimba Hills to parkland about 65 km away resulted in the animals becoming disoriented and trekking back towards the coast, eventually reaching another forest reserve further north. Conservationists are divided in their views about such massive translocations of elephants. Daphne Sheldrick who runs the David Sheldrick Wildlife Trust feels that the money could be better spent in erecting a proper barrier fence. Besides, moving elephants from such lush habitats in Shimba Hills to the dry area of Tsavo East national park, may be harmful. But KWS is of the view that unless the overcrowding is eased, elephants will continue to break down barriers.

Source: Jeevan Vasagar in Guardian Weekly, September 2-8, (2005).

South Africa, Mozambique & Zimbabwe

World's biggest Transfrontier Park

An initiative of the Peace Parks Foundation (PPF), the proposed Great Limpopo Transfrontier Park will be the world's biggest animal kingdom covering an area equivalent to half of Scotland and crossing the borders of South Africa, Mozambique and Zimbabwe. These countries are merging three game reserves, thereby creating a 35,000 sq. km conservation area that will expand eventually to cover 100,000 sq. km. The project has been praised as an example of regional cooperation and sustainable development, raising foreign investment and creating much-needed jobs. But some people are not happy. In Mozambique, people from Salani village fear that they will no longer be the hunters but the hunted. Some villagers complain that animal rights have taken precedence over human rights, while others are waiting to see what happens.

Source: Kristy Siegfried in Guardian Weekly, Oct. 28-Nov.3, (2005).

Malaysia

Asian Elephant Range States Meeting

The Meeting of the Asian Elephant Range States was held on January 24-26, 2006 in Malaysia. The meeting commenced with an inaugural session, where Dr. Holly Dublin - the Chair of IUCN Species Survival Commission delivered the key note address, followed by addresses made by the Director General of the Department of Wildlife and National Parks, Malaysia (Perhilitan), and the Parliamentary Secretary of the Ministry of Natural Resources and Environment (NRE). Dr. Dublin highlighted the importance of this meeting, considering the participation of all 13 range states of the Asian Elephant at this occasion to discuss conservation issues relating to the Asian Elephant. The DG of Perhilitan highlighted several issues related to the conservation of Asian Elephants, and stressed the need for dialogue and collaboration between range states. Subsequent to the inaugural session, Dr. Dublin gave a general introduction to the meeting, stressing that the objective was to initiate a dialogue among range states to discuss issues and experiences, and develop consensus towards achieving long-term conservation of Asian Elephants. Dr. Meenakshi Nagendran from the US Fish and Wildlife Service (USFWS) Asian Elephant Conservation Fund highlighted the participation of all 13 range states at this meeting as a great achievement and stated that this was a good opportunity for the range states to discuss the whole range of issues related to the conservation of Asian Elephants, and she indicated that the USFWS would be able to help implement some of the follow-up actions suggested at this meeting through their grant programme.

The key issues highlighted were (a) population management, such as addressing cross border problems, is hindered by information gaps on distribution and population status; (b) lack of standardized methods for population survey and monitoring leading to a lack of good quality data about population distribution and status; and (c) dangers of designing conservation strategies based on guesses about population sizes and trends (efficient allocation of resources for conservation of Asian elephants requires much better data). The recommendations included the need to establish a standardized database on the status and distribution of the Asian Elephant; and the update of existing information through well-designed field surveys using modern peer-reviewed techniques.

Source: AsESG Co-Chairs (2006).

Comment

In a recent issue of the journal *Nature* (438: 1097-1098; December 22-29, 2005), David R. Greenwood, Dan Comeskey, Martin B. Hunt & L. Elizabeth L. Rasmussen have published a paper that deals with the impact of the pheromones associated with the phenomenon of musth on reproductive behaviour of Asian elephants. The word 'musth' means 'intoxicated' in Urdu, and the phenomenon has been known to elephant handlers and keepers for many centuries in India and Sri Lanka. But it is only now, thanks to the studies of Dr. Bets Rasmussen and her colleagues (both in the USA and New Zealand) we seem to understand the role played by the pheromones involved in musth. During musth, Asian bull elephants go through a heightened period of sexual and aggressive activity. The hormone testosterone controls such sexual and aggressive behaviour in bull elephants. In Africa, a musth bull walks with an assertive, purposeful stride and holds the head higher than the shoulders most of the time (Poole, 1987). Kahl & Armstrong (2002) refer to such musth walk as the "John Wayne walk" 'because of its self-confident, take-charge swagger'.

Musth is exhibited only by mature males, usually over 24 years of age (Poole, 1987) and the behaviour of the bulls in musth is the same in both Asian and African elephants (Kahl & Armstrong, 2002). Musth in Asian elephants is an annual phenomenon, and its duration varies from individual to individual depending on age, physical condition and social status. It may last from a few weeks to even months. In captive situation, bulls in musth are always separated from conspecifics and cared for until the musth period is over. When elephants get out of musth, they tend to become more social, amicable and manageable. Although non-musth bull elephants can mate successfully, musth improves the competitive ability of the bulls in their efforts to have access to estrus females. In Asia, older bulls in musth seem to have a significant reproductive advantage over younger bulls. In the captive elephant facility known as the Elephant Orphanage at Pinnawala, Sri Lanka, almost all the young ones that were born were sired by just a few old bulls.

During musth, Asian bull elephants secrete a powerful, pungent smelling fluid from the temporal glands situated on the face. A previous study carried out by Rasmussen *et al.* (2002) on musth in Asian elephants has shown that young socially immature bulls release honey-like odours to avoid conflict with mature bulls, while older bulls in musth broadcast foul-smelling odours to deter young bulls. This was a significant finding that confirmed what the ancient Hindu poetry refers to the phenomenon of bees being attracted by the secretions of the temporal glands in young musth elephants.

As Greenwood *et al.* (2005) point out, musth among Asian elephants is mediated by the release of a pheromone called frontalin, which exists in two chiral forms or molecular mirror images or enantiomers. They are referred to as + and – enantiomers. The researchers have found that these enantiomers of frontalin are released in specific ratio that depends on the animal's state of musth and age. Depending on the ratio of the enantiomers released, other bulls and cows in a population may react and respond in different manners.

Asian bull elephants reach sexual maturity when they are between 12-15 years old, but until they become socially mature, they have very little reproductive success in the wild. Social maturity may take another 5-8 years. The study also shows that frontalin is released in young bulls in late teens and the secretion increases 15-fold in 25 year age span – the time when the bulls become socially mature. As young bulls become sexually mature, they secrete more of the + variety of frontalin than the – variety but as they become socially mature, the proportions of the two enantiomers become equal (1:1 ratio). It is this ratio that enables other elephants (both bulls and cows) to distinguish both the maturity of the bull concerned as well as its phase of musth and respond appropriately.

Other studies have shown that the length of musth increases as bull elephants mature, with the fittest demonstrating a long mid-phase. The Greenwood *et al.* (2005), studies demonstrated that during mid-musth these older males release 'an optimal ratio of frontalin enantiomers'. Estrous females respond positively to such mid-phase release of pheromones, especially during the time of ovulation, and the musth bulls concerned are therefore able to send a precise message to females in estrus, perhaps helping their reproductive success over other less mature bulls. Since female elephants are in estrus only for about 4 days every 4-5 years in the wild, it is important that bulls find them and mate with them. As Kahl & Armstrong point out, musth helps a mature bull in finding and impregnating a receptive female.

The findings of Greenwood *et al.* (2005) and Rasmussen *et al.* (2002) have important relevance in the dealing with crop-raiding wild elephants in Asia where most of them are bulls and quite a number of them are in musth. An understanding of musth and behaviour of musth bulls would help formulate more effective deterrent measures to mitigate the perennial human-elephant conflict in Asia.

While the misfortunes of the African elephant are due to its tusks for which it is being slaughtered in large numbers irrespective of sex, in Asia given that females do not have tusks and not all males carry them either, elephant poaching may be a minor problem and so poaching cannot be the terminal threat it is in Africa. Nevertheless,

elephants in Asia are being killed as they interfere with agriculture. The long-term future of elephants, outside the protected areas in Asia is inextricably linked to the tolerance of man.

The human-elephant conflict in Sri Lanka is real, and it is leading in just one direction: the destruction and eventual elimination of elephants, males in particular, from agricultural areas, unless innovative measures are adopted to address the legitimate concerns of the farmers. The management of human-elephant conflict has to be integrated into a proper land-use policy and also must recognize the elephant as an economic asset to the community. Unless people value living with elephants, the slaughter will go on. If the local people could perceive the elephant as an economic asset instead of as an agricultural pest, they will tolerate it on their land. One way that local people can benefit from the elephant in their midst is from revenues it generates, whether through small-scale ecotourism or from projects that help manufacture paper from dung, produce biogas from dung, or promote organic farming using dung.

The human-elephant conflict has replaced poaching as the biggest threat to the elephant in Asia. While the international conservation organizations are concerned over the trade in ivory, non-tuskers or *makhnas* continue to be slaughtered in large numbers. The debate over elephants is an emotional one, between the preservationists and the pragmatists. The problem with wildlife is that the people who wish to preserve it, are rarely those who have to bear the cost. Given that the human-elephant conflict is already bad today, it may become worse tomorrow. Even if we cannot eliminate the conflict altogether, we need to reduce it to tolerable levels. This is the biggest challenge facing the AsESG.

Charles Santiapillai

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Photo: Dr. H. I. E. Katugaha

Genetic assessment of Borneo elephants: origin and conservation implications

Prithiviraj Fernando, John Payne, Geoffrey Davison, Raymond J. Alfred, Michael Stuewe and Don J. Melnick.

Abstract The origin of elephants on Borneo has been controversial, with competing suggestions that they were introduced by humans, or indigenous to the island. Genetic analysis of Borneo elephants and comparison to other Asian elephant populations across their range has shown that they are genetically unique and divergent from all other populations (Fernando *et al.*, 2003). The genetic uniqueness of Borneo elephants suggests that elephants colonized Borneo in the Pleistocene and that they have had an independent evolutionary trajectory since then. Here we discuss the possible factors limiting the distribution of the species in Borneo, and the conservation implications of their newly discovered genetic status.

Introduction

The origin of elephants (*Elephas maximus*) in Borneo is controversial. While some authors have suggested elephants were not indigenous to Borneo but introduced by humans (Shoshani & Eisenberg, 1982), others (Deraniyagala, 1950; 1955) have postulated a natural origin. With a land area of approximately 745,000 km^2, Borneo is the third largest island in the world. Sabah, a state in the federation of Malaysia, occupies the north-eastern tip of Borneo, while contiguous and to the south is the Indonesian province of East Kalimantan (Fig. 1). Elephants are restricted to north-east Borneo (eastern Sabah and the northern part of East Kalimantan) within an area approximately 5% of the island. The north-east, south-west orientation of the longitudinal axis of Borneo, makes this area the farthest part of the island from the closest free ranging elephant populations outside of Borneo, in Sumatra and Peninsular Malaysia (Fig. 1).

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The earliest detailed description of Borneo by a visitor to the island is that of Antonio Pigafetta, the Italian chronicler of Magellan's Spanish fleet, which sailed into Brunei on the north-west coast of Borneo, in 1521. Pigafetta's group was taken to visit the sultan of Brunei on two tame elephants (Harrisson & Harrisson, 1971). There have been no subsequent reports of elephants in Brunei or western Borneo. The next published record of elephants in Borneo is that of Dalrymple, who reported in 1767 that "the eastern part of Unsang abounds with wild elephants". Tanjung Unsang, presumably the Unsang mentioned by Dalrymple, is near the eastern-most tip of Sabah. In 1811 Hunt reported that wild elephants occurred at Kenibatangan (= Kinabatangan), Unsang and Sabahan, and that ivory was traded from Kinabatangan. The reports of Dalrymple (1767) and Hunt (1811) suggest the presence of a large free ranging elephant population in northeastern Borneo in mid 18th century. Ivory from Borneo is reported to have been imported into China in the middle ages (Laufer, 1925). The massive expeditions of Admiral Cheng Ho, which sailed from southern China to South-east Asia in 1405, may have visited the southern Philippines and possibly Kinabatangan (Harrisson & Harrisson, 1971) but did not leave a written record concerning elephants or ivory.

Were elephants introduced?

There are two factors that suggest elephants may not be indigenous to Borneo. Firstly, it is the common belief, of uncertain but long-standing origin, among people who live or work within the Borneo elephant range (J. Payne pers. obs.). Secondly, it seemingly offers a parsimonious explanation for the limited and unusual distribution of the species in Borneo.

Many authors have commented on the possible

anthropogenic origin of elephants in Borneo. Among them, Silva (1968) mentions "...the popular presumption that they are the progeny of elephants given to the Sulu Sultan by the East India Company in 1750..." but provides no reference. Harrisson & Harrisson (1971) summarize: [among] "...the many and conflicting statements we have heard on the subject at various places in Sabah... [during the 1950s-1960s]... a long time ago the Sultan of Sulu, who had previously received some elephants as a gift, decided to move them from his small island and place them on the Borneo coast. The purpose of this act was that these elephants were his representatives in a territory which he claimed to control..." These animals presumably originated from India, as the operations of the East India Trading Company were mostly in India, and it was a center of elephant commerce. Medway (1977) quotes earlier authors (Müller, 1839-1840; Everett, 1893; Banks, 1931) who made similar but unsubstantiated assumptions. Hunt (1811) reported the presence of elephants on Sulu island (southern Philippines), where he spent six months, and he states that these elephants were imported from Banjarmasin (in Borneo) by Banjar settlers. There is also evidence that a flourishing regional trade in elephants existed, with large numbers caught and exported from Sumatra in and before the 16th century (Marsden, 1811) and from the west coast of Peninsular Malaysia in and before the 18th century (Andaya, 1977).

A 'natural' origin?

In antiquity, Borneo formed part of a single land mass referred to as Sundaland, which also included peninsular Malaysia and the islands of Java, Sumatra and many smaller islands of the western Indo-Malayan archipelago (Holloway & Hall, 1998). Sea level fluctuation during Pleistocene glaciations periodically disconnected and reconnected the Sunda islands through submersion and emergence of low lying parts of the Sunda shelf (Holloway & Hall, 1998; MacKinnon *et al.*, 1996). A savannah corridor which allowed faunal and floral migrations from the mainland to the Sunda islands, is thought to have existed between southeast Asia and Borneo during the highly seasonal climates of the late Tertiary and mid-Pleistocene (MacKinnon *et al.*, 1996). Therefore, it is possible that Borneo was colonized by elephants, through land connections with the mainland and other Sunda islands, and that the current population is descended from those early founders.

There have been a few subfossil or fossil remains in Borneo indicative of a pre-historic elephant population. Ribs and a femur of an animal assumed to be *E. maximus*, now in Lambung Mangkurat Museum, Banjarbaru, were dug up in 1987 from a swamp near Banjarmasin, South Kalimantan. They have not been dated but appear to be relatively recent and not fossilized. A portion of a right upper first molar of *E. maximus*, said to have come from a cave in Belait District, Brunei is believed "more likely to be Pleistocene than Holocene" (Hooijer, 1972). Other fossils found in Borneo and reported to be of "elephants" are either extinct genera (*Stegolophodon* and *Palaeoloxodon* teeth of uncertain origin) or tapir (Cranbrook, 2000; Cranbrook *et al.*, 2000). The paucity of *E. maximus* fossils in Borneo is in contrast to the presence of Holocene (< 11, 000 years) fossils (at Niah, Sarawak and Madai, Sabah) of the Malayan tapir (*Tapirus indicus*) and Javan rhinoceros (*Rhinoceros sondaicus*), both of which are now extinct in Borneo. Holocene *E. maximus* teeth have been found in caves in Sumatra (Medway, 1977) and late Pleistocene and Holocene fossils of *E. maximus* in Java (Van den Bergh *et al.*, 1996), suggesting a late Pleistocene colonization of the Greater Sunda islands by *E. maximus*. However, *E. maximus* fossil and subfossil material is rare over much of its range (Maglio, 1973) and the scarcity of such remains in Borneo may be due to chance (Medway, 1977) or may reflect the paucity of zoo-archaeological studies.

Elephant distribution and numbers in Borneo

The earliest records from which distribution data can be gleaned, date back to the late 19th century (St. John, 1863; Pryer, 1881; Jentink, 1884; Anon, 1886; miscellaneous reports in the British North Borneo Herald during the late 19th to early 20th century). The elephant distribution at that time appears to have been similar to that in 1980 with the exception of the Sandakan Peninsula and extreme south-east Sabah, where plantations excluded elephants during 1955-1980 (Davies & Payne, 1982). Thus, apart from the reduction in species range over the past 20 years due to forest loss in Sabah, the distribution of elephants in Borneo appears to have been rather stable as far back as their distribution can be inferred from historical records.

In 1949, the Conservator of Forests, British North Borneo (H. Keith, quoted in de Silva, 1968) estimated the Sabah elephant population size at 2000 animals. His successor, G. S. Brown commented that Keith considered " the actual number may be only half as much or perhaps twice as many" (Deraniyagala, 1955). Contemporary estimates by foresters and planters ranged from 500 to 5000 (Banks, 1949). Davies & Payne (1982) provided an estimate of between 500 (based on known groups in accessible areas) and 2000 (based on known species distribution and likely average population density). Currently, it is estimated that between 1100 – 1600 wild elephants live in Sabah (Asian Rhino & Elephant Action Strategy (AREAS) project, unpublished data), while a much smaller number occur in the northern part of East Kalimantan, contiguous with the Sabah population.

Possible source populations

Transporting elephants by sailing ship across oceans a few hundred years ago would necessitate their boarding, disembarkation and restraint on board, hence a well trained animal. It would also require the transport of large quantities of food and fresh water. Given the logistic difficulties, geographic proximity makes Sumatra

or Peninsular Malaysia the most likely source of animals introduced to Borneo. However, as commonly believed, if they did originate from animals gifted to the Sultan of Sulu by the East India Company, the source population could also be India. Comparison of the Borneo population to the three putative source populations Sumatra, Peninsular Malaysia and India and in addition, to those of Laos, Cambodia, Thailand, Bangladesh, Bhutan, and Sri Lanka in both mitochondrial and nuclear DNA analysis and additionally Vietnam in the mitochondrial analysis, found it to be unique and not closely related to any of these populations (Fernando *et al.*, 2003). Thus, both mitochondrial and nuclear data suggest elephants are indigenous to Borneo and not introduced by humans (Fernando *et al.*, 2003). In the case of mitochondrial DNA, the evidence supporting a 'natural' origin of Borneo elephants was three fold; the uniqueness of the Borneo haplotype, the degree of divergence from other Asian elephant haplotypes, and congruence with the patterns of distribution and relatedness of other Sunda haplotypes.

Although the mitochondrial genome in general accumulates point mutations much more rapidly than the nuclear genome, and the d-loop of the mitochondrial genome faster than other mitochondrial regions, the rate of evolution of the Asian elephant d-loop is only about 3.5% per million years (Fleisher *et al.*, 2001). The earliest time elephants could have been introduced to Borneo by humans is only a few hundred years ago, which would approximate zero in a time scale relevant to mitochondrial evolution. Thus, if elephants were introduced to Borneo, a haplotype identical to that found in Borneo would be found in the source population. The study by Fernando *et al.*, (2003) sampled almost all extant Asian elephant populations across their range but did not observe the Borneo haplotype anywhere else. Therefore, Borneo elephants could not have originated from any extant population.

Given that the Borneo hapoltype was unique, the arguments for an anthropogenic origin of the Borneo population are, 1) Introduction from a source population that has since become extinct or 2) Fixation in Borneo of a very rare haplotype not represented in the range-wide sample. Although the current Asian elephant range is highly fragmented, the extant populations are spread out over a larger part of the historic range. The representative sample analyzed from extant populations in Fernando *et al.*, (2003) is likely to have captured a high proportion of the mitochondrial diversity of the species. The capture probability of a haplotype is directly proportional to its frequency in the population and the size of the sample collected. Therefore, common, rather than rare haplotypes have a greater probability of being 'captured', be it capture of individuals for introduction a few hundred years ago, or collection of samples for study today. If elephants were introduced to Borneo, the founder population would have been only a few individuals and the haplotype/s represented would likely have been the common haplotypes in the source population. Given the study sample in Fernando *et al.*, (2003), it is unlikely that either an extinct source population in which the Borneo haplotype was common, or the introduction of a rare haplotype not sampled in other populations, provide sufficient explanation for a unique Bornean haplotype.

Since 1980, one of us (J. Payne) has been informed many times by people working in the timber and plantation industries in eastern Sabah that elephants were introduced for logging, and have run wild. This suggests that elephants in these forests are those that were released or escaped the logging camps, and their descendents. Indeed, several Thai or Burmese elephants were brought to British North Borneo (now Sabah) by the Bombay Burmah Trading Company around 1948 for log hauling in Tingkayu, south-eastern Sabah and they were all later returned to Thailand because feeding elephants in the hill dipterocarp forests was too problematic (Q. Phillipps & R. Ibbotson, pers. coms.). Therefore, the elephants in eastern Sabah could not be descended from the logging elephants and the study by Fernando *et. al.*, (2003) also supports this. However, it illustrates how an incident within living memory may lead to propagation of a theory in contradiction of historical evidence.

Distribution of elephants in Borneo

As far as can be ascertained from published records, the historic distribution of elephants in Borneo appears to have approximated the current distribution. There is no clear evidence to suggest that elephants were more widespread in Borneo during pre-historic times. Thus, unless fresh evidence is found in the form of sub-fossil or fossil material confirming their pre-historic occurrence in other parts of Borneo, it has to be assumed that their current distribution reflects the past. This limited distribution could be due to ecological or biogeographic factors.

1) Ecological factors: Elephants appear to be largely limited to habitat below 600 m in Borneo and areas of intensive use are below 300 m. Until the widespread commercial logging in the hill and mountain ranges of Borneo started about 30 years ago, the preferred elephant food plants (monocotyledons and pioneer dicotyledonous plants; Olivier, 1978) were very sparsely distributed in these high, predominantly steep regions, and were mainly found along the larger river valleys in the lowlands. The scarcity of suitable food resources in the higher reaches could have limited dispersal and determined elephant distribution. Sukumar (1989) proposed that an Asian elephant needs 75-100 g of sodium daily in order to avoid a deficit. Davies & Payne (1982) and Payne (1992) suggested that availability of sodium strongly influenced the distribution of large mammals, especially elephants and rhinoceros, in Sabah. In Borneo, natural mineral sources such as salt-rich springs and "mud volcanoes", the latter being grey-coloured mineral-rich mud which is forced from underground by methane gas, appear to be more common in the lowlands and are used today

by elephants. Deficiency of minerals in the montane flora and the apparent lack of alternative mineral sources could have influenced elephant distribution.

2) Biogeographic factors: If elephant distribution in Borneo was shaped by the effects of climatic and geologic history, Pleistocene land connections, and geographic barriers to dispersal, we would expect them to similarly affect other taxa, leading to concordant distribution patterns of multiple taxa. Indeed, peculiarities in the distribution of both flora and fauna support the recognition of northeast Borneo as a unique biogeographic unit (MacKinnon *et al.*, 1996). The north-western lowlands are considered much richer floristically than the north-east or south (Ashton, 1972; MacKinnon *et al.*, 1996), and an area concordant with known elephant distribution in Borneo is recognized as the east coast Sabah floristic sub-province (Wong, 1998). This area lies east of a rough arc from Mount Kinabalu along the eastern flank of the Crocker Range southeast through the Sook, Pendawan and Maliau basins to the Tanjung Redeb area of northeast Kalimantan. A number of mammals including two endemic squirrels (*Petaurillus hosei* and *P. emiliae*), two rats (*Chiropodomys major* and a newly discovered species at Danum Valley, Sabah), a mongoose (*Herpestes hosei*) (MacKinnon *et al.*, 1996) and 24 species of bats (Payne *et al.*, 1985) are confined to this region. This is also reflected in the avifauna, with a number of species replacements in Sabah by semispecies or allo-species (black-headed pitta *Pitta ussheri* versus garnet pitta *P. granatina*, white-fronted falconet *Microhierax latifrons* versus black-thighed falconet *M. fringillarius*), several species absences in Sabah where a form that is montane in the rest of Borneo occupies both the montane and the lowland niche of the "missing" Sabah lowland form (grey-breasted spiderhunter *Arachnothera affinis*, black-fronted leafbird *Chloropsis flavocincta*), species absence in Sabah without any replacement form (Hose's oriole *Oriolus hosei*), and presence in Sabah without any replacement form elsewhere in Borneo (fulvous-chested flycatcher *Rhinomyias olivacea*). The latter species and two woodpeckers, the speckled piculet *Picumnus innominatus* and greater goldenback *Chrysocolaptes lucidus*, are examples of species that are widespread in South and South-east Asia, yet—like the Asian elephant—are confined in Borneo to Sabah in the north-east. These examples are all described in Smythies (1999). Thus, the distribution of elephants could be a consequence of biogeographic factors.

It is possible that resource availability and biogeographic factors, or both led to the limited elephant distribution in Borneo. However, elephants are extreme generalists and are able to survive in a wide range of habitats. Also, in many parts of Asia, elephant range extends well over 1000 m [upto 3200 m in NE India (AREAS unpublished data)]. Therefore, while resource availability may have had some bearing on the distribution of elephants, there does not appear to be a clear correlation, and data on resource availability is insufficient to make a compelling argument. In the same manner, the referred to biogeographic patterns are based on species distribution, hence afford only very coarse comparisons. Future genetic analysis of other taxa both widespread and limited in distribution to the northeast, and correlation with their ecological affinities and species history on Borneo could better evaluate the relative importance of the two hypotheses. We also encourage detailed morphometric analysis of Borneo elephants, as well as search for sub-fossil and fossil *E. maximus* material in Borneo to further establish the evolutionary history of Asian elephants in Borneo.

Conservation implications

Deraniyagala (1950; 1955) considered the Borneo elephant a distinct subspecies, based on its appearance, the examination of a type skull in the British Museum and a sub-fossil tooth, originally reported to be of an elephant, from a cave in Bau, upper Sarawak, now in the Sarawak Museum. He considered Bornean elephants to be smaller in stature, have straighter more slender tusks and their skull to be shallower dorsally above the rostrum, than Indo-Ceylon (Ceylon = Sri Lanka) elephants (Deraniyagala, 1950; 1955). Subsequent workers have considered them not to be a distinct taxon, but the same as the Indian elephant *E. maximus indicus* (Shoshani & Eisenberg, 1982) or Sumatran elephant *E. maximus sumatrensis* (Medway, 1977), based on the assumption that they originated from stock introduced by humans or that the morphological differences were insufficient to warrant such a distinction.

The difficulty of delineating subspecies has led to the development of subspecific designations that are more definable and relevant to conservation, such as Evolutionarily Significant Units (ESU) and Management Units (MU) (Ryder, 1986; Moritz, 1994), although they too are not without problems (Paetkau, 1999). In the case of the Asian elephant, based on mitochondrial DNA analysis, the Sumatran population has been suggested to represent an ESU (Fleischer *et al.*, 2001). If Borneo elephants were feral descendants of introduced animals, in terms of Asian elephant conservation they would be of lesser importance than as a naturally occurring unique population at the edge of the species range. Conversely, if they were indigenous, they could represent an ESU or MU depending on their level of divergence, and they would need to be managed separately from other Asian elephants especially in *ex-situ* conservation.

Borneo elephants were monophyletic in the mitochondrial phylogenetic analysis and displayed uniqueness in the microsatellite analysis of Fernando *et al.*, (2003). The independent evolutionary trajectory of Borneo elephants from that of other Asian elephants, fulfill the criteria for recognition as a separate ESU (Fernando *et al.*, 2003). Thus, there is good reason to devote continued efforts to maintain wild breeding populations of the Borneo elephant and their *in-situ* conservation should be a priority in Asian elephant conservation plans. In addition, Borneo elephants should

be managed separately in *ex-situ* conservation with the objective of preserving their unique genetic make up and should not be cross bred with animals originating from other Asian elephant populations. Examination of pedigrees of captive bred animals and planned future mating of selected individuals, as well as avoiding further breeding of animals with mixed parentage, would be desirable.

The extent of genetic variability within a population determines its evolutionary potential and its ability to cope with environmental change, disease, and demographic perturbations. Loss of genetic variability can result in lowered individual fitness, impaired adaptability (Frankel & Soule, 1981; Allendorf & Leary, 1986), and inbreeding depression (Ralles *et al.*, 1986; Charlesworth & Charlesworth, 1987). However, some natural populations appear to thrive in spite of greatly reduced genetic variability (Ellegren *et al.*, 1993) and populations that undergo inbreeding for extended periods could purge deleterious recessive genes from their genomes and reduce so-called genetic load (Lande, 1988). Although outbreeding generally has beneficial effects, outbreeding depression can occur through loss of local adaptation or the dissolution of co-adapted gene complexes (Templeton, 1986).

Borneo elephants display a significantly low level of genetic variability (Fernando *et al.* 2003). A lesser degree of genetic diversity loss in African Addo elephants led to recommendations for introduction of elephants from other populations (Whitehouse & Harley, 2001). However, the loss of diversity in Addo elephants was very recent and human induced. Given the evolutionary history of Borneo elephants, we would advocate caution before any such intervention is considered. Studies of overt indicators of inbreeding depression such as congenital deformities, behavioral changes, lowered fertility, sperm deformities and lowered recruitment would be logical next steps, in the conservation and management of this population. A wider study of the genetic variability of the Borneo elephant, with an extensive geographic sample and analysis of additional nuclear markers such as Major Histocompatibility Complex (MHC) loci, which are directly involved with the immune response, would provide greater insights into their genetic viability. Additionally, studies on the ecology, behavior and social organization of Borneo elephants could provide insights into the adaptation and survival of insular populations of large mammals.

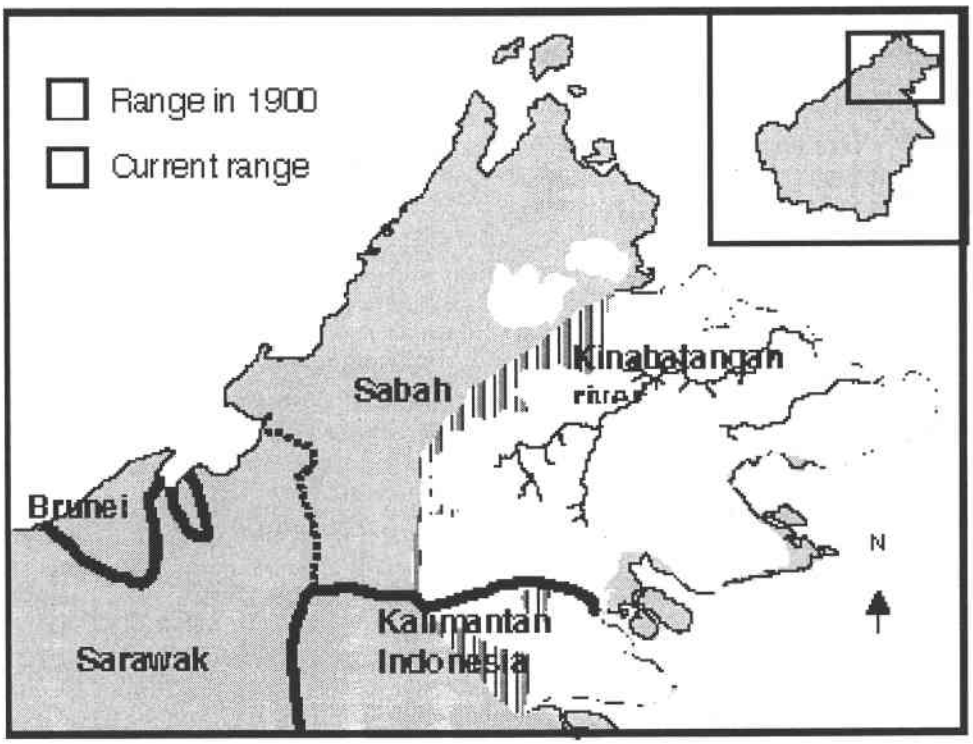

Fig. 1 Map of NE Borneo showing past and present Elephant ranges.

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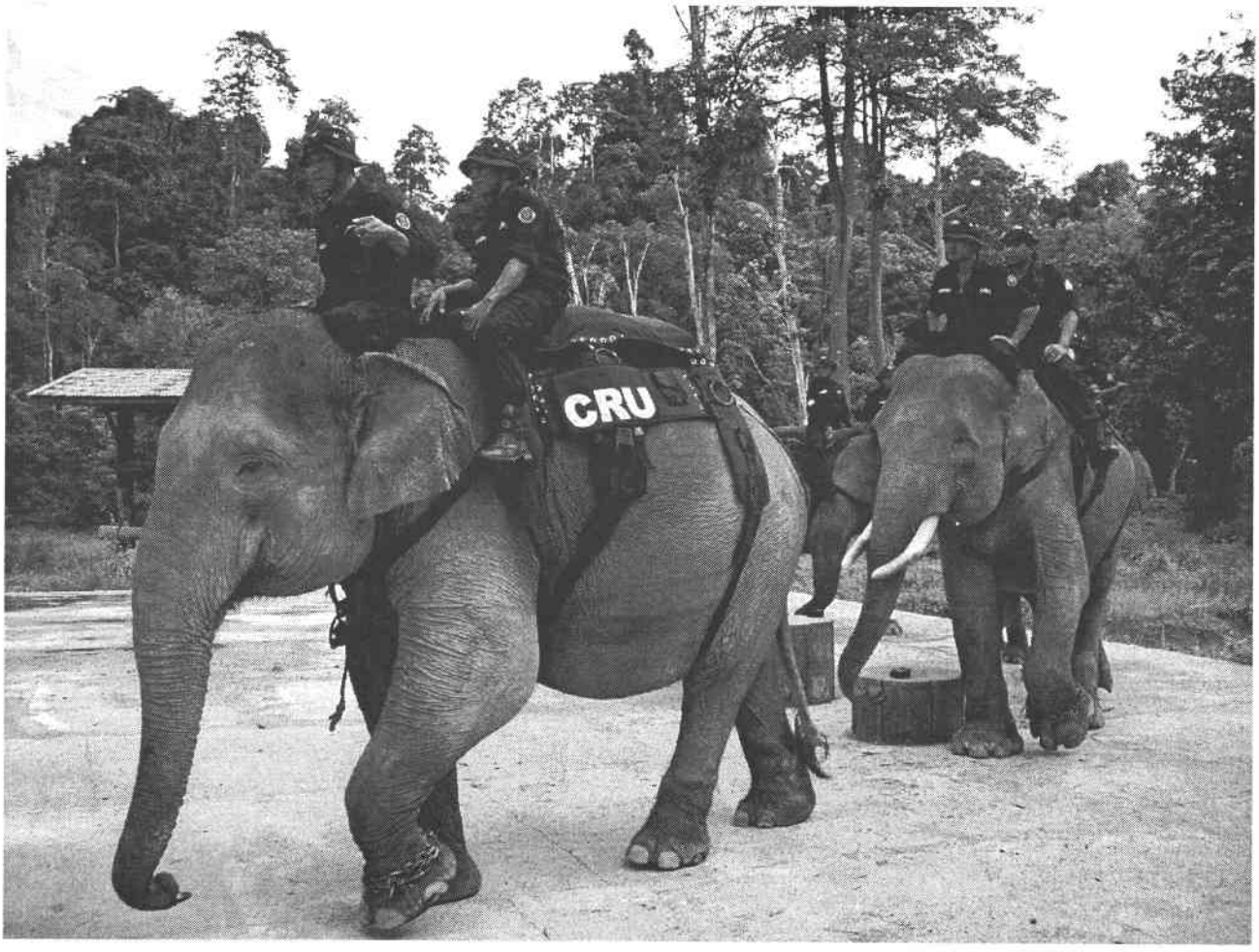

Photo: Heidi Riddle for International Elephant Foundation (IEF)

Establishing a sustainable model for the long-term conservation of the elephant in Sri Lanka

Ravi Corea

The conservation of large vertebrates will be one of the biggest challenges that would be faced by conservationists in the new millennium. Shrinking habitats mainly due to human population pressures are creating a situation that is making even the most ardent conservationists feel current efforts can end as dismal failures. A reoccurring lament is how could the Asian elephant (*Elephas maximus*) be saved in numbers large enough to sustain it amidst such a discouraging and impossible situation?

The last large populations of the endangered Asian elephant share space with some of the most marginalized groups of people in the elephant's range countries. For example, in Sri Lanka the population is 78 percent rural and the elephant shares space mostly with rural farmers. Marginal lands are increasingly brought into agriculture production even though agriculture is the least dynamic sector of the economy, accounting for only 19.4% of GDP in 2001 as shown by a survey conducted by the Asian Development Bank. So nearly 70% of rural farmers are marginalized and live in significant poverty. A Participatory Rural Appraisal conducted by Sri Lanka Wildlife Conservation Society (SLWCS) sociologist, Zeenath Khalid of the Weheragalagama village in the Wasgamuwa region showed that 65% of the population moved in a constant debt cycle. Such low and unpredictable incomes are key features of poverty.

Adding to the considerable suffering of these people is the human-elephant conflict. Human-elephant conflict is perhaps one of the biggest environmental issues Sri Lanka is facing today. Elephants being the largest terrestrial mammals frequently range outside the borders of even the largest national parks in Sri Lanka. Thus setting aside enough habitats to support a large population of such a highly mobile animal as the elephant is almost impossible. Current research conducted by the SLWCS in the Wasgamuwa region shows that there are more elephants outside the Wasgamuwa National Park substantiating the claim that nearly 70% of the elephants in Sri Lanka roam outside the protected areas. Obviously the number of elephants that can be supported by a conservation area and its buffer zone will depend on the tolerance of the people who share their land with the elephants. People will tolerate elephants in their backyard only if they can reap tangible benefits from their presence or if they are provided protection from the frequent elephant attacks on their crops, property and lives or adequately compensated for their losses. Ensuring the long-term survival of such a large and highly mobile animal as the elephant outside the network of protected areas though difficult is critical for the long-term conservation of the elephant. It is also highly unlikely that one government department will ever have the capacity to handle an issue of such magnitude alone. Private-public partnerships will play an important role in ensuring a future for the Sri Lankan elephant in the new millennium. At the government level, there must a be sincere effort to appreciate and accommodate the contributions of private organizations and individuals for elephant conservation. Policies must be developed to encourage such public-private partnerships. Collaboration and sharing of information between individual researchers and conservation organizations is also vital to support these efforts. Additionally the international donor agencies that support elephant conservation should provide incentives for such collaborative efforts and public-private partnerships.

There is a need to develop an innovative approach to elephant conservation in Sri Lanka if elephants are to survive in significant numbers outside the system of protected areas. At present there are no incentives at all for rural people to support elephant conservation.

In the efforts to conserve the elephant some of the biggest and pressing issues are:

1. How can the need to conserve and protect the elephant be reconciled with issues such as human elephant conflict and with the needs and aspirations of stakeholders who are most impacted by elephants.

2. How to develop economically and logistically feasible solutions that are sustainable as well as support the lifestyles and culture of the people of an area.

3. How to protect the last remaining habitat of elephants outside the protected areas.

At present most conservation measures have been developed as reactive measures in response to the proximate issues of elephant conservation, which are: protection, management and establishment of protected areas. Most of these efforts though have been applied in an *ad hoc* manner and have not contributed greatly to conserve the elephant, or address the ongoing issues of human elephant conflict. There is also an urgent need to apply conservation measures in a proactive manner especially in areas where conflict is still low in intensity

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and there is still opportunity to set benchmarks for elephant conservation. An example of such an approach to elephant conservation is the Somawathiya Chaitiya Temple Project of the SLWCS, which was initiated this year.

Another mostly ignored issue is how to sustain projects that are initiated with donor funding. There is a vital need to understand that while donor funding is critical to keep the processes of conservation moving forward and to initiate new projects, it would be a misjudgment to believe that this periodic infusion of donor funds dispersed annually would suffice to protect elephants or help maintain projects over the long term. Currently there is a tendency to focus solely on projects and their immediate outcomes and ignore other issues such as:

Institutional infrastructure
Individual researcher capacity
Operations and administrative overheads
Institution/individual capacity building
Long-term funding
Sustainability

As much as there is a need to help the elephant, there is a critical need to help the individuals and organizations that are committed to long-term *in-situ* elephant conservation.

A good example is the efforts to mitigate human elephant conflict. There is no definite pathway to resolve human-elephant conflict one hundred percent even with community participation. Considering it is a human endeavor, these efforts are always challenged by new concerns, issues and problems. The whole human-elephant conflict resolution effort is an exercise in incremental learning where we are constantly learning new things about working with rural communities as well as about the ingenuity of elephants. So it is necessary to have an adaptive management approach to apply lessons as they are learned through ongoing research efforts. The most important lesson the SLWCS has learned is that you cannot just erect an electric fence or initiate a project and then walk away. It is important to be involved in the project throughout either directly or indirectly so as to make sure there is accountability, as well as monitoring and evaluation of these efforts continuously over time, as well as to make sure that these efforts stay current by applying new concepts as they are developed from lessons learned in the field. For an individual researcher or an organization to invest such an amount of time on a project means they need to have the resources to keep them in operation over the long term. This lack of operational support is what has curtailed the success rate of efforts to conserve the elephant in the wild as well as to resolve human elephant conflict successfully.

While there is heightened awareness internationally in regard to the need to conserve both the African and Asian elephant – there seems to be a conflict of interest between *in-situ* and *ex-situ* conservationists as to how to move forward in this regard. International institutions such as zoos, safari parks and circuses have been investing most of their resources on *ex-situ* conservation efforts, obviously in an attempt to circumvent the increasing global objection to the capture of wild elephants for trade, they have a critical need to develop a sustainable captive population to fulfill their needs. The irony of this is that for conservationists who are working on *in-situ* elephant conservation, breeding elephants is not an issue – in fact elephants breed too well in the wild contributing to the overall problem. The issue for *in-situ* conservationists is to save as much of the remaining habitat available for elephants especially outside the protected areas. So while zoos, safari parks and circuses are investing millions of dollars on developing artificial insemination techniques and trying to understand the estrus cycle of female elephants, the *in-situ* conservationists receive only a fraction of this amount for their efforts to save the last wild elephants and their habitat. A major effort must be made to reconcile and integrate the efforts of both parties so that the captive elephants in these institutions can be a conduit to channeling more resources for the *in-situ* conservation of their wild cousins. Other international donors such as WWF, CI, etc., are more interested in safeguarding their corporate images than actually funding *in-situ* conservation initiatives! False labeling has become pandemic - where stickers with the corporate emblems of these organizations are widespread even in countries where they are not active giving a false impression that elephant conservation is receiving more support than it is really getting.

The Sri Lanka Wildlife Conservation Society (SLWCS) for the past 8 years have been developing a sustainable *in-situ* conservation model for elephant conservation in Sri Lanka under its flagship project, Saving Elephants by Helping People (SEHP). The SLWCS practices a holistic approach to conservation. The Society helps local people who are the most affected by wildlife and who in turn most affect wildlife since if we are to effectively conserve nature through research based conservation strategies, then we need to create local support for these projects and programs. Even after eight years the SEHP project stands out as one of the most successful attempts to resolve human elephant conflict in Sri Lanka in an area where humans and elephants share space. By integrating economic incentives such as nature, recreational and responsible tourism to its projects SLWCS is generating revenue to attain sustainability to its elephant conservation, research and community development efforts. The revenue generated helps to:

- Maintain field projects
- Employ local field staff

*The advantages of training villagers as opposed to employing non-locals as field assistants are:

- Facilitation of long-term monitoring and surveying of wildlife by providing resident researchers.
- Capacity building increases the ability of villagers to gain revenue through conservation.
- Increased environmental awareness and appreciation

of nature by locals who are otherwise likely to have adverse impacts on the environment.
- To obtain local support for the entire project and avoid conflict that often arises between local habitants and non-local scientists as a result of their differing interests.
- Reduced costs in conducting long term field research
- Maintain electric fences
- Defray costs of community development programs
- Develop education and awareness programs
- Provide micro loans
- Set up community cooperatives for sustainable development
- Establish insurance and compensation schemes
- Develop grassroots environmental organizations.

The SEHP project integrates ecological research, applied conservation, community participation, community development and sustainable economic development. It is the first community based elephant conservation and research project in Sri Lanka and has received continuous support from the Asian Elephant Conservation Fund of the US Fish & Wildlife Service, Disney Wildlife Conservation Fund, International Elephant Foundation and from Sanjay Kumar and Computer Associates, Inc., of the USA. While the SEHP project is the longest operating program of the Society, the SLWCS has several additional projects for elephant conservation that are at various stages of operations and development.

A project to cultivate crops such as citrus that are not desired by elephants but still have the potential to bring farmers a decent income is in the developmental stages. By encouraging the cultivation of such crops it is possible to buffer farmers from total economic ruin when their fields and homes are raided and damaged by elephants.

The SLWCS has just completed Phase 1 of a broad ranging program at Somawathie Chaitiya National Park with funding support from the Alexander Abraham Foundation. Phase 1 was building an electric fence to avoid the eventual conflict that would have resulted between the increasing number of pilgrims and elephants. The Somawathie Chaitiya temple is 2300 years old and is one of Sri Lanka's oldest temples, lying just north of the Polonnaruwa Archeological/UNESCO World Heritage site and is situated right in the middle of a national park, which consist of prime elephant habitat. The SLWCS built an elephant friendly fence, which does not prevent the elephants from moving in and around the temple premises and Chaitiya but prevents them from harming pilgrims and temple property. The Somawathiya Project offers an incredible opportunity to apply proactively all the knowledge, experience and skills SLWCS has gained from its ongoing elephant research and human elephant conflict resolution projects.

At the request of the Department of Wildlife Conservation a project was initiated recently to resolve human-elephant conflict at one of Sri Lanka's smallest national parks, the Lahugala Kitulana National Park, which is 1,500 ha in extent but has one of the largest populations of elephants numbering over 250. The US Fish & Wildlife Service, Disney Wildlife Conservation Fund and the International Elephant Foundation are providing the funds for this project. Lahugala will be the culminating point of all the experiences that the SLWCS has gained from its community-based human elephant conflict resolution projects. The Society is bringing together for the first time in Sri Lanka the national and local government officers such as the Divisional Secretary, Department of Wildlife Conservation, Grama Niladharis, · Police Department; Provincial Administrators, Provincial Council officers & members, villagers and village level societies to develop and maintain a human elephant conflict resolution project.

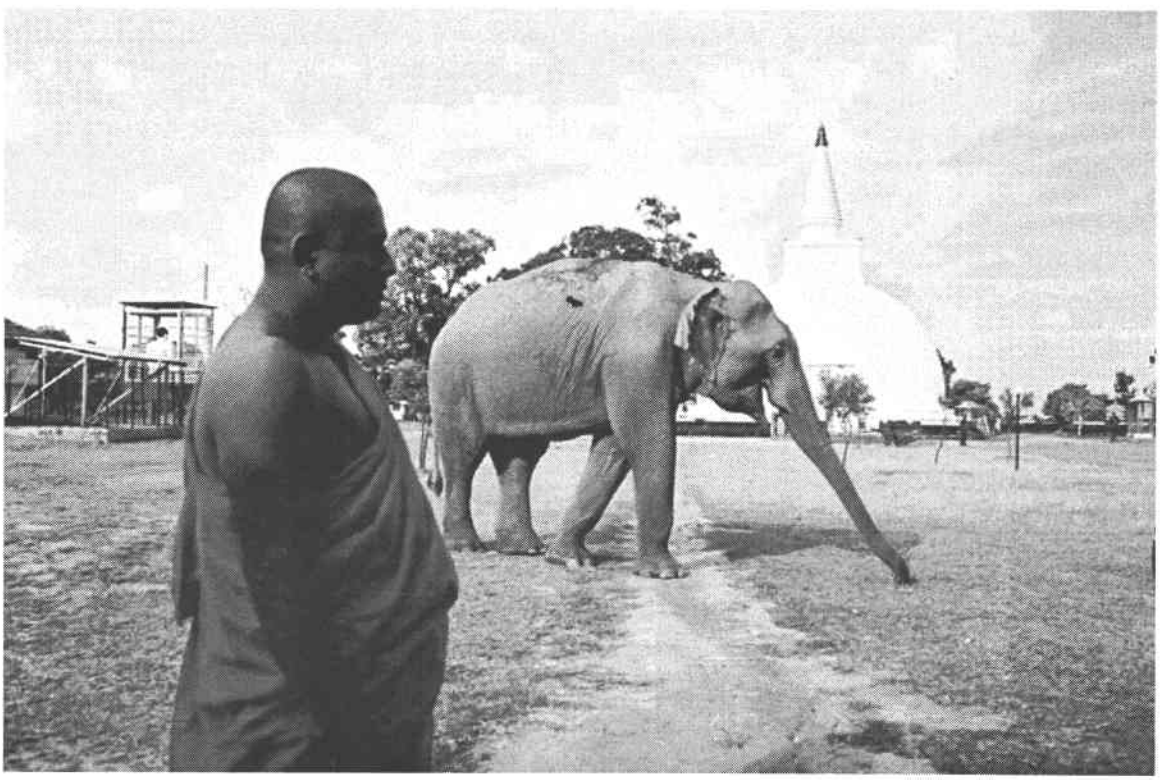
To achieve environmental conservation goals today it has become important to move away from a purely protectionist method of conservation to a multidisciplinary science. The final outcome of our collective efforts will be measured by how well we have balanced the needs of people while at the same time preserving nature. At the same time it is imperative that conservation must be practiced at a scale that will provide protection to the most diversity of species and ecosystems to ensure sustainable livelihoods for people over the long term. The Sri Lankan elephant is a flagship for the diminishing biodiversity of Sri Lanka. It is also an inherent artifact of Sri Lankan culture, folklore and religion thereby the elephant is a representative of the cultural traditions and history of Sri Lanka. By focusing attention on the elephant's plight we are providing protection to a multitude of other species, habitats, ecosystems as well as conserving some of the cultural traditions of Sri Lanka.

For the past one-year the SLWCS has been integrating responsible travel initiatives to make its projects sustainable over the long term as well as to develop economic incentives for the local people at our project sites to support as well as benefit from the elephant conservation and research efforts of the Society. All these efforts fall into the goals SLWCS have for long-term elephant conservation work in Sri Lanka. We are stressing that community development and sustainable economic development must be ultimate goals that coincide with our conservation and scientific research efforts. The education and sustainable economic development of rural communities is imperative for the co-existence of both elephants and humans over the long-term. If wildlife conservation is to really work then it must move from the administration, management and operations domain of private and public conservation institutions into the hearts, minds, outlook and aspirations of local stakeholders. SLWCS projects offer great opportunities for regular people to get involved in actual field research, *in-situ* conservation, community development and capacity building programs. Further information on how to get involved is available in the Society's website at www.SLWCS.org.

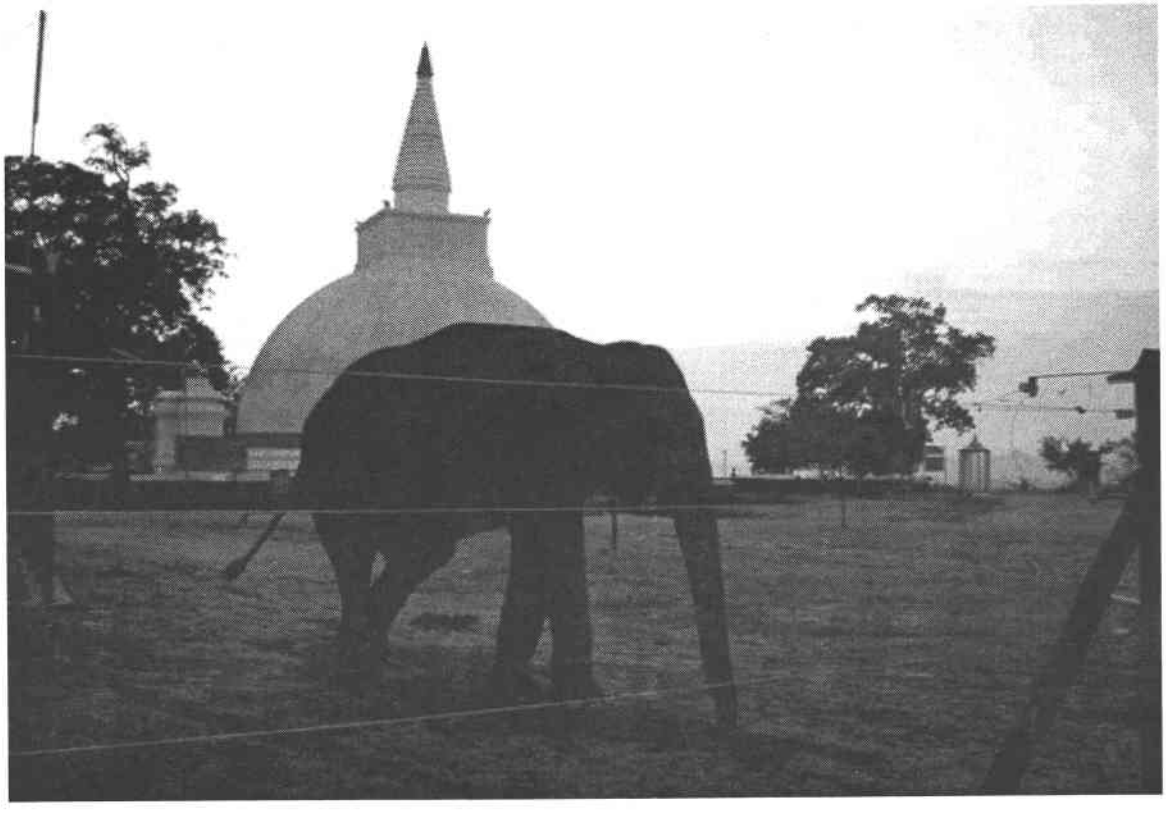
Acknowledgements

The Sri Lanka Wildlife Conservation Society is extremely grateful to the following organizations and individuals who have supported us financially and believed in the vision we have for sustainable wildlife conservation in Sri Lanka. It is mainly their support that helped us to be successful in our conservation efforts. We sincerely thank the Disney Wildlife Conservation Fund, ASPCA, Computer Associates International Inc., Asian Elephant Conservation Fund of the US Fish & Wildlife Service, International Elephant Foundation, the Leo Model Foundation, UNESCO, United Nations Foundation, Travellers Conservation Foundation, the Abercrombie & Kent Global Foundation, the Rufford Maurice Laing Foundation, the Born Free Foundation, The Nature Conservancy, Cleveland Metro Park Zoo and the Alexander Abraham Foundation, and individuals such as Sanjay Kumar and Sir Arthur C. Clarke for giving us grants to conduct our projects as well as to develop the Society. Additionally we thank the numerous people who had volunteered their time or had worked for us and made available their knowledge and expertise over the years to make our projects successful. A special thank you to our village hosts, who by participating in our projects ensured their success.

On a personal note, I thank the Center for Environmental Research & Conservation at Columbia University and its Director, Dr. Don Melnick for giving me the opportunity to study and further my knowledge of Conservation Biology. The Wildlife Trust, USA and its Director, Dr. Mary Pearl for giving me the first grant to initiate my elephant conservation efforts, and Dr. Josh Ginsberg of the Wildlife Conservation Society, USA for being supportive of my conservation and education efforts. I especially like to thank the former Member of Parliament and Governor of the Central Province, the late Honorable Monty Gopallawa for his unstinting support to SLWCS and its projects. I warmly thank Lyn de Alwis, Jayantha Jayewardene and Dr. Charles Santiapillai for their advice and continuing support from even before the establishment of the Saving Elephants by Helping People project and Dr. Natarajan Ishwaran for his continuing support with the current conservation efforts. I also like to say a sincere Thank You to all the SLWCS staff members without whose dedication and commitment none of this would have been possible.



Before the electric fence there was no boundary to separate elephants and humans



The fence provides a non-lethal and safe boundary between elephants and humans

Artist: Manjula Wijesundara

Survey of Elephants in the Mannar District, Sri Lanka

S. Wijeyamohan, S.R.B.Dissanayake and Charles Santiapillai

Participants who assisted in the survey of wild elephants in Mannar District: Ms. A.S. Rangini, Ms. A.A. Hirosha, Ms. R.K. Nishanthy, Ms. P. Ahalya, Ms. S. Vasuki, Mr. J.S. Bernard, Mr. T.M. Sajithran, Mr. V. Ravi, Mr. U. Ragulan, Mr. K.V. Vijithan, Mr. S. Kajendran, Mr. T. Chawchangan, Mr. S.L. Abdul Majeed, Mr. T. Sumanenthiran, Mr. V.S.S. Pragash, Mr. G. Jayaseelan and Mr. S. Krishnakumar (from University of Jaffna, Vavuniya Campus). Ms. Nilmini Jayasena, Ms. H.R.N. Jinadasa and Mr. M.U.A.K. Munasinghe (from University of Peradeniya, Faculty of Veterinary Science). Dr. T. Prasad and Dr. V. Perera (from the Department of Wildlife Conservation, Sri Lanka).

Introduction

The Mannar region is bounded by 8° 30' N latitude and 80°30' E longitude (Eriyagama 1961). The Mannar District with a total land area of 1,985 km^2, extends from the Moderagam aru in the south to beyond Pali aru in the north. It was and still is a part of Vanni (Lewis 1894). The Mannar District is bounded on the west by Indian Ocean, to the north by Kilinochchi District, to the south by Puttalam District, and to the southeast by Anuradhapura District, and to the northeast by Mullaitivu District and to the east by Vavuniya District. The Mannar District consists of the following four Administrative Divisions: (i) Mannar, (ii) Mantai, (iii) Musali and (iv) Nanadan (Fig. 1). Of these four Divisions, Mantai is administered by the Liberation Tigers of Tamil Eelam (LTTE). The human population is estimated at 140,000, distributed in 528 villages. With a population density of 71 people per km^2, Mannar District is also one of the sparsely populated areas in Sri Lanka.

Historically Mannar District has been the gateway to Sri Lanka. Mannar itself was known in King Solomon's times. The Arab trade between the East and West of India was transacted through the channel in Mannar. Vijaya and his band of followers who constituted the first Sinhalese, are said to have sailed down the west coast of India from Supparaka (north of present day Bombay) and landed in Sri Lanka at Tambapanni, which according to Dipavamsa (the oldest of the Ceylon chronicles) was 'on the most lovely south bank of the river'. The river in question is the Kadamba nathi (Aruvi aru or Malwattu oya) along which Vijaya and his followers traveled to Upatissagama and finally reached Anuradhapura (Nicholas, 1959).

As Brohier (1960) points out, centuries before Vijaya and his Aryan followers reached Sri Lanka, the coastal region of Mannar was 'a great commercial emporium', which was visited by Phoenicians from the Red Sea. The city of Mantai (or Matottam) on the mainland had an extensive trade link with Rome and Greece in the 2nd century A.D, but the archaeological evidence, according to Weerakkody (2000) goes to show that Mantai served as the regular port for foreign trade and travel from as early as the 5th century B.C to the 12th century A.D. and beyond. Ptolemy's account of Ceylon in the 2nd century A.D. names it as 'Margana'. The main exports from Mantai were the famed pearls, precious stones, cinnamon, spices, shanks and elephants (Nicholas, 1959). Pearl fishery in Sri Lanka was the most ancient industry in the world, carried on for 2,000 to 3,000 years (Vane, 1887). According to Abayakoon (1950), Cleopatra's pearls may have come from Mannar, for the Mannar coast was known in Tamil as Muttukarai (pearl coast) in reference to the rich pearl banks or paars found in the shallow sea from Negombo to Mannar in general, and between Marichchikaddu and Silavaturai in particular. Coins of Claudius and Annus Plocamus were used in the purchase of pearls by Romans (Abayakoon, 1950). Robert Knox, the celebrated English prisoner of the last king of Kandy escaped from captivity and arrived at Arippu on the west coast.

Climate

With more than six arid months, the Mannar District is situated in one of the driest areas in Sri Lanka. During the dry season, which extends from mid-March to mid-October, daytime temperatures of well over 30°C (or 85°F) have been recorded. The hottest month is May, when the southwest monsoon is at its height in the south and central hills. The coldest months are December and January coinciding with the northeast monsoon during which the region receiveds between 760 and 1000 mm (or

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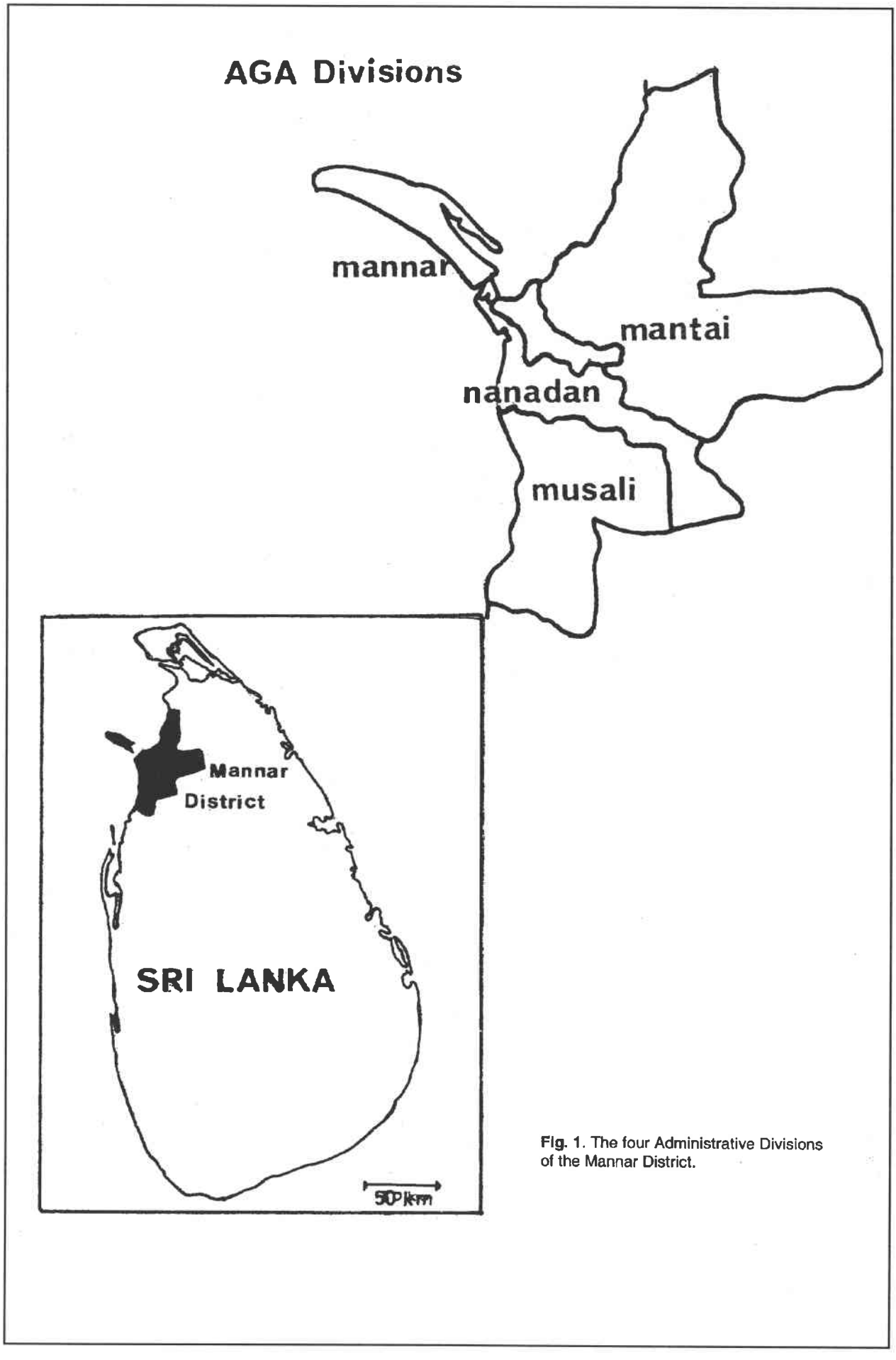


Fig. 1. The four Administrative Divisions of the Mannar District.

30-40 inches) of rain from mid-October to mid-February. The wettest month is November. Erratic showers are not uncommon during the southwest monsoon, but such rainfall has hardly any appreciable effect on the vegetation as the prevalent heat and comparatively lower humidity result in rapid evaporation (Eriyagama 1961).

Physiography

Much of the land area is flat, being less than 3.65m (12ft) altitude above sea level. Along the coast are sand dunes but towards the Giant's Tank, the landscape takes on a gently undulating aspect, which is more pronounced in the northern direction (Eriyagama, 1961). A few rivers drain the area, and they are from south to north, (i) Uppu aru (Modergam aru), (ii) Kal aru (or Cheddikulam aru, a river formed of two streams which rise in the high ground of the southern corner of Kilakkumulai South), (iii) Aruvi aru, (iv) Nay aru, which enters the sea to the south of Vidattaltivu, (v) Paranki aru, which reaches the sea at Illupaikadavai and (vi) Pali aru, which flows almost due west, forming the northern border of Mannar District and the southern boundary of Tunukkay division (Fig. 2). It falls into the Gulf of Mannar in the extreme north of Mannar District (Lewis, 1895). Except for Moderagam aru and Aruvi aru, all other rivers become bone dry during the peak of the dry season. A channel from Aruvi aru feeds the Giant's Tank – the largest irrigation reservoir in Mannar District, while another goes to feed the Ahathimurippu tank. Irrigation in Mannar District takes the form of hundreds of man-made reservoirs or tanks scattered all over the country to catch as much water as possible during the short rainy season (Fig. 3). As Lewis (1895) points out, these tanks for the most part form a connected series, one above the other, those lower down receiving the surplus water of the higher tanks. Water from Giant's Tank feeds 160 other lesser tanks before reaching the seas, and only about 4,000 million cubic metres of water finally reach the sea.

Soil

Except for the narrow sandy coastal strip, much of the Mannar District is composed of soils that are grayish-brown sandy clay to sandy clay loams with concretions of carbonates of calcium, sodium, and manganese oxide (Eriyagama, 1961). This fine clay tends to become stony-hard during the drought, making it extremely impervious to water. Given the combination of high impermeability and the high content of sodium, the soils are characterized by a high salt content and high pH (i.e. highly alkaline). Murunkan clay in particular is well known for its excellent qualities to support agriculture. Further inland, soils are reddish-brown in colour. Such soils are well drained and are ideal for agriculture. According to Boake (1888) the subsoil of loam or clay is very fertile, producing most of the timber trees indigenous to the island. Some fields yield 30-fold of paddy and tobacco.

Vegetation

Despite the arid climate and inhospitable landscape, a substantial part of Mannar District is still forested (Fig. 3). The area is rich in biological diversity. Given the arid climate and edaphic conditions, the region has its own peculiar fauna and flora. Along the coastal sand dunes can be seen patches of *Spinifix littoreus* in association with *Ipomoea pescaprae*. Suriya (*Thespesia populnea*) and Malitan (*Salvadora persica*) are two of the commonest trees in the coastal areas of the dry zone. The principal vegetation type is thorn-scrub, which provides some sort of ground cover over much of the region for the soil against excessive loss of water through direct evaporation (Eriyagama, 1961). Many of the plants show marked xerophytic characters such as thorns and spines to protect them against grazers and browsers and also to keep transpiration to a minimum. Much of the island of Mannar is covered with Palmyrah (*Borassus flabellifer*) and Coconut (*Cocos nucifera*) palms. As Eriyagama (1961) points out, given the economic importance of the coconut, it has to a limited extent, replaced palmyrah. The coastal vegetation is characterized by stunted cockspur-thorn (*Acacia eburnea*) and buffalo-thorn. The scrub vegetation consists mainly of species such as *Cassia auriculata, Phoenix zeylanica, Euphorbia antiquorum, E. tirucalli, Calotropsis gigantean*, and *Glycosmis pentaphylla*. The ground vegetation consists of *Aloe vera* var. *littoralis* (Komarika) and *Opuntia spp*. Much of the former extensive mangroves that bordered the causeway between the mainland and Mannar island has been destroyed as a result of almost 20 years of civil conflict. *Rhizophora spp.* with their characteristic stilt roots and numerous pneumatophores are still common in swampy areas, while the ground flora is mostly of the fleshy *Salicornia brachiata* and *Tamarix gallica* (Eriyagama, 1961).

On the mainland, the subsoil of loam or clay being very fertile, most of the economically valuable timber species thrive here. These include Palu (*Manilkara hexandra*), Wira (*Drypetes sepiaria*), Buruta (*Chloroxylon swietenia*), Kohomba (*Azadirachta indica*), and Ebony (*Diospyros ebenum*) typical of the dry evergreen forest. Between Oddaipelankulam and Marikapelankulam on the coastal road to Pooneryn, there are, according to Eriyagama (1961) vast extents of damana land and semi-arid thorn scrub, mainly of cockspur-thorn (*Acacia eburnea*), associated with Murunkan soils. The riparian dominants are the Kumbuk (*Terminalia arjuna*), Kon (*Schleichera oleosa*), and Siyambala (*Tamarindus indica*). The Baobab trees (*Adansonia digitata*) that are found in Mannar and on the mainland are not indigenous to Sri Lanka but were introduced by Arab traders from Africa several centuries ago.

Biological diversity

Mannar District is also rich in mammalian and avian biodiversity. According to IUCN (1990), over 30 species of terrestrial mammals have been recorded but additional

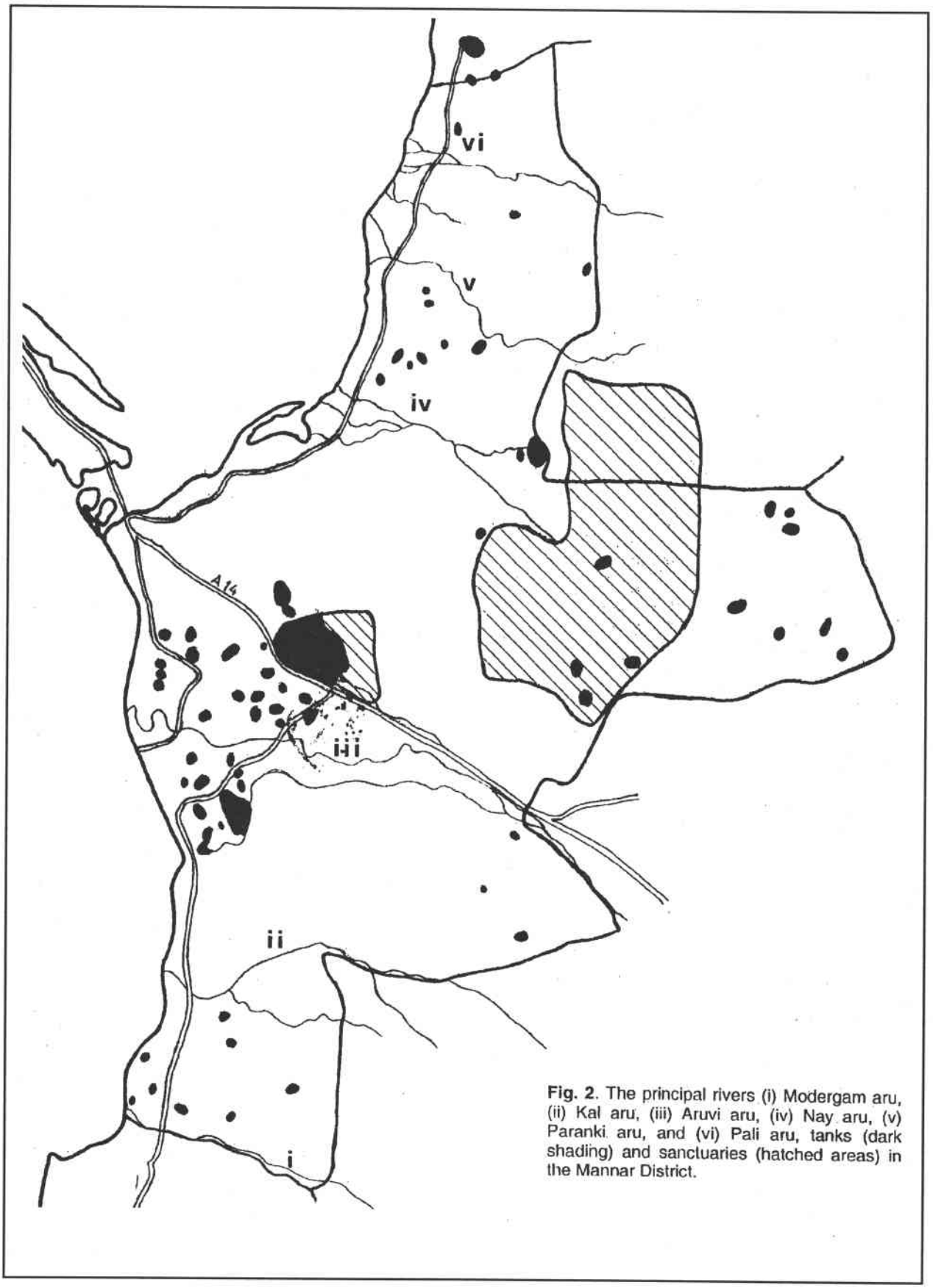


Fig. 2. The principal rivers (i) Modergam aru, (ii) Kal aru, (iii) Aruvi aru, (iv) Nay aru, (v) Paranki aru, and (vi) Pali aru, tanks (dark shading) and sanctuaries (hatched areas) in the Mannar District.

species of Rodents and Bats are present. Threatened animals include the Asian elephant (*Elephas maximus*), sloth bear (*Melursus ursinus*), leopard (*Panthera pardus*), and the water buffalo (*Bubalus bubalis*). A variety of herbivores, such as the spotted deer (*Axis axis*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjak*), mouse deer (*Tragulus meminna*), wild boar (*Sus scrofa*), and the black-naped hare (*Lepus negricollis*) occur in the District. In addition, all four species of primates are found here, including the Slender Loris (*Loris tardigradus*). In the coastal waters of Mannar is found one the most seriously endangered large marine mammals, the dugong (*Dugong dugon*).

The villu ecosystem supports a variety of resident and migratory waterfowl, including large breeding populations of painted stork (*Mycteria leucocephala*) and open-billed stork (*Anastomus oscitans*). Other wetland species include garganey (*Anas querquedula*), pintail (*A. acuta*), whistling teal (*Dendrocygna javanica*), spoonbill (*Platalea leucordia*), white ibis (*Ardea melanocephala*), large white egret (*Egretta alba*), cattle egret (*Bubulens ibis*), and purple heron (*Ardea purpurea*). Indian darter (*Anhinga melanogaster*) is abundant in tanks with high fish density. In addition, Wijeyamohan *et al.*, (2002) have recorded a minimum of 33 resident species from the Giant's Tank alone. This tank alone supports 16% of the national total of birds resident in Sri Lanka, and at least 74% of all the waterfowl in the island.

Protected areas

Despite its vast area and sparse human population, Mannar District has only two areas under protection: (i) The Giant's Tank (3,941ha), and (ii) The Madhu Road (26,677ha) Sanctuaries (Fig. 2), but they represent 15.3% of the land area in the District. The Giant's Tank is situated on the coastal plain of northwestern Sri Lanka, about 5km from the sea near Murunkan, 18km southeast of Mannar. It was declared a sanctuary on 24 September 1954 (IUCN, 1990). The Giant's Tank sanctuary is built around the ancient reservoir which has a maximum depth of 3.2m and a pH of 7.5. It is one of the largest and shallowest reservoirs in Sri Lanka known for its high productivity in freshwater fish and a rich avifauna, especially waterfowl. Fish production is estimated at about 200 metric tones per year (IUCN, 1990). The Giant's Tank and its adjoining Sanctuary provide one of the key habitats for the Asian elephant.

The elephant in Mannar District

Historically, the Mannar District has been famous for its rich and diverse wildlife, and was particularly known for its elephants. In 1888, the them Assistant Government Agent of Mannar, Mr. W.J.S. Boake, wrote as follows about the elephant, "*The elephant still finds a home here, and during the rainy season makes his appearance in considerable numbers, being driven out of the denser jungles by the flies and mosquitoes, which infest such localities, into the low scrub and open plains by the sea. They are not very numerous as they used to be, but still may be always found in or near this District. One seldom hears of a tusker now, or of a rogue, but rogues have been present in Vilankulam*" (Boake, 1888).

Elephants have been caught and tamed in Mannar District from very early times. They were exported from the ancient port of Mantai which now lies buried under the sea opposite Mannar island. Claudius Ptolemy (c. 121-150 A.D.) refers to this ancient port as the chief outlet for the export of elephants (Nicholas, 1954a). A particular group of Muslims known as Panikkars were adept at catching wild elephants using a noose. Panikkars were originally from Batticaloa and Badulla. Kraaling was not practiced in the north given the heavy mortality such a method entailed. In 1665 only 20 of the 90 elephants that were captured reached Jaffna alive (Nicholas, 1954b).

In 1880 elephants were very numerous in the Nanadan area that they were regularly captured and sold, mainly to India (Boake, 1888). Even then elephants caused great damage to crops and therefore rewards were paid for their destruction. In 1867, elephants to the value of 2,328 sterling pounds were exported (Boake, 1888).

Rationale for the survey

The last "island-wide" survey of elephants that was carried out in June 1993 (Hendavitharana *et al.*, 1994) did not include the north and east of the island because of the civil conflict then raging in the country. Prior to this survey, Norris (1959) arrived at an estimate of 1500 wild elephants in Sri Lanka, but he did not give any details about the distribution of the elephants. Subsequently, the only comprehensive assessment of elephant range and number was that of the team from Smithsonian Institution between 1967 and 1969 during which McKay (1973) estimated between 1600 and 2200 elephants as a minimum figure for the number of wild elephants in Sri Lanka. Even then, much of the northern portion of Sri Lanka, including the Mannar District and the rest of Vanni was not surveyed in any detail. McKay (1973) estimated the total population in this area to be "probably between 200 and 500 elephants". Therefore, as far as elephants are concerned, the Mannar District has never been surveyed in any detail. Hence the need for an update on the range and abundance of elephants here.

Organizing the survey: *the modus operandi*

The survey of elephants in Mannar District is a part of the overall survey of the elephants in the northwestern region of the island organized by the Department of Wildlife Conservation (DWC). We were given the task of organizing the survey in the Mannar District simultaneously with that in the northwest between 25-27 September 2004.

Surveying elephants in the wild is not an easy exercise. It is even more difficult if the distribution of elephants cuts across areas under different administration, as it is in the

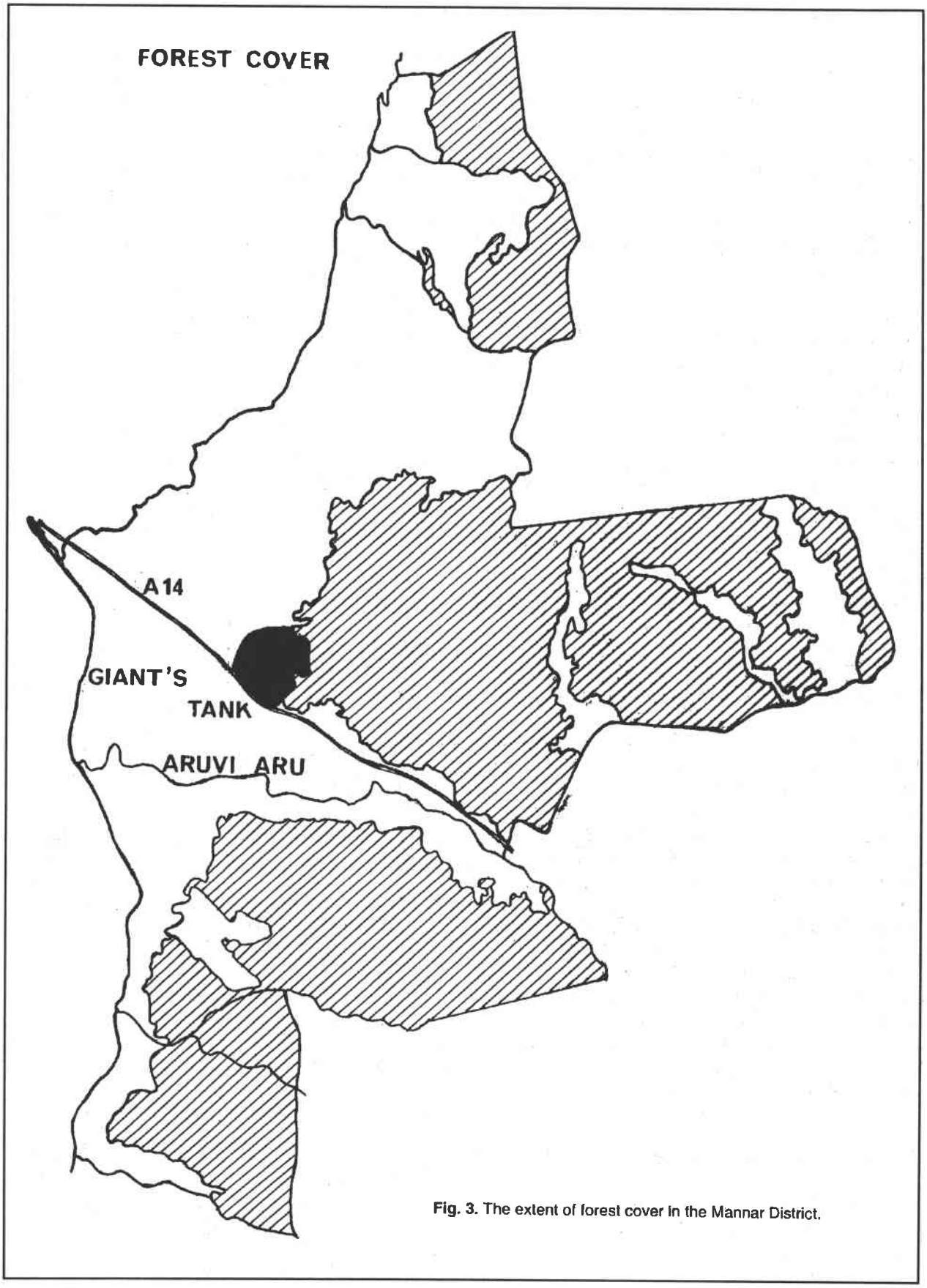


Fig. 3. The extent of forest cover in the Mannar District.

Mannar District. During the preliminary meeting that was held at the Department of Wildlife Conservation in Colombo, we were entrusted with the survey of elephants in the Mannar The Government Agent, Mr. V. Visuvalingam reacted positively to a request made by Mr. D. Karyawasam, the Director-General, Department of Wildlife Conservation (DWC) for assistance in the survey, and promptly convened a meeting of the Assistant Government Agents and Grama Niladharis from the four AGA Divisions (Fig. 1) and briefed them of the nature of the survey and requested that all assistance be given to us. He furthermore, drafted a letter to the Area Commander of Mannar District, Brigadier Sarath Fernando to inform him of the proposed survey. Mr. Visuvalingam also made an appointment with the Brigadier and took us to discuss the logistics of the survey. In this way, we kept the Army Commander fully informed of the dates and places where the survey would take place. We also informed the Inspector of Police, Mr. Navarathna C. Kumara of Murunkan of the planned survey and enlisted the help of his staff. The Government Agent discussed the survey with several NGOs and made sure that there were sufficient number of vehicles and drivers to transport the students to their observation points. His house functioned as an interim office and hostel for the participants during the survey. Prior to the survey, a training workshop was held at the Vavuniya Campus of the University of Jaffna, at Kurumankadu, Vavuniya in order to introduce the survey techniques to the students.

Mantai is under the control of the LTTE, and hence without the explicit permission and support of the LTTE the survey could not have been carried out by anyone. Thus, our first task was to explain the nature of the work to the LTTE and enlist their support for us and the students from the Universities to enter the areas under their control and carry out observations during the day and night. The LTTE gave us their full support for the survey to be carried out in areas under their control.

Survey and census

While it may be possible to count all the elephants in an area of 10 km^2 it is a much more difficult task to count them in an area of 2000 km^2 as for example in the Mannar District. Nicholas (1955) quotes Col. Stevenson-Hamilton, the late Warden of the Kruger National Park in South Africa, who stated categorically that it was impossible to make a census or accurate count of animals including elephants in the bush country of Kruger National Park. What is impracticable in Africa, according to Nicholas (1955) "is altogether impossible here". Their skepticism highlights the difficulty of counting even the largest terrestrial mammal. A large area needs a greater amount of time or a large number of people. This raises the problem of over or under counting due to animal movement during the census, and to different observers recording (or ignoring) the same animal (Rodgers, 1991).

Keeping such constraints in mind, the DWC proposed the adoption of the water-hole count as a basis for determining the range and possibly some assessment of the number of elephants in the northwestern region of Sri Lanka.

In small areas where a distinct dry season limits the availability of water for elephants, it may be possible to get a crude estimate of elephant numbers by counting those that visit all the water holes on a single day (Ramakrishnan *et al.*, 1991). The critical assumption here is that all elephants would visit a water hole once during the day. In the survey of elephants in Mannar District, we adopted this method in order to assess the structure of the elephant population, the abundance being a secondary concern. For management of elephants, it'd be more useful for us to know the percentage of tuskers among the bulls, the proportion of calves in the population, and the sex ratio of adults. We hoped that these could be determined through visual observation of the animals at water holes.

Abundance, as Caughley (1977) argues, can be measured in three ways: (i) as the number of animals in a population, (ii) as the number of animals per unit of area (absolute density), and (iii) as the density of one population relative to that of another (relative density). One of the central issues in wildlife management concerns the estimation of population size. In the absence of information on the size and spatial distribution of a population, it would be almost impossible to investigate size-dependent or density-dependent relationships (Williams *et al.*, 2002). Reliable estimates of elephant populations are essential to address some of the important conservation issues. However, as Caughley (1977) points out, "the majority of ecological problems can be tackled with the help of indices of density, absolute estimates of density being unnecessary luxuries".

It is therefore necessary that methods that are adopted to estimate elephant numbers (N) and density (D) meet at least the minimal standards for scientific rigor. Elephants can be estimated either in a **census** operation where all the individuals of a population are counted, or in a **survey** of a sample of the population. Elephants can be counted either from air, or from the ground on foot or from a vehicle in open areas (Direct observations). An estimate of population density, as Jachman (19696) points out, is obtained simply by dividing the number counted by the size of the area censused, and the density figure obtained in this way can then be applied to surrounding areas with similar characteristics, such as soil types and vegetation. Elephant numbers can be estimated based on signs such as dung-piles, tracks, feeding signs etc (Indirect method). This method is useful in areas where it is almost impossible to observe elephants.

Methodology

The survey of wild elephants was carried on two days (25 and 26 September 2004), and it involved the services of 24 participants. On 25 September, the northern part of the

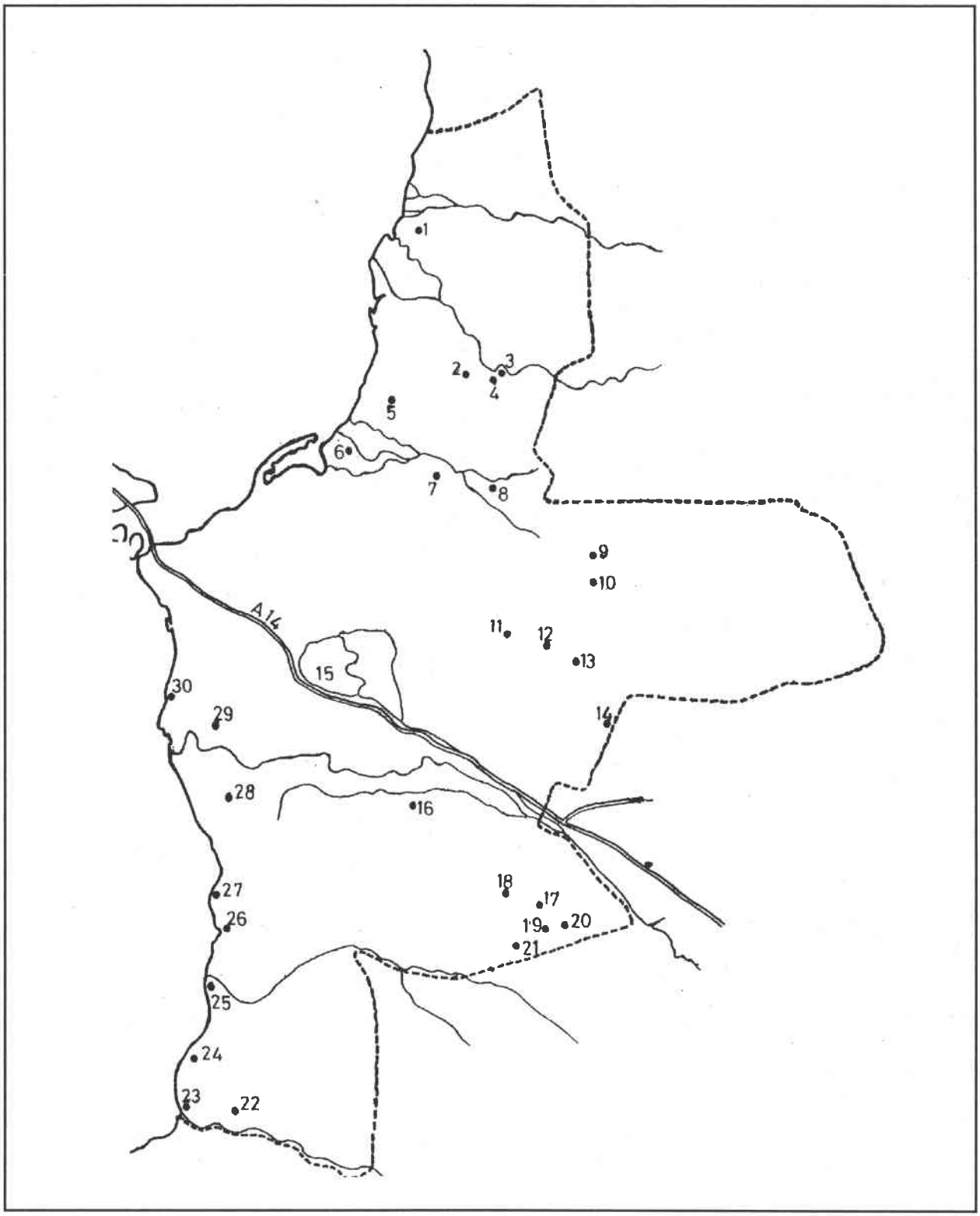


Fig. 4 Elephant observation points: 1. Moodampitty, 2. Kurai, 3. Parankikulam, 4. Sethuvinayagar, 5. Kovitkulam, 6. Palamadu, 7. Sannar, 8. Periyamadu, 9. Palampitty, 10. Thandikulam, 11. Periyavillu, 12. Sinnavillu, 13. Madu, 14. Pandivirichan, 15. Giant's Tank, 16. Pannaivattuwan, 17. Kunjikulam, 18. Uvayadikulam, 19. Puthukulam, 20. Kalliadikulam, 21. Periyamurippu, 22. Periyakattu, 23. Mullikulam, 24. Karadikulam, 25. Kal aru, 26. Anaivillu, 27. Kakkupadayan, 28. Pandarikulam, 29. Eruvettan, 30. Achchankulam.

Mannar District was covered. This area is largely under the control of the LTTE, while on the second day, the southern part of the District was surveyed. Observations were carried out from 1600 to 2300 hrs and beyond in some areas. A number of water holes or (Fig. 4) were identified from where observations on elephants could be carried out. At every water hole, a group comprising 2-3 students was stationed with either a Grama Niladhari or a local villager. A mobile patrol visited all the observation points and covered other areas which were not manned by observers. Direct observations of elephants were the preferred method of investigation. At every sighting of elephants, their number and composition was noted.

The most direct way to estimate the abundance of an elephant population is to count all individuals in a defined area. As Shoshani *et al.*, (2004) point out, counting elephants was done so that only the minimum number of individuals is reported. Duplication was reduced to a minimum or avoided by keeping a tab on the time and distance between successive observations. Wherever possible, animals were classified into calves, juveniles, subadults, adult females and adult males and tuskers. Therefore interviewing local residents is an extremely important aspect of this survey. However, elephants visit water holes frequented by people, more during the night than in the daytime. If no elephants were sighted, then the number of elephants that visited the area most. recently was recorded from the villagers. In areas where there were clear, fresh footprints, their diameter or circumference was measured in order to estimate the approximate shoulder heights of the elephants that visited the area, using the formula that twice the circumference of the front foot gives the approximate shoulder height of an elephant (Boyle, 1929; Sukumar *et al.*, 1988). In Africa, elephant's should height has been estimated indirectly using the hind footprint length since the latter is known to relate to shoulder height, and so it could be used to estimate age distributions in a population (Western *et al.*, 1983). Dung and footprints or other spoor, such as chewed vegetation and scratching posts, provide indirect data (Shoshani *et al.*, 2004).

Results and discussion

There were three problems that faced the observers. The **first** relates to the unexpected rainfall which was very high on the second day of the survey. In Mannar District, the northeast monsoon rains usually commence by mid-October. Hence the survey was planned in advance of the rains so that elephants could be observed, sexed, classified and counted at the few remaining waterholes that are not bone dry. In Mannar District, almost all the waterholes had become dry and the drought was one of the worst in living memory of the people. In the LTTE controlled areas, only one tank (besides the Giant's Tank) had water and that is at Sannar which, according to local people, never dries up. South of the A14 highway, Mullikulam had little water but Periyakattukulam had become dry by the time the survey had started. However, the sudden and unexpected rain (which fell first on 23 September) shifted the movement of the elephants away from the water holes and dispersed them into the forest and along the rivers. Hence the low counts at the observation points on the second day of the survey.

The **second** problem relates to the ban imposed by military on taking binoculars into LTTE controlled areas. As a result of this constraint, it was not possible to sex and classify animals seen at a distance. It is unfortunate that even *bona fide* researchers are denied an opportunity to use the binoculars at a time when the guerrillas all over the world have access to high-powered night vision equipment, telescopes and Global Positioning System (GPS) for surveillance!

The **third** problem concerns the danger posed by unexploded landmines in some areas which poses a serious threat to the life and limbs of people. Such areas could not be surveyed. In the estimation of elephant numbers, every effort was made to discard numbers that may belong to the same population (e.g. in Giant's Tank, a group of 53 animals was not included as it may belong to the much larger group of 77 animals recorded from here).

Distribution of elephants

Elephants in Mannar District enjoy wide distribution that stretches from the Modergam aru in the south to north beyond Mundrampitty near Pali aru (Fig. 5). They are absent along the coast from north of Achchan kulam to just north of Kalliyadi. Despite this large extent of elephant range, the density of elephants varies from place to place, being more in the areas under the LTTE control, just north of the A14 highway. This is largely due to the fact that there are numerous water holes scattered in this area and also substantial forest cover to the east. Elephants are known to move from the south to the north across the A14 highway. However, the appropriation of land along the A14 highway by the Army and the establishment of camps and bunkers, in some places, disrupts elephant movement. Besides, at least 5 elephants have been electrocuted along the A14 highway between Parayanalankulam in the east and Murunkan in the west, during the past three years, through contact with the low-slung naked electricity wires that the army and police use to tap electricity from the national grid.

Abundance of elephants

The results from the survey are given in Table 1. A total of 220 elephants were recorded from the survey, of which 169 were from the LTTE controlled areas, while 51 animals were recorded south of Aruvi aru. In addition, information provided by villagers (and hunters) indicates that up to 350 animals could be using the Mannar District as their habitat during the drought. We should not ignore the knowledge and experience of the local rural people, who in most instances know much more about elephants than urban pundits who just visit an area for a day or two.

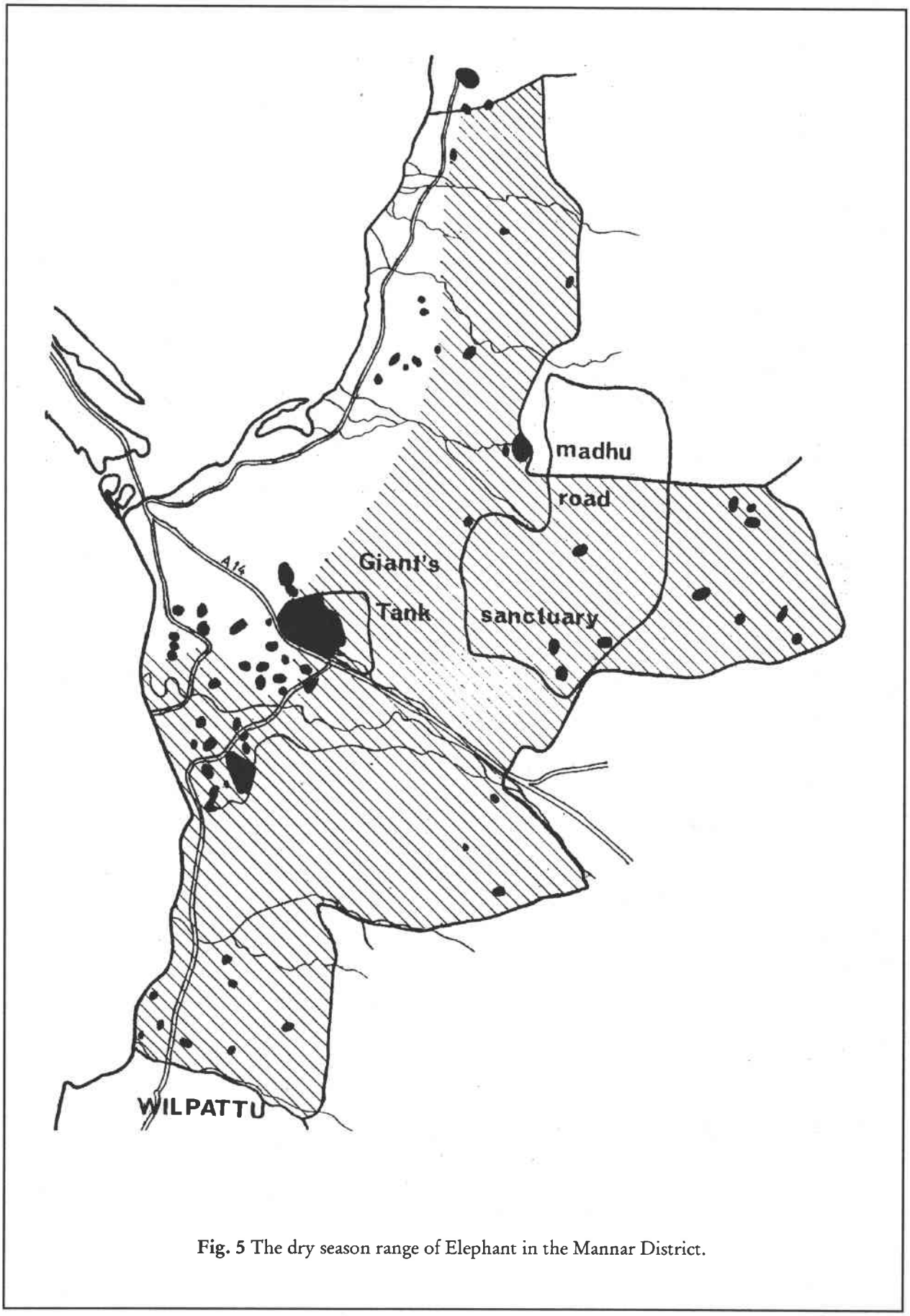


Fig. 5 The dry season range of Elephant in the Mannar District.

As Blanc *et al.*, (2003) point out, even the guesses made by people who know the area in question have to be relied upon. Given the closeness of the two estimates of 169 and 189 from the observers and villagers in the LTTE controlled areas for the number of elephants (Table 1), the estimate given by the villagers should be considered an informed guess. Even this figure must be considered a minimum estimate, given the difficulty of counting elephants in forests. A population of 350 elephants in the Mannar District represents approximately 10% of the national total. This translates into a crude density of 0.18 animal per km^2. However, ecological density for the elephant can be much higher in areas of optimal habitat, or during periods of concentration at the height of the drought (Eisenberg & Lockhart, 1972).

The elephant biomass calculations at the crude density of 0.18 per km^2 in Mannar District, work out to be 326 kg per km^2. At ecological densities of 1.0 to 1.2 animals per km^2, the elephant biomass may reach 1,800 to 2,170 kg per km^2. Density, expressed either as individuals per unit area, or as an index to numbers (e.g. number of faecal droppings per 100 stations), is often a valuable and necessary piece of information for management of elephants (Riney, 1982). If measured during the same season in consecutive years, changes in density-related figures will indicate increases or decreases in the population. Biomass refers to the total weight of animals supported by a unit area. The biomass level that a species population sustains represents a relation between the production of food in the environment, and the ability of animals of the species to transform the food into animal biomass (Owen-Smith, 1988).

For such a large mammal as the elephant that can tolerate a lower quality of diet than smaller herbivores, a high proportion of available herbage becomes acceptable food. Density and biomass supply helpful information on what exists at a particular time (present status, standing crop, occurrence).

It appears that there are far more elephants today in Mannar District than was expected. This is not surprising given the resources available to the elephants in Mannar District. In the first place, there is extensive forest still intact in the north. Sri Lanka's forest cover has declined to less than 22% and much of what is left can be found in the north and east. Thus elephants have sufficient habitat, low human population density, and hundreds of man-made reservoirs, a number of which hold permanent water even during the peak of the dry season. The Giant's Tank provides the best area for elephants and other wildlife, especially birds. The LTTE has imposed a strict ban on illegal timber harvesting within the forests in the north. No tree can be cut without their permission. Thus elephants have sufficient habitat to move about and adjust their densities to changing patterns in vegetation.

Population structure

The unexpected rain was in a way, a blessing in disguise in that in some areas, it was possible to see clear footprints which were measured to estimate the approximate shoulder heights of the elephants. A total of 21 elephant footprints in two separate areas were measured. On the basis of the footprint measurements (see Table 2), it appears that the population structure consists of adults (47.6%), subadults (23.8%), juveniles (14.3%) and calves (14.3%). The size classes were estimated based on the criteria given by Eisenberg & Lockhart (1972) and McKay (1973). It is interesting if the observed percentages of the size classes in Mannar District are compared to what was found by Eisenberg & Lockhart (1972) in Wilpattu National Park, where adults comprised 49%, subadults 25%, juveniles 20% and calves 7%. Thus the observations in Mannar District appear to be in keeping with the more extensive censuses performed by Eisenberg & Lockhart (1972). More than 10% of the animals are calves, which is a healthy indicator of recruitment in the population. As Moss (1988) points out, age structures of elephants usually contain peaks and troughs – i.e. there will be numerous individuals in one age class, very few in the next and so on. There is no even distribution of ages through the population. In respect to sex-classes, the male-female ratio is equal until the adult class is reached, whereupon there are only 8% males compared to 31% females (Kurt, 1969). On a separate day, following rains in the LTTE controlled area of Moondrampitty south of Pali aru, we found one very large footprint 39cm in diameter, which is likely to belong to a bull that is about 2.45m in height at the shoulder.

Tuskers

The survey reveals the presence of at least 4 tuskers in the District (Table 1). The proportion of bulls bearing tusks varies enormously among different Asian elephant populations (Sukumar 1989). In Sri Lanka, Deraniyagala (1955) found that 324 bulls out of a sample of 364 were without tusks. i.e. 89% were tusk less or makhnas. McKay (1973) in a much smaller sample of 25 captured bull elephants found 23 (or 92%) were tusk less. In comparison, almost 90% of the bulls are tuskers in South India. It is difficult to determine the % of tusker in the Mannar District based on the results of this survey as it was not possible to determine the adult sex ratio of the animals recorded. However, if we assume an adult male: female sex ratio of 1:3, then the proportion of tuskers in Mannar District would be about 7.3% - exactly the same as that arrived in 1993 census (Hendavitharana *et al.*, 1994).

Human-elephant conflict

The survey also revealed skulls and bones of two elephants but the cause of death could not be ascertained. While there had been much discussion in the media about the impact of wild elephants in agricultural areas in the south, no one highlighted the plight of the people *vis-à-vis* elephants in the LTTE controlled areas.

A key element of elephant conservation is monitoring

Table 1. The number of elephants recorded during the survey. Numbers within [brackets] refer to the approximate number of elephants recorded by villagers just prior to the survey to survey.

location	time	tuskers	adults	subadults	juveniles	calves	total
Day 1 (25 September 2004)							
Parankikulam	1840						2
Parankikulam	1910						13
Palampiddy	1950						[120]
Palampiddy (feeding sign)	1930					1	
Palampiddy (f-prints)	2110						2
Palampiddy (f-prints)	2110						8
Koorai		1	13	7	3	2	26
Giant'sTank	2335	1	43	8	25 (plus calves)		77
Giant's Tank	2350	1	1	1	1	4	
Periyavillu							[30]
Periyavillu (heard)	2025						1
Pandivirichchan(heard)	2340		1				1
Aryvi aru							5
Potkerni							1
Maruthmadhu jct							3
Veppankulam							1
Pitchaivaniparkulam							3
Vilatikulam							[35]
Periyamadukulam							2
Periyamadu							[4]
Periyakattu	2320						15
Total						169 and [189]	
Day 2 (26 September 2004)							
Adaipankulam	1900	1					
Aruvi aru bridge	1715	1					1
Pannivattuwan	2400						1
Pannaivattuwan	0615+			4			4
Pannaivattuwan							[100]
Periyamuripukulam	0600+						1
Thekka pannai		1					[12]
Aathikulam							3
Kallikulam							[19]
Arippu							[30]
Periyakattu	1900						7
Karadikuli	2300						2
Mullikulam							5
Aruvi aru	2220						12
Kal aru (f-prints)	0930						11
Madhu Rd-Mannar A14	2140						3
Total						51 and [161]	
Grand Total	4 tuskers					220 and [350]	

how different forms of human activity influence elephant distribution and abundance (Walsh *et al.* 2001). One of the serious issues that need to be mitigated in the Mannar District is the growing threat of elephants to people and cultivation. The problem has been compounded by the fact that for much of the past two decades, the area was plunged into an internecine civil war and people fled the area to the safety of India as refugees, abandoning their homes, goods and chattel. Today, with the fragile peace still holding between the LTTE and the Government of Sri Lanka, refugees are slowly returning to their original homes to face an unexpected threat – this time from wild elephants. These animals moved into the abandoned home gardens, attracted by the abundance of palatable and highly nutritious food plants. With plenty of food and water, the animals have become 'permanent residents'. Therefore returning refugees have to compete with elephants in cultivating their own land. Elephants killed at least two people and a few were injured but to date no one has received any compensation. The DWC sent some thunder flashes to Mannar District for the first time, so that they could be used to ward off elephants. Elephants can be saved if even a small portion of the money now being used in workshops, symposia, meetings and conferences is directed towards alleviating the hardship of the poor people who bear the brunt of elephant depredations. Conservation has to sustain not only the spirit but also the stomach.

Impact of the civil war on environment

The civil war has radically altered economic, political, and social conditions of the people in the Mannar District with profound impacts on the environment, natural resources and biodiversity. The impact of armed conflict on the environment in Mannar District is perceptible and it occurs through habitat destruction and loss of wildlife, over-exploitation and degradation of natural resources (Shambaugh *et al.*, 2001). Many of the refugees rely on bushmeat for protein. The LTTE has banned the hunting of wildlife except the pig and hare in areas under their control. Outside however, illegal hunting for bushmeat is rampant. At least 50 hunters are involved in the Mullikulam area alone in bushmeat harvesting. Yet bushmeat hunting should not be banned since it would deny the poor people living in remote areas an important source of protein (Whitfield, 2003). It should be regulated. If such harvesting is not regulated, there is a risk that resource depletion and environmental degradation can drag the people into a vicious circle: poverty, further political instability, more armed conflict, greater environmental degradation, and even greater poverty (Shambaugh *et al.*, 2001). Depletion of biodiversity and the natural resource base can undermine the sustainable livelihoods for the people (Santiapillai & Wijeyamohan, 2003).

Conclusion

The survey of wild elephants in the Mannar District represents the first attempt to obtain reasonably reliable minimum estimates of their number. It is a part of a much larger survey carried out simultaneously by the Department of Wildlife Conservation in the northwestern region of Sri Lanka. Until this survey was carried out, there had been no reliable information on the elephant's range and numbers from the north in general and the Mannar District in particular. The status of the elephant varies widely across its range in the island, and moreover its long-term survival is more threatened in some areas than in others. Therefore regional assessment of elephant range and numbers is crucial given that elephants move long distances across political boundaries and protected areas. This is an important consideration in the north since the Vanni is under the control of the LTTE, while all the national parks are under the control of the Government. Decisions made in one area may therefore affect elephant populations in the other.

The water hole count method adopted during the survey is not perfect but useful in areas where the objective is not simply to estimate the number of elephants but more importantly, to understand their distribution, structure and composition. Total counts do not have the advantage of sample statistics to give measures of precision of the estimate (Rodgers, 1991). Besides, the longer the time period taken to do the count, the greater the chances of double counting. This is the reason the survey was limited to just one day in each area. Despite the drawbacks, the survey provided information on the structure and composition of the groups, the percentage of calves and the proportion of tuskers – information useful to wildlife managers. One clue to the reliability of this method is to repeat the survey immediately. An immediate recount means, as Rodgers (1991) argues, there is no chance of conditions changing. Ideally the survey needs to be carried out twice a year in the dry and rainy seasons to determine the changes in the range and abundance of the elephant.

An index of abundance would be sufficient to tackle many of the wildlife problems. Wildlife management authorities need to know the status of the elephant populations, whether they are increasing, decreasing and whether their numbers should be regulated to reduce conflict and to relax the pressure on habitats (Blanc *et al.*, 2003).

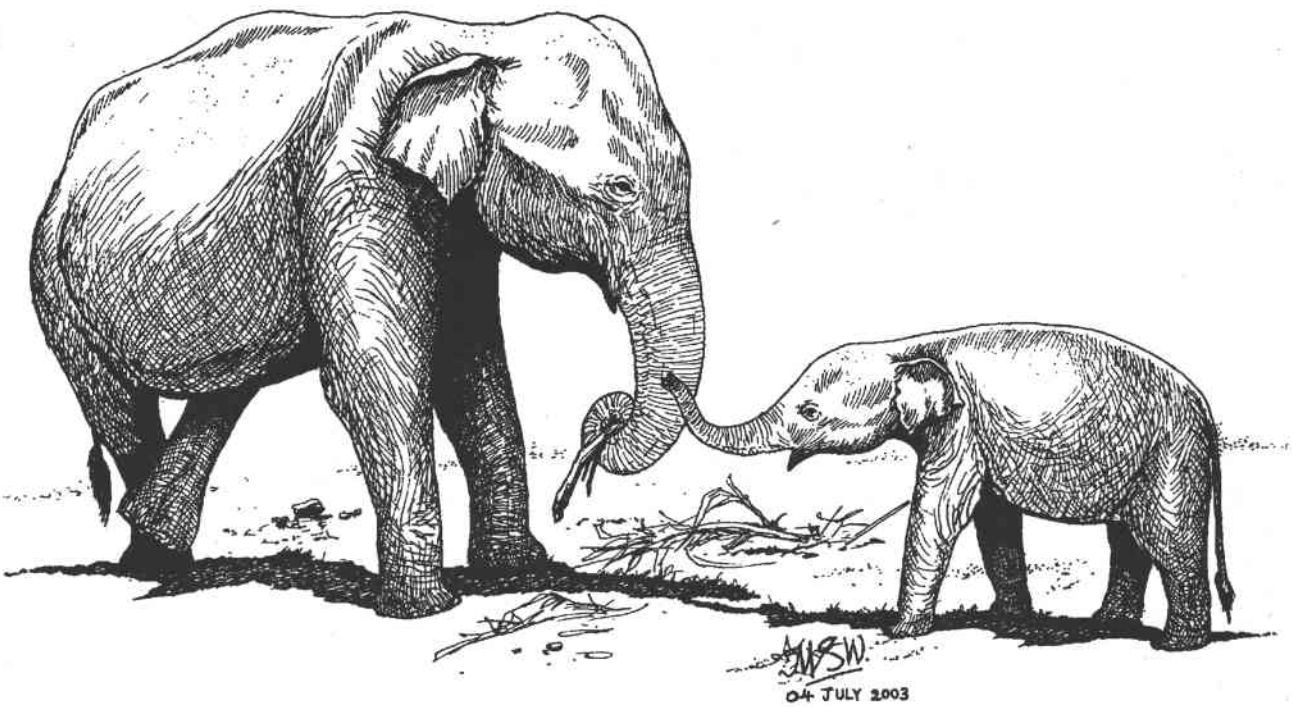
McKay (1973) estimated that there could be between 200-500 elephants in the entire northern Sri Lanka in the late 1960s. The present survey indicates that at least 220 elephants are present in the Mannar District alone, but the numbers could be even as high as 350 or higher. Such information, however imperfect it may be, would be useful for the effective conservation and management of elephants. While the effect of the elephant on its habitat may benefit many other species of wildlife sympatric with it in the area, it can also have a detrimental impact on the vegetation, should elephant density increase.

Mannar District represents an important area for elephants. It provides a connection for the elephants in

Table 2. Estimates of shoulder heights of elephants based on footprint diameter based on the criteria established by Eisenberg and Lockhart (1972) and McKay (1973).

#	fore foot diameter (cm)	circumference (in cm)	shoulder height (m)	size class
1	33	102.3	2.08	adult
2	15	47.1	0.96	calf
3	16	50.3	1.01	calf
4	37	116.2	2.36	adult
5	20	62.8	1.27	juvenile
6	37	116.2	2.36	adult
7	34	106.8	2.17	adult
8	32	100.5	2.04	adult
9	22	69.1	1.40	juvenile
10	28	87.9	1.78	subadult
11	29	92.1	1.85	subadult
12	17	53.4	1.08	calf
13	30	94.2	1.91	subadult
14	35	109.9	2.23	adult
15	18	56.5	1.15	juvenile
16	34	106.8	2.17	adult
17	32	100.5	2.04	adult
18	24	75.4	1.53	subadult
19	32	100.5	2.04	adult
20	35	109.9	2.23	adult
21	30	94.2	1.91	subadult

Number of adults 10 (47.6%), subadults 5 (23.8%), juveniles 3 (14.3% and calves 3 (14.3%)



Artist: Manjula Wijesundara

Wilpattu National Park and those in the Giant's Tank and Madhu Road Sanctuaries. In addition to enhancing elephant movement and gene flow, the area has great value as habitat for plant and animal communities. The survey has shown that elephant distribution is not confined to such protected areas alone. The majority of elephants appear to be found in unprotected areas. Therefore this situation could lead to increased conflict with people, especially in areas where refugees have been resettled and agriculture is the principal land use. There is an opportunity in Mannar District to link up the Wilpattu North Sanctuary with the Giant's Tank and Madhu Road Sanctuaries (Fig. 2) through a forest corridor to enable the elephants to move to and fro across the A14 highway. This is possible given the low human population density in the area and the presence of many water holes and forest blocks. Such a forest corridor provides a means of ensuring connectivity for elephant movement across landscapes threatened with fragmentation. The proposed corridor being more than 10km wide, it would be more than adequate to ensure the gene flow between elephant populations to the north and south of the A14 highway. As Sukumar (2003) argues, if the objective of a corridor is merely to act as a passage for elephants, it would be better to maintain the vegetation in a state that encourages rapid movement rather than a prolonged stay that could promote conflict.

Information on elephant number, minimum viable population (MVP) size, and movement pattern would be invaluable to define clearly the management objectives for both protected and unprotected areas of elephant range (Lindsay, 1993). Furthermore, should a national park, nature reserve or forest corridor be planned in the Mannar District to ensure the long-term survival of the elephant, such information would be most useful.

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Mahouts and their elephants working as Conservation Response Unit in Sumatra

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The importance of Sumatran Elephants

Due to the large home range and its ecological requirements, the elephant is an ideal flagship and indicator species for the conservation of forest and associated biodiversity in Sumatra. Elephants are also an umbrella species in that they use a variety of habitats occupied by other charismatic species such as Sumatran Rhino, Sumatran Orang Utan and Sumatran Tiger.

Regarding the Asian Elephant, high conservation priorities should be given to populations harbouring the greatest proportion of the species' genetic variability, and to genetically unique populations. Mitochondrial DNA analysis of the Sumatran Elephant has suggested that it represents a separate Evolutionary Significant Unit (ESU), thus supporting their separate sub-specific status. Recent work conducted by Fernando et al. using micro satellite analysis has confirmed the unique ESU status of both the Sumatran Elephant and the Borneo Elephant (Fernando *et al.*, 2003).

Lack of a conservation vision in the land use planning process

As found in other Asian elephant range countries, the fragmentation of elephant habitat in Sumatra is a well-recognised problem. Habitat patches are becoming smaller and are more isolated from each other, increasing the vulnerability of elephant populations. Two thirds of current Asian elephant range is in non-conservation areas (Sukumar, 1989). Most of the current conservation/ protected areas in Sumatra are inadequate in their design to effectively protect Sumatran elephants because they do not protect prime elephant habitat. Most wild elephants are present in blocks of forest outside of conservation/ protected areas, invariably creating a high potential for incidents of human-elephant conflict. These issues reflect the failure of the current land-use planning system to take into account elephant habitat requirements and the long-term benefits of forest conservation. Ramono (2000) stated that the conversion of primary forest into agricultural holdings has been one of the main causes of conservation problems in Sumatra and the elephant has been among the large mammals most seriously affected by it. Development programmes have led to the annual elimination of tens of thousands of hectares of elephant habitat.

Economic incentives have dominated land use planning in Sumatra, resulting in a substantial loss of highly bio diverse forest to cultivation. Most of the lowland forests that are well recognised as containing the richest biodiversity and prime elephant habitat have been allocated for other purposes such as logging concessions, transmigration sites and large-scale plantations. In North Sumatra Province, 900,000 hectares of lowland tropical rain forest has been converted into small-scale and large-scale oil-palm plantation in the period of 1990-2005. This development movement has lead to substantial and higher pressure on Gunung Leuser National Park in the form of land encroachment for small-scale oil plantation.

Despite containing some of Sumatra's most extensive forests only 10% of Aceh is protected as Gunung Leuser National Park and habitat loss continues through legal forest conversion activity, illegal deforestation and settlements both outside and within Protection Forest and Protected Areas. Habitat fragmentation is the by-product of this process and now is threatening to break the chain of forest running along and flanking the central mountainous range of Bukit Barisan from the North in Aceh to the South. As a result, elephant habitat has been scattered and some of the small populations are being isolated in a block of forest, increasing the risk level of extinction. The overlapping of elephant habitat with human activities in the same area also significantly increases the number of human-elephant conflict incidents.

Human-elephant conflict

In the recent past, human-elephant conflict in Sumatra has been handled by capturing the raiding elephants, driving them or scaring them off using sound and fire, while a few plantations use modern technology such as electric fences.

Biological considerations of elephant demography indicate much lower intrinsic rates of population growth in rain forest habitats as compared to drier forests. This means that capturing elephants from rain forests, as a means of containing depredation or for other reasons, is more likely to result in a depletion of the populations as these recover only at a very slow rate. Capture should

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thus be the last resort of management and should be confined to non-viable populations preferably for translocation, or for identified "rogue" elephants which are a serious threat to human lives (Sukumar, 1999).

The long-term conservation of the elephant in Sumatra, however, requires that elephants and people co-exist with minimal conflict. Otherwise demands for the removal of elephants will be politically difficult to ignore, resulting ultimately in the depletion of elephant populations on the island. Thus we have to find appropriate methods to mitigate elephant-human conflict in Sumatra before the situation reaches a point of no-return for the elephant.

Elephant camps as a result of human-elephant conflict

As a result of escalating human-elephant conflicts in the 1980s, the Indonesian Directorate General of Forest Protection and Nature Conservation (PHKA) ordered the capture of wild problem elephants and Elephant Training Centres (ETCs) were established in six provinces throughout Sumatra. These were later renamed Elephant Conservation Centres (ECCs). In 2001, in collaboration with FFI, PHKA registered 482 elephants in captivity in Sumatra (Janis *et al.*, 2001). The low survival rate in the capturing and training process implies that a higher number of elephants have actually been captured. Most of these elephants are located in government managed Elephant Conservation Centres. An unexpected result of the capturing policy has been over-crowding in all ECCs in Sumatra. To add to this, all the centres lack funds for good management enforcement so camps cannot demonstrate their roles in the global effort of in-situ elephant conservation, which was part of their original purpose.

Establishing Conservation Response Units

The Conservation Response Unit (CRU) concept is founded on the belief that diversity is only secure when diverse conservation strategies are employed. In-situ and ex-situ approaches are not mutually exclusive; no single method of conservation is optimal for all situations, and no single method can succeed alone. Different conservation systems can complement each other and provide insurance against the shortcomings of any one method. Ultimately, the success of both in-situ and ex-situ approaches depends on forging strong links between the two.

The CRU model is but one method that provides a strong link between *in-situ* and *ex-situ* elephant conservation. This model is utilising once neglected captive elephants and their mahouts for direct field based conservation interventions to support the conservation of wild elephants and their habitat, and achieve positive outcomes for both elephants and people. By creating this link, and ensuring that these elephants are seen as an important resource and doing positive deeds, it is expected that local communities, decision-makers and other stakeholders will recognise their contribution and hopefully focus greater attention on protecting Sumatran Elephants, in the wild and in captivity.

This philosophical background of the CRU concept has been positively received by both the national and international elephant community, and the concept is being implemented in a wider part of Sumatra, in a collaboration between Fauna and Flora International (FFI), International Elephant Foundation (IEF) and Balai Konservasi Sumber Daya Alam (BKSDA) as part of the Sumatran Elephant Conservation Strategy with a multiple year partnership commitment.

Local governments and communities should be convinced that Sumatran elephants are worthy assets and genetically important for global elephant conservation. Elephants can play a significant role in generating income for local people through ecotourism and by protecting the function of the forest, which is elephant habitat. Without making this connection and ensuring that these elephants are seen as an important resource, there will be a continuing welfare problem and the important genetic resource that these animals represent (as a high proportion of an ESU of the Asian elephant) will be lost.

Structure and goals of the CRU

The CRU teams are composed of 14 captive elephants from two ECCs (Aceh and Seblat) and 14 of their mahouts, 14 government forest rangers, and 3 FFI conservation officers spread over three CRU posts placed in targeted working areas. Working in partnership with local government, local communities and NGOs, the CRU project has 4 main objectives: 1) mitigating human-elephant conflict; 2) reducing wildlife crime activities in the important elephant habitat through forest patrol and monitoring; 3) raising awareness among local people of the importance of conserving elephants and their habitat; 4) establishing community-based ecotourism to ensure long-term CRU financial sustainability. Working towards field-based conservation intervention, both captive elephants and mahouts have been offered a new alternative future. Captive elephants play an important role by providing transportation during forest monitoring patrol activities, as a tool for gaining local community interest during awareness events, and driving away crop raiding wild elephants should conflict incidents arise. Mahouts, as part of the CRU team, not only take care of the elephants but are involved in all CRU activities and have gained training in wildlife observation techniques and basic use of navigation devices and mapping.

CRU as a site specific project

During the early stages of the CRU operation, various problems and issues specific to each working area were identified and will be the focus of activities in the next phase of the CRU project.

One of the CRU sites, in Bengkulu Province, successfully addresses the land encroachment and illegal logging issue inside the ECC area and identified the need to increase the protection status of the ECC area, as well as expand the protected area and establish a corridor to the Kerinci Seblat National Park. The proposed corridor will increase the protected forest area from 6865 ha. to 18.000 ha. The Bengkulu Nature Conservation Agency (BKSDA) has taken the leading role in proposing this increased protection status to the Indonesian Forestry Ministry, with the endorsement of the local government. Establishing a good management plan for the new proposed protected corridor and elephant camp forest has become the focus of the CRU work in this area.

The CRU in North Sumatra, in collaboration with Gunung Leuser National Park, is working to empower the National Park resort posts in Langkat district through the implementation of CRU activities. Illegal logging and land encroachment still remain the main issues to address. Working closely with the local community, the CRU is also involved in developing eco-tourism in the Tangkahan area, as one way to maintain the CRU objectives by the community itself with support from eco-tourism activities.

In the Tangkahan area, adding revolving positions for three local villagers to the CRU team to learn, assist, as well as provide contributions to all CRU activities on a daily basis offers an opportunity for the CRU team to transfer their skills and share knowledge locally.

Training and capacity building

With the establishment of each CRU team, capacity building has been an initial focus for staff and project partners. Training sessions have been conducted with topics covering:

- Survey and forest monitoring techniques, including basic navigation techniques using a hand held GPS
- Human-elephant conflict mitigation
- Wildlife data recording
- Community awareness

Some CRU staff has been sent to other elephant projects, such as the ones managed by the Wildlife Conservation Society (WCS) to learn about the Way Kambas ECC in Lampung Province, and to share skills with the Crop Protection Unit Team operating under the supervision of WCS.

With the support of IEF, one of the CRU team leaders was sent to the elephant camp at the Jaldapara Wildlife Sanctuary (India) to learn different methods for similar projects (i.e. patrols, camp management, etc). IEF is also committed to support the first mahout workshop in Sumatra to be held in 2006, to establish a communication forum and share knowledge amongst representative mahouts from each of the various camps in Sumatra.

Most of the CRU team members have little educational background, yet through a series of capacity building activities have been trained in assessing and selecting priority areas for CRU activities and field patrols, operating hand held GPS units, filling in standardised data-sheets for forest patrolling and conducting HEC assessments. This empowerment has provided a sense of dignity to the mahouts, a yet unexplored potential source of human resources working for field based conservation.

In the future, with identified field work requirements gathered from experience during implementation of the program, further training needs will be assessed to best approach site specific issues.

Elephant back patrols

Each CRU post is divided into teams who conduct patrols for 7-10 consecutive days a month, during which CRU team members record sightings or evidence of illegal activities, human-wildlife conflicts and wildlife presence. Communities in these critical conservation areas are exposed to elephants in a positive context through their physical presence whilst passing through villages on patrols. The team carries hand-held GPS units to properly identify sighting locations, and a digital camera for documentation purposes. They also fill out report sheets and a narrative when they return from patrol and this data is provided to the partner BKSDA and GLNP offices.

Whilst on patrols, the CRU team records findings as follows:

1. Forest crimes which include illegal logging, land encroachment, illegal hunting, fish bombing, etc.
2. Areas where wild elephants and other wildlife are present, including saltlicks and other means of verification.

Assisted by the data processing group of FFI's Sumatran Elephant Conservation Programme (SECP), information captured on the GPS devices is downloaded and digitally mapped to record patrol routes, illegal activities and wildlife presence in order to best focus patrolling efforts and to explore new areas. Project activities have provided important basic and baseline data about the current extent of forest cover and the status of key biodiversity components in each CRU working area, and this data has been a strong justification for the new forest protection area proposed in Bengkulu-Seblat.

Mitigating human–elephant conflict

The CRU concept addresses human-elephant conflict mitigation not only as an effort to avoid further risk of property loss, but of equal importance is parallel consideration of elephant conservation aspects.

The current CRU teams have been trained and subsequently developed their own capacity to assess HEC mitigation options in their specific working areas. The teams have collected detailed information from field based assessments on various aspects of the issues of conflict.

The pattern of human-elephant conflict, as expected, is intermittent. Teams are responding on a regular basis in the working areas, often driving wild elephants back into the forest and also undertaking detailed assessments of any site damage, especially in the Bengkulu-Seblat area. The presence of the CRU has done much to dispel local fears, and the existence of CRU teams is helping keep the HEC issue under control. The continued presence of the CRU posts will ensure that HEC issues do not create animosity in the local community, which has already led to large-scale elephant killings throughout Sumatra.

Awareness programs

Communities in critical conservation areas are exposed to elephants in a positive context through their physical presence as CRU patrols pass through villages, and as they reduce human-elephant conflicts. These visits are used to reaffirm positive attitudes towards elephants and the link between elephant and habitat conservation, promoting a message of tolerance and understanding of the needs of wild elephants, as well as improving attitudes towards the intrinsic value of wildlife.

Conservation awareness programs conducted by the CRU teams include school visit activities, village visits, slide and film programs, games and competitions for visitors and communities living in surrounding locations. The partner NGOs (FFI and IEF), BKSDA and GLNP have developed flyers with general information about elephants, conservation and the CRU project, as well as similar themed children's booklets which are handed out during these community awareness activities.

Elephant related eco-tourism

Sumatra has a large potential for nature-based tourism to generate income for local communities. Many of Sumatra's megavertebrates, such as elephants, rhinos and tigers, are difficult to view because of their low densities, dense vegetation and difficult terrain. Wild Sumatran elephants, for instance, have rarely been seen by tourists or even researchers. However, at some CRU sites there is the potential to set up elephant related tourism projects. The CRU teams in Tangkahan and Seblat are developing a plan for long-term sustainability, as well as a publicity campaign to promote the issue of eco-tourism.

Conclusion

For Indonesia the CRU concept is intended to be one step in reviewing and adopting a new culture of managing elephants, in the wild and in captivity, with the view to ensure acceptance of improved human-elephant relationships within the framework of the country's development programs.

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The shifting chemical signals of Musth

Heidi S. Riddle, David R. Greenwood, and L.E.L. (Bets) Rasmussen

Studies of captive elephants have significantly contributed to our understanding of how olfaction influences elephant behaviour throughout their lifetime, with special importance during the reproductive years. These studies allow longitudinal sample collections coupled with observations of individual elephants over time – something that is difficult in field conditions. The infusion of data from captive studies continues to fill in details on the physiology of musth and some of this information has been correlated by observations of wild elephant herds (Rasmussen & Perrin, 1999; Rasmussen *et al.*, 2002; Rasmussen *et al.*, 2005; Greenwood *et al.*, 2005).

Elephants receive chemoesthetic sensations, or smell, via several systems. In the main olfactory system the trunk is a conduit to the extensive olfactory epithelium covering the numerous turbinates. The billions of olfactory neurons are sensitive to low levels of gaseous compounds. Throughout the mucosal lining of the trunk are the free nerve endings of the trigeminal system, detecting compounds present in higher, often toxic concentrations. Furthermore, elephants have a third chemodetection system: the vomeronasal organ. It is the interplay between the main olfactory system and the enormous vomeronasal system that gives elephants one of the most sensitive and precise "smell" detection systems among mammals (Rasmussen, 1999).

We first began our chemical communication research on signals released in urine by female Asian elephants during the periovulatory period. Separation techniques of a postulated pheromone were based on the high frequency of flehmen responses by male elephants assessing isolated fractions. This assessment mechanism presumably involves the vomeronasal organ system as the trunk tip places liquids on the opening to the vomeronasal organ ducts in the roof of the mouth. These studies were begun in facilities in the USA and, in the controlled captive environment, led to the identification of a urine-derived acetate and demonstration of the bioactivity of its synthetic form. This female-to-male signal met the criteria of a pheromone (Rasmussen *et al.*, 1996).

What about male-emitted signals - what were these signals and did any facilitate reproductively oriented behaviors? Early studies showed that cyclohexanone in temporal gland secretions of musth elephants elicited behavioral responses from females with calves (Perrin & Rasmussen, 1994). To better understand the nature and function of any signals, we needed to study the chemosensory influences of male elephants as related to the phenomenon of musth.

A serendipitous observation of a young captive Asian male elephant heightened our male-focused chemosensory studies. The observation by one of us that a young teenage Asian elephant in a first musth smelled like honey triggered detailed studies of these young males and their secretions (Rasmussen *et al.*, 2002). Subsequent chemical analyses revealed that young Asian male temporal gland secretions (TGS) were composed of a bouquet of sweet odors: acetates, an alcohol (3-hexen-2-ol) smelling like leaves, and pleasant smelling ketones (acetophenone and 2-heptanone). This finding provided the real impetus for in depth chemosensory studies comparing young and older males, as well as musth and non-musth males.

Not only do young Asian male elephants experiencing their first musth emit sweet compounds, but their behavior is unpredictable and erratic. These teenage musth episodes are short in duration and have been termed "moda" (Chandrasekharan *et al.*, 1992). Older males are not only much larger but our studies have shown their musth has a distinctive chemical signature; mature Asian male elephants in musth secrete a very different mixture of chemicals than teenage males (Rasmussen *et al.*, 2002). The older males are more socially and sexually adept and, importantly, capable of sustaining long periods of musth, sometimes several months in duration. During these extended periods not only do they release secretions distinctive of adult musth, but compounds characteristic of the specific phase of these long musth periods.

The concurrent chemical and hormonal maturation of musth is an integral part of the long process of male maturesence within elephant society. When teenage males reach their early twenties, sweet smelling acetates are no longer detectable in their secretions. Our captive studies have shown that pleasant-smelling compounds are transitionally replaced by carboxylic acids; such acids reduce the pH of the temporal gland secretions as low as pH 5.5. During this transitional phase, trace amounts of an acrid ketal, frontalin [1,5-dimethyl-6,8-dioxabicyclo[3.2.1]octane] a demonstrated pheromone, are occasionally

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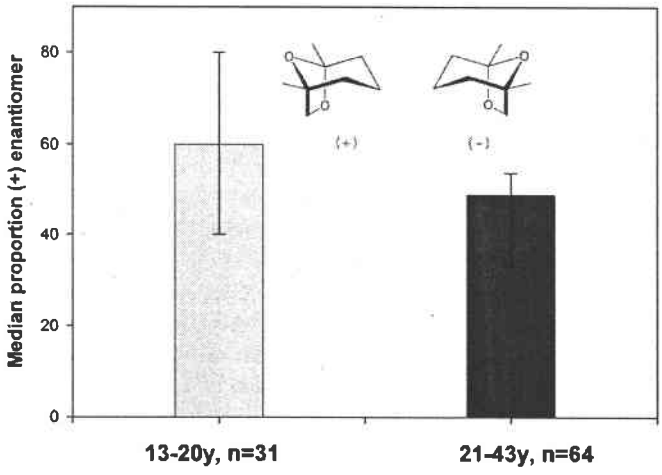

Fig.1 Proportion of enantiomer forms of frontalin during musth

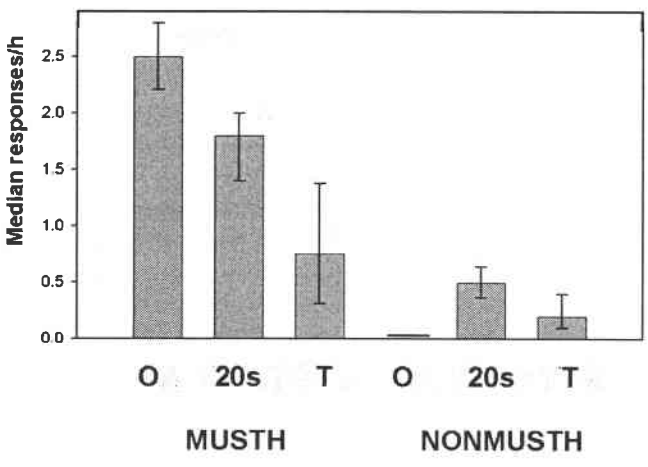

Fig.2 Frequencies of checks to expelled female urine

O=older males (+30 years); 20s=males + 20 years old; T=teenage males

detected (Rasmussen & Greenwood, 2003; Rasmussen & Greenwood, in prep.). Significantly, we have recently discovered that these young male Asian elephants in musth release both sterically possible enantiomers, or mirror image forms, of frontalin but the proportion of forms varies widely from day to day, with the (+) form usually the more dominant one (Greenwood *et al.*, 2005). However, as males continue to mature, not only do the pleasant odors make way for malodorous ones, but the proportion of mirror image forms stabilizes, especially at mid-musth, to almost 50% (Greenwood et al., 2005). Eventually and particularly during the mid-point of a musth episode, older males broadcast mixtures of less volatile, more alkaline-based, longer-lasting ketones, increasing amounts of the bicyclic ketal, frontalin as an almost racemic mixture of the enantiomers of frontalin (Fig. 1) (Rasmussen *et al.*, 2002; Greenwood *et al.*, 2005).

Based on this observed gradual change of chemical emissions, especially of frontalin, we conducted behavioral bioassays both with whole collected TGS and the synthetic form of frontalin at three facilities with captive Asian elephants in the USA (Riddle's Elephant and Wildlife Sanctuary, the Ringling Center for Elephant Conservation, the Oregon Zoo) and at the Auckland Zoo in New Zealand. Behaviors observed in response to presentations of synthetic racemic frontalin were consistent with the results observed with whole temporal gland secretion from older males whose mid-musth secretions contained almost racemic mixtures of frontalin. These behavioral responses were related to the sex, developmental stage, and physiological status of the responding individual.

Thus frontalin, as a racemic synthetic compound, elicited behavioral responses from both males and females. Female reactivity varied with hormonal state and male reactivity varied with age and musth status. Frontalin, either released in the natural TGS by older males or presented as a synthetic component, attracted reproductively ready females, but elicited apprehension from pregnant females, whereas luteal phase females were indifferent. Among males, the older adult males were mostly indifferent to frontalin in either presentation medium, whereas sub-adult males were highly reactive, often exhibiting repulsion or avoidance. Such differential responses may facilitate the smooth functioning of elephant society. This facilitation may occur among males by clarifying who is in musth, in what phase of a musth episode, and who is not, and also revealing male maturity. Females' differential responses, and thus the impact of chemical signals on them, may also affect their reproductive strategies. Many of these social influences and controls within and between male and female groups, especially those affecting breeding strategies, are mediated in large part through the dual olfactory systems.

Wild Asian male elephants are found in transitory groups if not in pairs or solitary. A male may dramatically increase its home range during the weeks when he comes into musth (Desai & Johnsingh, 1995; Fernando & Lande, 2000). Older males, especially but not exclusively, during the annual musth period apparently maintain a subtle, somewhat loose control over non-musth and younger males, and such control increases in area concurrent with home range expansion during musth. The presence of older, larger musth males is effectively signaled by their distinctive TGS and urine chemical signatures that include specific ketonic components; statistically significant captive studies have demonstrated retreat by young males to both musth males actively secreting or presented whole TGS or selected secreted compounds, such as higher molecular weight ketones and frontalin (Rasmussen & Greenwood, 2003; Perrin *et al.*, 1996). A recent anecdotal observation noted that wild elephants in Assam (NE India) were deterred from coming close to previously regularly raided paddy fields by the presence of an older (+30 years old) captive male tethered near the fields during his musth (Dr. K. K. Sarma, personal communication). Observations of wild herds have noted instances of retreat by young males in moda musth to TGS left on substrates by older males in musth (Dr. V. Krishnamurthy, personal observation). In the wild, both the presence of such older males (in musth or not) and internal physiological conditions of the moda musth state may be decisive in determining a young male's investigative behaviours toward females. Teenage males in moda musth may or may not retreat in the presence of a dominant male (especially one in musth), whereas non-musth teenage males are certain to retreat (Rasmussen *et al.*, 2002).

Captive Asian elephant studies have implicated that from a female perspective, musth males are preferred over non-musth males. Females near ovulation were observed to show more interest in urine from musth males whose serum testosterone levels are above 10 ng/ml and especially those above 20 ng/ml (Schulte & Rasmussen, 1999a). Recently our studies demonstrated the reciprocal - namely that musth males have the most direct access to females and that chemical signals influencing the outcome of male dominance interactions reinforce this superior access by musth males.

We examined this in greater behavioral depth among a wild population of elephants in Asia (Rasmussen *et al.*, 2005). Wild male elephants were identified as individuals and categorized by age (and thus size) and musth characteristics. The quantitative appraisal of musth in each male was provided using attributes of musth that included physiological and behavioural characteristics. These characteristics were scored and combined with the chemical assessment of the presence, absence, or relative amount of selected urinary ketones. These appraisals gave a measure of the maturity and degree of musth in individual wild males when compared to data available from precisely studied captive males. Our field data have shown that musth males, in comparison to non-musth males, interacted much more frequently with pre-ovulatory females and demonstrated a strikingly higher frequency of chemosensory responses to females and their urine (Rasmussen *et al.*, 2005).

Not only do musth males interact with more females and more frequently, but also specific olfactory-related responses and patterns of response vary with age and are different between musth and non-musth males. Adult males (+20 years old) while in musth demonstrate a higher frequency of responses to females than their non-musth counterparts. These responses include both distant and close sniffs, trunk tip checks to both the urogenital region of females and their expelled urine (Fig. 2), and flehmen responses. Musth males also characteristically monitored multiple females in succession. Apparently they are more skilled at detecting by olfaction the precise ovulatory status of females.

Male age (and thus size) also influenced responsivity and eventually access to females. Larger, older males (+30 years old) in musth performed significantly more distant sniffs and total contact chemosensory responses than their younger counterparts in musth and than older males not in musth. Among all three primary contact responses - urogenital checks, expelled urine checks, and flehmens - older males in musth exhibited higher responsivity than younger males in musth, with non-musth young males not showing any contact interactions with females. This avoidance of contact responses toward females suggests that perhaps either experience has taught these young males to avoid direct contact with females during their non-musth period (as females may not be interested), or male behaviours are more rational during non-musth.

Specific premating behaviours (e.g. mounting) were more frequent among young males in musth than the older group, suggesting that experienced older males could judge proximity of females to ovulation more accurately and thus expended less effort on non-fertile females. Further down the age structure, teenage males show much lower frequency of distant sniffs toward females than older males, again suggesting their inexperience in recognizing the distant odor of reproductively active females. These quantitative differences in varied responses among different categories of males offer clues about the biological roles in breeding tactics and elephant social structure.

Age revealed different frequencies of chemosensory responses and premating behaviours when teenage males (both in moda musth and non-musth) were compared with their older counterparts. Older males (+30 years old) exhibited the highest chemosensory responses, but summed chemosensory responses by musth and non-musth teenage males were slightly higher than in young adult (+20 years old) counterparts. This high responsiveness by the maturing teenage male group may reflect attempts by this male category to gain sexual knowledge about females through increased contact chemosensory responses. Inexperienced teenage males may lack knowledge of the chemical identity of the pheromone or the ability to precisely assess concentrations, either of which could be the result of learning. Teenage males are still in an experience-gaining period and thus are deciphering the attributes of female cycles, fine-tuning how to socialize with females, and decoding which males are dominant or in musth or both.

Breath also contains relevant social signals. In the somewhat redundant chemical signaling system of elephants, many communicative compounds are present in the blood and excreted or secreted into the urine, TGS or breath. The focus of much of our efforts has been on the influence of chemical signals and pheromones from the urine and temporal glands on elephant societal interactions (Rasmussen & Krishnamurthy, 2000). Our research has demonstrated a correlation between blood constituents and TGS components, yet many of these same chemical communicator molecules are excreted to the outside environment through the breath. Frontalin, indicative of musth in older males, is an especially redundant signal present in blood, TGS, urine and breath. Over a 10-year period (1994-2004), using special stainless steel evacuated canisters to collect exhalant breath, we analyzed more than 100 samples from 10 captive male elephants – both in musth and non-musth. As Asian male elephants often reduce their caloric intake during the musth state, they lose body condition (Desai & Johnsingh, 1995) and a weight loss of hundreds of kilograms has been documented in captive elephants during a musth period; such weight loss implies first a depletion of fat reserves and eventually muscle breakdown. Our breath sample analyses and physiological measurements in blood confirmed such patterns. Breath volatiles were different between male elephants in musth and those not in musth, i.e. clear-cut qualitative and quantitative differences distinguished that a spectrum of ketones, as well as several related alcohols are significantly elevated (Rasmussen & Riddle, 2004). However, while at first ketone levels increased subsequently pentane, an indication of muscle breakdown, was elevated. This correlates with documented elevations in serum lipase and triglycerides. However, the lack of changes in serum creatinine phosphokinase during musth suggests that muscle metabolism may be less affected than fat metabolism, and only after a lengthy period of starvation (Schulte & Rasmussen, 1999b; Rasmussen & Perrin, 1999).

What makes breath signals special is that they are more ephemeral than urinary or TGS secretions. They are carried in the air, probably in part on aerosols, and are usually rather volatile. They diffuse rapidly in the air medium and are subject to photo oxidation. Thus their message is immediate, often close range and non-persistent, and may be individual-to-individual communication. Further studies on the meaning of chemical signals released in breath may help explain why captive male Asian elephants in musth will blow at each other across fences or under doors, strongly suggesting a transfer of chemical signals between individuals.

In exploring breeding strategies it is noteworthy that the Asian elephant shares some breeding tactics common to other sexually dimorphic cognitive mammals, such as a