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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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Counting elephants in the wild

People in general are curious to know just how many elephants there are in an area. They are obsessed with numbers. Laymen often make the mistake of assuming that since elephants are so huge that it would be relatively easy to count them accurately in the field. Sometimes the less somebody knows about a subject, the easier they find a solution to it. Unfortunately, it is more difficult to count elephants in a forest than fish in a pond. As Cynthia Moss (1988) who has studied elephants in the wild in East Africa for more than two decades points out, it is precisely because they are so large that we can miss those animals that are either hidden behind the bulk of some huge ones or enclosed within a herd. Even in the grasslands of Sri Lanka where elephants are easily observed, sometimes one has to count a small herd of elephants several times before the exact number of animals can be determined.

To a fishery biologist, the number of fish of a particular species in a pond is important, as it constitutes a biological unit. But for an ecologist studying elephants, the size of an elephant population has very little biological significance, as the population cannot be circumscribed in the absence of clear boundaries. As Graeme Caughley (1977) argues, "density rather than size provides the biologically real measure of abundance", and "the majority of ecological problems can be tackled with the help of density, absolute estimates of density being unnecessary luxuries". Numbers do not represent much more than informed guesses. A population of 100 elephants in a particular area today would be of little significance if its habitat is to be converted to a sugarcane plantation or a housing estate in a few years' time.

Ideally, the collection of data on elephant numbers should be left to the management authority using qualified and experienced staff and standardized methods. In Sri Lanka, given the plethora of 'experts', elephant data are collected by a multiplicity of agencies and individuals using a variety of methods. Elephants are usually counted either from the air or from the ground. Ground surveys involve total counts by recognition and registration of individuals, or more commonly, dung counts. In Africa, where the bush elephant (*Loxodonta a. africana*) can be spotted easily as it moves across open savanna grasslands, the quickest technique for its census is the aerial survey conducted from fixed-wing aircraft or helicopter. Even aerial surveys are subject to considerable bias, and hence spot surveys on foot should be carried out in selected areas to establish 'ground truth' (Said *et al.*, 1995). But in Sri Lanka where the dense and tangled nature of the vegetation in the low country dry zone makes it difficult to observe elephants, aerial surveys are useless.

Estimating elephant numbers is not only difficult but expensive as well. The first attempt to estimate the number of elephants in Africa was made by Iain Douglas-Hamilton

in the 1970s, who arrived at an estimate of at least 1,300,000 animals. By 1987 the number of elephants in Africa was estimated to have declined to 750,000, and the African elephant was therefore placed on Appendix I of the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1989. Today only about 600,000 animals are estimated to be present in Africa. Much of the information on elephant numbers in Africa and Asia is pure guesswork. Given the uncertainty, in Africa elephant numbers are assigned to four groups, **Definite**, **Probable**, **Possible** and **Speculative** (Said *et al.*, 1995). Thus the lack of accuracy of the number of elephants in the wild is not something unique to Asia.

The Asian Elephant Specialist Group (AsESG) of IUCN's Species Survival Commission (SSC), puts the number of wild elephants in Sri Lanka as anything between 3,000 and 4,000. It would not be possible to come out with an accurate estimate for the total number of elephants in the wild in Sri Lanka given that much of the north and east of the island could not be surveyed, because of two decades of war. The last survey of wild elephants in Sri Lanka was carried out by the Department of Wildlife Conservation in June 1993. Although the survey revealed that at least there were a minimum of about 2,000 elephants in the so called "safe areas" (Northwest, Mahaweli, Central, Eastern and Southern regions), the objective was not to estimate the number of elephants, instead it was designed to determine the structure and composition of the various groups of elephants that were encountered. The study provided information on the age and sex ratios, proportion of calves and percentage of tuskless elephants in the populations.

All the gains in agriculture, literacy, healthcare in Sri Lanka are being undercut by one basic fact: the island's human population has increased from 3.6 million (or 55 people per sq.km) in 1900 to more than 19 (or 290 people per sq.km) in 2003. The trend in natural forest cover runs counter to the human population growth. As the forester R.W. Szechowycz (1956) pointed out almost 50 years ago, "Ceylon (as Sri Lanka was then known) from a point of view of forestry is analogous to a crowd of people moving happily around a floating ice which melts quickly till finally nothing stands under their feet". With an estimated forest cover of less than 23%, we are rapidly heading towards this situation. With the conversion of forest to other land uses, the elephant is running out of space in Sri Lanka. Most of the protected areas inhabited by elephants are small, less than 1,000 sq. km in size; nevertheless elephants, especially the bulls, may range over hundreds of square kilometers. The land/man ratio has declined from 2.7 ha in 1871 to less than 0.35 ha in 2000. The factors adverse to the survival of the elephant outside the protected areas stem not only from sheer growth in human population but also from the demands of the urban rich for goods of the kind that contribute to the degradation of elephant habitat. Their sheer size and gargantuan appetite mean that elephants and people cannot live together where agriculture is

the dominant form of land use, unless the damage they cause to farmers can be compensated. There are no easy solutions for resolving the human-elephant conflict in Sri Lanka. Much will depend on how rural people, gripped in the poverty vortex associated with poor soil and unreliable rainfall, perceive the worth of the elephant. To stop the wanton killing of elephants requires changing the perceptions of the farmers who suffer constant depredations from the animals. The capture of some elephants as a short-term solution was recommended long ago by Mr. Christy Wickremasinghe (retired Divisional Game Ranger of DWC) in 1964. The Ex-

President of the Wildlife and Nature Protection Society, Mr. Thilo Hoffmann too recognized the need to capture, over a few decades, as many as 1,000 elephants from areas outside the protected reserves. Unfortunately, their recommendations fell on deaf ears. Many are now convinced that the only way man and elephant can exist successfully in the same environment is through finding ways to use the elephant as a sustainable economic resource. In the final assessment, it is understanding rather than sentimentality that will do most for the conservation of the elephant.

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References

- Caughley, G. (1977) *Analysis of Vertebrate Populations*. John Wiley & Sons, Chichester
- Moss, C. (1988) *Elephant Memories: Thirteen Years in the Life of an Elephant Family*. Willima Collins Sons & Co. Glasgow.
- Said, M.Y., Chungue, R.N., Craig, G.C., Thouless, C.R., Barnes, R.F.W. & Dublin, H.T. (1995) *African Elephant Database 1995*. IUCN, Gland, Switzerland
- Szechowyez, R.W. (1956) Some observations on the forests of Ceylon. *The Ceylon Forester*, 2: 192-198



A herd of elephants in Minneriya National Park, Sri Lanka. (photo: S. Wijeyamohan)

Guest Editorial

The meeting of the Asian Elephant Specialist Group (AsESG) at Phnom Penh, Cambodia, in May 2002 took stock of the status of elephant population and the conservation issues in the course of revising the Action Plan of 1990. The issues have largely remained as before – loss and fragmentation of habitat and escalating elephant-human conflict, in addition to poaching and a crisis with captive animals. We now have a much better appreciation of the magnitude of poaching for ivory and other products. The programme of Monitoring the Illegal Killing of Elephants (MIKE) under the auspices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), already operating in Africa, is now beginning in Southeast Asia and South Asia. A task force of the AsESG has also been working on a framework for the welfare and management of elephants in captivity.

The meeting brought in newer information of the status of elephant populations. With a few exceptions the news is grim – the Asian elephant is in dire straits in the Indo-China region, continues to be captured in significant numbers in Sumatra, and seems destined to lose habitat rapidly in Borneo. Even in India where the elephant is still holding its ground in terms of population numbers or even increasing in size, a combination of factors including escalating elephant-human conflict (in the east-central region), the selective poaching of tusked males (mainly in the south but also elsewhere), and deforestation (in the northeast) poses a threat.

The most exciting new information on the Asian elephant is undoubtedly the molecular genetic structure of the species emerging from the work of one of our members, Dr. Prithiviraj Fernando, working on populations across the range of the species outside India, and of Ms T.N.C. Vidya working primarily on the Indian populations. This work has been carried out using a non-invasive technique of extracting tiny amounts of genetic material (DNA) from the dung of wild elephants. Work on mitochondrial DNA (inherited maternally) and the nuclear DNA is underway. The results, some of which were recently presented at a symposium of the Society for Conservation Biology (held at Canterbury, U.K. in July 2002), promises to take our understanding of the phylogeography of *Elephas maximus* to a new level. This has important implications for conservation strategies of the species.

Sri Lanka has high genetic diversity among its elephant populations going by the amazing number (more than 15) of “mitochondrial haplotypes” seen across the island country. In contrast, the large elephant populations of southern India are low in mitochondrial genetic variation. The Indo-China region, whose elephants are in a precarious state, also seems to have high genetic variation in some of its small populations. There is however no case for treating the Sri Lankan elephants as a distinct sub-species because many of the haplotypes here are shared with populations on the Asian mainland. On the other hand, the Sumatran elephant, along with those of

peninsular Malaysia, does show a certain distinctness. Another interesting result has been from the island of Borneo (the origin of the elephants here has been a matter of speculation). Preliminary work on the elephants of Borneo indicates a unique mitochondrial haplotype not found anywhere else in Asia.

The genetic information on Asian elephants will give us an additional criterion, as important as population or habitat size, for recasting the framework under which conservation strategies and priorities are worked out. The implementation of conservation strategies and plans is however a more complex affair that is linked to the rapidly changing social, economic and political landscape of the elephant range states across Asia.

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A young tuskler from Sri Lanka
(Photo: courtesy: Dr. H. I. E. Katugaha)

Secondary sexual characteristics in relation to the health status of male Asian elephants in Nagarhole National Park, southern India

Cheryl D. Nath

Abstract This paper presents the results of a six-month study on the relationship between exaggerated secondary sexual characteristics and health status in male Asian elephants. The aim of the study was to find out if tusk length and musth intensity serve as honest signals of genetic quality that might enable female elephants to distinguish between potential mates, as suggested by the sexual selection theories of Zahavi (1975) and Hamilton & Zuk (1982). For this purpose, the intensity of musth and the tusk length of 30 individually identified wild male elephants in the Nagarhole National Park, Southern India, were examined in relation to two health status indicators: external body condition and intestinal helminth parasite load. The study produced some interesting results. Individuals exhibiting signs of early musth had significantly better body conditions and lower parasite loads than individuals exhibiting no signs of musth. However, longer tusks were not significantly related to better health indicators in the sample population. Dominance behaviours

recorded in dyadic interactions among male elephants indicated that dominance was associated with musth, height of the animal and tusk length in a high percentage of interactions. These results indicate that musth has the potential to be considered an honest signal of good health in male elephants, and hence female elephants might use this information when choosing mates. Since the period of research was short and the sample sizes of identified males might be considered small, these findings need corroboration by further investigations in this and other populations of wild Asian elephants. The study does provide a good basis for future investigations of musth as a signal of genetic quality and as an honest signal of handicap to female elephants and to humans trying to conserve the genetic fitness of this species in the long run.

Keywords musth, elephants, sexual selection, behaviour, parasite load, Nagarhole National Park.

Introduction

The development and expression of secondary sexual characteristics to apparently maladaptive extremes is an interesting and highly discussed phenomenon (Mayr, 1972; Kirkpatrick, 1982; Maynard Smith, 1991). Examples of exaggerated development of secondary sexual traits, which occur commonly in male animals (Kirkpatrick & Ryan, 1991) include the long tail plumes of birds, bright colours of butterfly wings and large, elaborate antlers of deer. Such exaggerated development has been attributed to consistent and heritable choice of these extreme characters by females (Fisher, 1930), and to the use of extreme phenotypic characters as signals of genetic quality by males (Zahavi, 1975, 1987; Hamilton & Zuk, 1982). Extremely developed secondary sexual traits in males have good potential to serve as signals of quality to females due to their higher intrasexual variances within populations, in comparison to other traits (Moller, 1994). This large range of variance exhibited by secondary sexual character traits (sometimes referred to as male ornamentation or sexual signals) may provide the basis for discriminatory choice of males by females.

Consistent selection of mates by females, on the basis of sexual signals, is a critical aspect required for exaggerated male signals to develop over evolutionary time (Darwin,

1871). Several theories have been advanced to explain the basis of consistent female choice of exaggerated and apparently maladaptive male characteristics. Fisher (1930) proposed that females might initially prefer a particular trait that reflects some aspect of male genetic quality. Subsequently the preference for this trait that is inherited by succeeding generations of females would cause the "runaway" development of the trait in succeeding generations of males who inherit that signal characteristic from their reproductively successful fathers.

An alternative to Fisher's 'Runaway Hypothesis' was provided by Zahavi's (1975) 'Handicap Principle', according to which females who always choose mates based on a signal that provides current information about male quality would always benefit from better genes for their offspring. Hence, males that signal their quality are more likely to be chosen than males that do not signal their quality. Further, only honest signals that consistently and objectively represent differential qualities of different males can serve as effective sexual signals, ensuring that signalling and signal-based choice do not lead to selection of poor quality males (Zahavi, 1987, 1991, 1993). In animals that do not exhibit paternal care of offspring, such as elephants, choice of good quality males to sire their offspring may be critical for females, who may rely heavily on honest signals of quality by males. Improved female discriminatory ability is constantly demanded and would benefit from increasingly finer resolution between competing male signals. Simultaneously, competing males across populations and successive generations would benefit from marginal increases in the magnitude of their signals (within biological limits), given female fidelity to those particular signals across populations and generations. The

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large range of signal variance between competing males might then produce some males that have developed the traits to such an extreme that their own survival is compromised by those highly developed traits. They thus become handicapped, although not severely compromised in terms of their survival prospects, by their signalling traits (Zahavi, 1977). A crucial argument of this theory is that only those males of exceptionally good genetic quality would be capable of producing and sustaining this handicap signal, while it would be extremely deleterious or lethal for an individual of poor genetic quality to produce or maintain the same signal. However, given consistent female preference for males exhibiting comparatively "better" signals, overdeveloped secondary sexual characters may ultimately confer a selective reproductive advantage that offsets the survival disadvantage in those males.

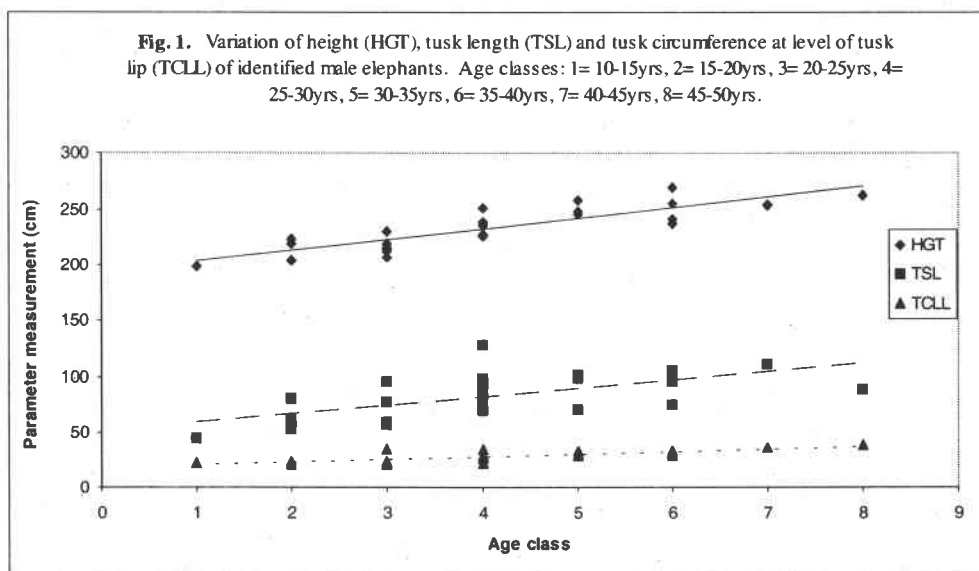
A similar theory put forward by Hamilton & Zuk (1982) argued that bright plumage in male birds might signal their genetic ability to resist chronic parasite infestations. Only very healthy birds would be able to invest in and maintain bright plumage, while weak and parasitized birds would have relatively dull plumage.

Among elephants, we can expect the evolution of discriminatory choice of males by females due to the higher Investment in reproductive and parental effort by females (Poole, 1989b). On the other hand, males need to convey information about their genetic fitness effectively due to the high variance in reproductive success between individual males. The reason for high variance in male reproductive success may be the polygynous nature of elephant societies, which often results in a high proportion of all matings in a season or year being carried out by a few dominant ('high quality') individuals (Poole, 1989a; 1989b; Poole & Moss, 1981). This may favour the development of sexual signals that effectively convey the message of good quality genes in dominant males. In addition, the lack of synchrony in fertile or rut periods of male and female elephants results in severe competition around the few widely dispersed fertile females at any given time. Male elephants may experience musth (heightened sexual activity period) for varying lengths of

time during any season in a year (Poole, 1987; 1989a), just as females appear to come into oestrus once every 16 weeks (Hess *et al.*, 1983; Poole, 1989b). As a result, efforts are spent on signalling to and searching for mates (Poole & Moss, 1989). Signals that improve the likelihood of bringing together potential mates would tend to be selected over time (Rasmussen *et al.*, 1986; Poole, 1989b; Rasmussen, 1999).

The use of secondary sexual characters as honest signals of quality by male elephants was first investigated by Watve & Sukumar (1997), in their study of tusked male Asian elephants of Mudumalai Wildlife Sanctuary in southern India. Their study showed that the magnitude of positive deviation in tusk length from a standardised tusk length curve was significantly negatively correlated with intestinal helminth parasite load. Thus male elephants with relatively longer tusks apparently had relatively smaller intestinal helminth parasite loads. It was suggested that tusk length might serve as an honest signal of quality, within the framework of Hamilton & Zuk's (1982) theory of heritable true fitness. Since very long or crossed tusks may impose a heavy burden or hinder trunk movements when feeding, it was further suggested that longer tusks were also potential candidates in support of the Handicap Principle (Zahavi, 1975).

In addition to tusk length, in this study the phenomenon of musth was also considered as a potential sexual signal by male elephants. Musth in male elephants is a secondary sexual characteristic that aids in reproduction and dominance (Eisenberg *et al.*, 1971; Eisenberg & Lockhart, 1972; Poole, 1987). Among captive elephants in India, musth was found to be expressed more fully by male elephants in good health when compared with males in poor or debilitated condition (Chandrasekharan *et al.*, 1992). Testosterone levels in the body are elevated to around five times their usual levels (Poole *et al.*, 1984; Rasmussen *et al.*, 1996). This would serve to reduce the animal's immunity substantially, as elevated testosterone levels have been associated with reduced immunocompetence (Folstad & Karter, 1992). In addition, male African elephants in musth are known to greatly reduce the proportion of time spent on feeding, which could lead to a loss of body condition during this period (Poole, 1989a). Furthermore, the greater



the length of time spent in musth, the higher are the costs in terms of total body condition loss. In some cases, considerable loss of water, often a critical resource for elephants, results from the practice of dribbling urine continuously while moving, during the period of musth (Poole & Moss, 1989; Chandrasekharan *et al.*, 1992). Urine dribbling is thought to warn other males as well as to alert oestrus females who come across the urine path, of the presence of a musth (and hence more dominant) bull in the area (Poole, 1989a; 1989b). Musth is thus a particularly complex and highly developed secondary sexual character in male elephants, whose high physiological cost makes it a potential sexual signal.

This paper reports on a study of musth and tusk length of individually identified male Asian elephants, in relation to their health status. As both these characters have aspects that can be considered maladaptive if excessively developed, the study investigated their potential to serve as signals of individual genetic quality and as handicap signals to facilitate female choice. The main aim of this study was to test the relationship between the secondary sexual character traits, musth and tusk length, and two chosen indicators of genotypic quality in wild male elephants. The indicators of genotypic quality (as expressed by the current health status) chosen for this purpose were overall external physical (body) condition and internal helminth parasite burden (parasite load or parasite density). A subjective composite score called the "Body Condition Index" (BCI) and the objectively quantified helminth parasite propagule density (referred to as "parasite load") per individual were used as indicators of health. Increasing values of both scores were associated with declining health (i.e. declining external body condition or increasing parasite load) in the animals studied.

The following *a priori* assumptions were made, on the basis of published information, in order to take up the study:

1. The selected secondary sexual traits are heritable. Support for the assumption that secondary sexual characters are heritable comes from studies on antlers in male deer, a secondary sexual character that is believed by many to play an important role in mate selection by female deer. Goss (1983) mentions the importance of inheritance and hormonal regulation in shaping antler morphology, while experiments

performed by Harmel (1983) on white-tailed deer showed that although diet and nutrition may influence antler growth, genetics are of overriding importance in determining antler presence, length and quality. Further, another study by Scribner & Smith (1990) suggested that genetic heterozygosity might influence antler growth and size.

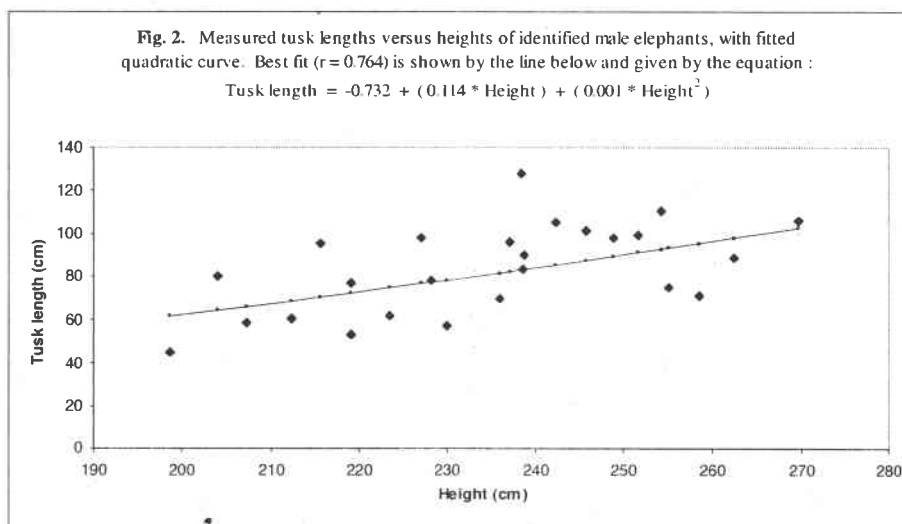
2. Female elephants in oestrus are selective in allowing male elephants to mate with them. This assumption of female choice of their mates is supported by long term studies of female African elephant behaviour (Moss, 1988; Poole, 1989b) and anecdotal evidence on captive and wild female Asian elephants (de Launey, 1938; Stracey, 1963; Krishnan, 1972).

3. Mate choice by females is based mainly on the genetic quality of males, which is indicated by the degree of exaggeration of selected sexual signals. Although this assumption is difficult to verify in the field, mathematical models of sexual selection (Kirkpatrick, 1982; Grafen, 1990) have shown that heritable characteristics of males, if consistently selected by females over several generations, can become stabilised in those populations.

Hypotheses were developed in the following manner for testing in the field:

Musth and relatively long tusks are signals of good health: If musth is a true signal of good quality, we would expect body condition to be very good before (or just before) an individual is able to attain and advertise a state of musth. Hence, assuming that musth intensity across individuals reflects comparable states of health and body condition, individuals exhibiting early stages of musth would be expected to have better health indicator values than other individuals. Further, we could also reasonably expect that the body condition of an individual would show a declining trend as musth intensity increases, if musth is truly a handicap to the individual. The durations of single episodes of musth show high variability across individuals. Reports range from a few days to several months of sustained musth for different animals (Toke Gale, 1974; Poole, 1987; 1989a; Chandrasekharan *et al.*, 1992). Poole (1989a) found that most males suffered increased weight loss as their duration of musth increased. Thus, the high

Fig. 2. Measured tusk lengths versus heights of identified male elephants, with fitted quadratic curve. Best fit ($r = 0.764$) is shown by the line below and given by the equation :
Tusk length = $-0.732 + (0.114 * \text{Height}) + (0.001 * \text{Height}^2)$



variation associated with this trait may be linked to individual abilities to overcome the physiological costs associated with sustaining musth over long time periods. With regard to tusks, as shown by Watve & Sukumar (1997), tusk length was expected to be significantly negatively correlated with intestinal helminth parasite loads and with body condition. Using subjective scores for musth intensity (Musth Composite Index or MCI) and external body condition (BCI), and objective assessments of helminth propagule densities per individual, the following hypotheses were tested:

1. Individuals in early musth or with relatively long tusks were expected to have better health indicator values than individuals which did not attain musth or which had relatively short tusks, respectively.

2. Health indicators for individuals during single episodes of musth, were expected to show a decline in health, as musth intensity and duration increase. (This relied on repeated samplings of identified individuals during single episodes of musth.)

Correlation between the two signals and relationship to social dominance hierarchies:

If both musth and tusk length are positively associated with higher health indicator values, then we can reasonably expect them to be correlated with each other. Thus they may be used together complementarily as signals of overall health and fitness. Furthermore, if health is an important criterion for signalling genetic quality to females, it may also be reflected in male-male dominance interactions. Dominance was examined in relation to sexual behaviour because elephants tend not to defend territories or food resources. Nevertheless, when guarding a female, the mate as a resource would be of great value to a dominant male (Poole, 1989a). Dominance is thus likely to play a significant role in male reproductive success and in female choice. Hence the following hypotheses were tested:

1. MCI and tusk length are correlated with each other.

2. Dominance in male-male interactions is associated with greater ability to come into musth and with longer tusks.

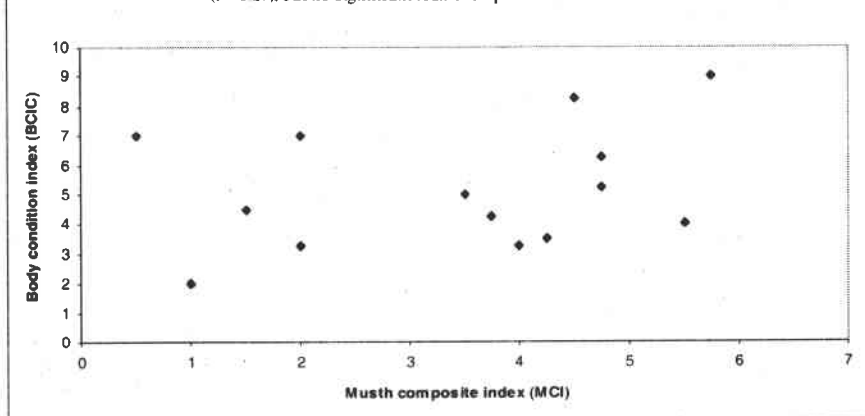
Study area

The study was carried out in the Nagarhole National Park in Karnataka, southern India, from mid-November 1998 to early May 1999. Healthy populations of large mammals such as the elephant (*Elephas maximus*), tiger (*Panthera tigris*), gaur (*Bos gaurus*), spotted deer (*Cervus axis*) and sambar (*Cervus unicolor*) are found in this area throughout the year. The Park is located between 11° 50' – 12° 15' N and 76° 0' – 76° 15' E, and has an area of 644 km². The study was carried out in an approximately 100 km² area on the eastern side of the Park.

Vegetation types in the study area included mostly dry and moist deciduous forests with an east-west gradient from drier to wetter types. The park receives much of its rainfall (900–1500 mm (Karanth & Sunquist, 1992) during the first monsoon (June–September), and continues to receive small quantities at other times, including the second monsoon (October–December). The south-eastern side borders the Kabini reservoir, which resulted when the Kabini River dam was completed in 1974. Clearance of forest vegetation to accommodate this reservoir has led to increased utilisation of this area during the dry and hot summer months of March–May, when the water level in the Reservoir drops and the extensive grassy banks exposed by the receding waters are exploited by grazing ungulates and elephants.

The flora is dominated by deciduous species such as *Anogeissus latifolia*, *Tectona grandis*, *Lagerstroemia microcarpa*, *Albizia* spp., *Grewia tiliacifolia*, *Bombax ceiba*, *Ficus* spp., *Butea monosperma*, *Careya arborea* and *Embilica officinalis*. Common shrubs include *Ziziphus* spp., *Lantana camara* and *Helicteres isora*. Extensive teak and eucalyptus plantations are found along the banks of the reservoir. *Bambusa arundinacea* and

Fig. 3. Relationship between musth intensity (indicated by MCI) and body condition index (BCIC), from sightings of male elephants in musth. There was a minor trend of association ($r = 0.27$), but no significant relationship between MCI and BCIC.



Dendrocalamus strictus grow thickly along the banks and in the interior areas.

The population of elephants in the park was estimated to be roughly 1448 (Alva, 1994), of which some are likely to be migratory. Between November and December maximum elephant movement occurred in the Antharasanthe Range, away from the Kabini reservoir. During this time elephants used waterholes near the Park boundary in close proximity to agricultural fields. In January and February (after the crops were harvested), elephant movements were higher in the more interior areas of the Park, although some males frequented the Kabini reservoir banks, feeding on bamboos and other shoreline vegetation. During March-April, however, peak elephant activity occurred along the Reservoir banks. Many female-led groups may have converged to form large groups totalling up to 50 animals while grazing the banks. This may have been an additional attraction for adult males who may have followed the family groups into this area. Interior areas of the Park were almost devoid of elephants as the smaller waterholes began to dry up in late February.

Data collection was facilitated greatly by the large congregations and tendency of elephants to remain resident on the banks of the Reservoir during March and April. As a result, social interactions could be clearly observed at close proximity and recorded continuously for long periods of time per day.

Methods

Identification, ageing and measurement of individuals

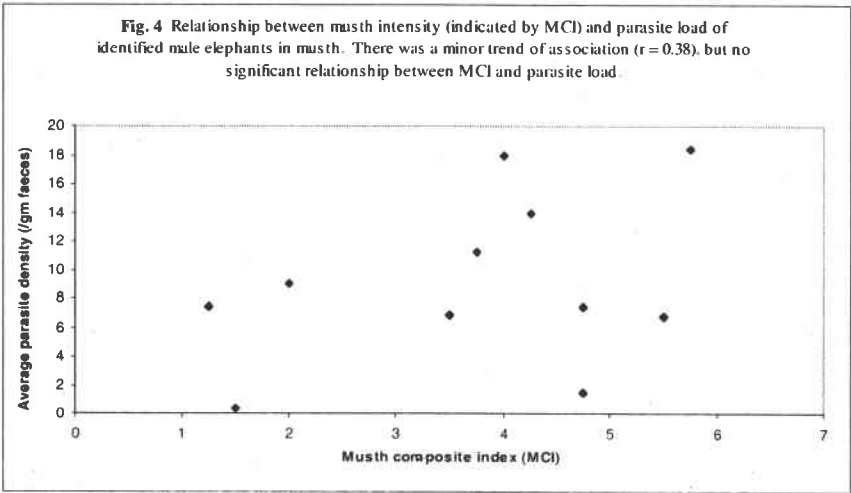
Individual male elephants were identified by photographing them and recording details of their tusks, ears, tails, backbone, "handedness" of trunk (or sidedness, as each individual used only one side of the trunk tip consistently when grazing), pink colouration, warts, wounds and bumps. These methods have been successfully used to uniquely identify large numbers of African elephants (Douglas-Hamilton, 1975; Moss, 1988). For the duration of this study and the number of elephants identified, a combination of all or most of the above features proved satisfactory for accurate

characterisation of different individuals. During the study 37 male elephants were positively identified (4 of these were estimated younger than 15 years old). Of these, 30 elephants were used in the analysis (two of which were estimated to be less than 15 years). Eleven elephants were seen in musth, of which data from 10 elephants were used in analyses.

Ages were estimated in the field by assessing height, tusk thickness at lip level, ear folding at the top edge, temporal depressions and body size. Elephants were assigned to 5-year age class intervals ranging from 10 to 50 years (8 classes) in the field. Whenever possible the circumferences of forefoot prints were recorded as this value doubled gives a rough field estimation of the elephant's height (Sukumar *et al*, 1988). Photographic records for measurement of height and tusk length were obtained by photographing elephants broadside on and then photographing a Field Assistant standing in exactly the same spot as the height reference. This method gave an error of 3-5% in repeated photographic encounters of individuals. The heights measured in this manner were consistently lower than those corresponding to the standard age-height-weight chart for elephants of southern India, established by Sukumar (1989). However, for the purpose of this study, absolute heights of individuals were not as important as consistency in the method of height estimation. Since the bias appeared consistent across all individuals, the heights obtained in this manner were considered suitable for further analysis.

Subjective Indexes

The overall external body condition was used as a first measure of the health status of individuals. A simple cumulative score of body condition, called the body condition index (BCI), was obtained on each encounter with an animal by scoring visibility of the backbone, ribs, pelvic girdle, pectoral girdle, buccal depression and temporal depression on a scale of 0-3. The scores for each of the physical features was then added up to give an additive BCI score. From previous field observations, older animals were generally thought to show increased facial depressions. Hence the BCI composite index, BCIC (described above), was divided into the BCI (Body), BCIB, and the BCI (Face),



BCIF, for better resolution of differences reflecting health, if any. These indexes could take the following ranges of values: 0 to 18 for BCIC, 0 to 12 for BCIB, and 0 to 6 for BCIF.

Musth intensity was rated similarly, to provide a cumulative musth composite index (MCI, ranging in value from 0 to 9), by subjectively assessing the following three externally visible characteristics of musth (Poole, 1987):

1. *Temporal gland swelling*. Values ranged from 0-3, depending on whether there was no swelling, the temporal gland area was flush with the skull, the gland was slightly swollen or the gland was prominently swollen.

2. *Temporal gland secretion (TGS)*: A copious discharge of fluid from the swollen temporal gland in male Asian elephants is a sure sign of the occurrence of musth. Rating of this feature ranged from 0-3 depending on the length and width of TGS flow down the side of the face.

3. *Urine dribbling*: This was rated on a scale of 0-3 depending on the rate of passive flow of urine, which is known to be a common feature of musth males, especially during peak musth. During this study, however, urine dribbling was observed only on two occasions. In the first case it was observed as an irregular wetness on the inner side of the hind leg of a musth male, and in the second case the entire inner side of the hind leg was wet and the male, in peak musth, was in hot pursuit of a female elephant. The actual dribbling of urine in the form of droplets, a thin stream or a steady flow, as described in African elephants (Poole, 1987), was not observed during this study.

Helminth parasite assessment

Samples of freshly dropped faeces were collected for quantitative estimation of helminth parasite propagule (eggs or ova) densities, after the method of Watve (1992). 4-8 gms

of fresh faeces from identified male elephants were collected and preserved in 10 ml of 10% formalin in the field. These were later filtered to remove fibres and large plant material, and centrifuged at 2000-3000 rpm for 5 minutes to concentrate ova in the pellet. The pellet was resuspended in 10 ml of saturated zinc sulphate solution and centrifuged at 2000-3000 rpm for 5 minutes to concentrate ova in the top layer of supernatant solution. An L-shaped wire loop was used to transfer the floating eggs onto a microscope slide for counting at a magnification of 100x.

The main types of parasites identified (using the references: Soulsby, 1973; Sloss & Kemp, 1978; Watve, 1992) were:

1. Strongyles and strongyle-like eggs of Class Nematoda (not distinguishable, but probably including *Quilonia* spp., *Murshidia indica* and *Coniangium* spp.) formed the bulk of the ova counted and ranged from 74-89 microns x 35-50 microns.

2. Spiroid nematode, *Parabronema* spp. 79 x 35 microns.

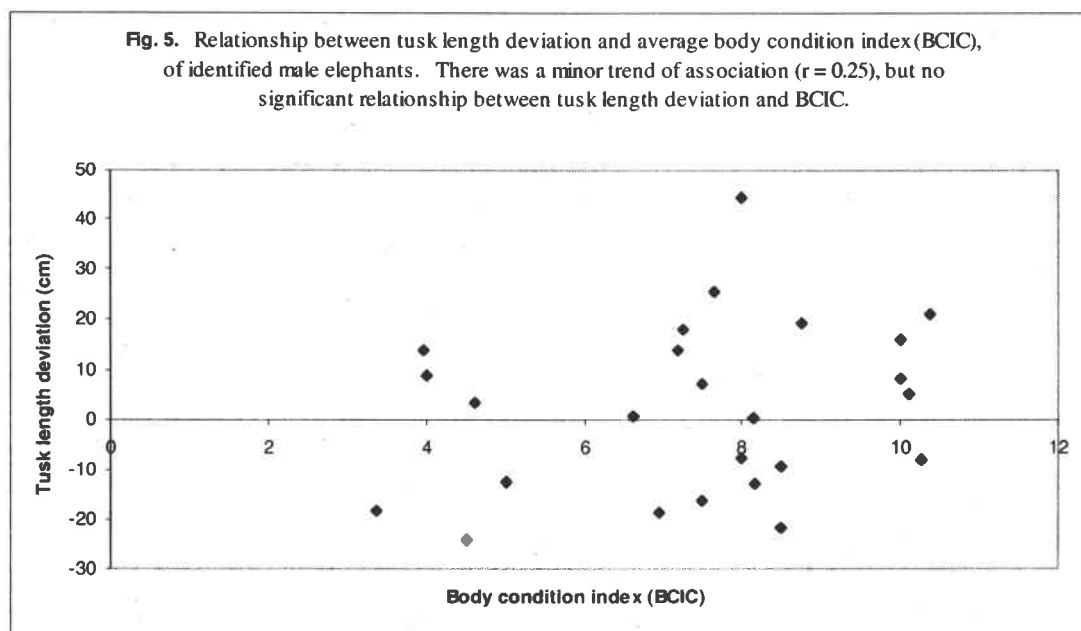
3. Tapeworm, *Anoplocephala* spp., 89 x 55 microns.

4. Other large trematode eggs, fluke eggs, 220-300 x 80-100 microns.

Total parasite loads per gram of sample were calculated for each individual. This value, representing internal helminth parasite load, was expected to provide a close approximation of the overall parasite resistance of individual hosts.

Behavioural sampling

Behavioural sampling of interactions between identified individuals was carried out using mainly focal group sampling (FGS). In FGS continuous monitoring of interacting elephants was carried out by focusing on each individual of the group in turn and recording its behaviour for 10-15 secs (including all actions initiated and received by that individual and its recipient or initiator), before moving on to the next



animal. This method ensured that all individuals of the group were represented approximately equally in terms of time and maintained a reasonably continuous record of behaviours of all individuals throughout the sampling interval.

Nine group interactions between identified individuals were examined for dominance interactions. The chosen behaviours were subjectively designated as dominant or subordinate, *a priori* (see Appendix), as small sample sizes precluded a conventional dominance analysis. Typical dominance behaviours observed were approach-retreat sequences, the use of trunk, tusk or body to push subordinates, and directed threats such as stamping or rubbing the forefoot in mud and throwing trunkfuls of earth over the head while facing the subordinate individual. Eleven group interactions were analysed for evidence of musth and other sexual behaviours. A complete list of behaviours used for analysis is provided in the Appendix.

Of the interactions recorded, 5 were paired interactions (Dyads) and 4 interactions involved 3 males (Triads). Two of the 4 triadic interactions had a single musth male interacting with 2 non-musth males. Dominant and subordinate behaviours were tallied for each individual and dominance within dyads was assigned to the individual that demonstrated higher frequency of dominant behaviours and/or lower frequency of subordinate behaviours. Triads were analysed for dominance in pair-wise interactions and dominance was assigned as described above.

Statistical Analysis

All distributions were assumed to be normal and hence parametric statistics such as Pearson's *r*, Student's *t*-tests, single factor ANOVA and binomial distribution probability test for parametric distributions were used. If a correlation was found to be significant but low, the Spearman rank correlation test was used to provide additional information.

In order to normalise the tusk length distribution (Sections 4.2.4 and 4.5.2), best fit curves were fitted to the data using the program CurveExpert (version 1.3). Deviations of measured tusk lengths from the standard curve were then used to assess the relationship between tusk length and other parameters.

Results

Details of parameters

Data was collected on identification of individuals, height, tusk length and circumference, external body condition (BCI), musth intensity (MCI), parasite load (/gm faeces) and social behaviour. It was not possible to collect all types of data from every encounter with elephants, nor to obtain re-sightings of every identified male. However, 17 identified males were re-sighted at least once during the study period and 11 were re-sighted more than once. Distribution of heights, tusk lengths and tusk circumferences (at the level of the tusk lip) across the sample of all identified elephants is shown in Table 1. The measured heights of all individuals showed good agreement with the subjective field assessments of age (Pearson $r = 0.85$, $df = 23$, $p < 0.001$) when compared with those of tusk length (Pearson $r = 0.61$, $df = 23$, $p < 0.02$) and tusk circumference at lip level (Pearson $r = 0.76$, $df = 23$, $p < 0.001$) (Fig. 1). Hence in further analyses, height was used as a proxy for age (since age could be resolved only to the level of 5-year age classes).

For all other parameter data collected, summary details are shown in Table 2. Faecal samples were obtained more than once from 10 individuals, which allowed for an assessment of intra-individual variation in total parasite loads. For these 10 individuals intra-individual variation was relatively high, and ranged from 0.5 to 33.2 parasite propagules/gm with an average variation of 13.1 propagules/gm (equivalent to 109% of the average parasite load in the sample population). In

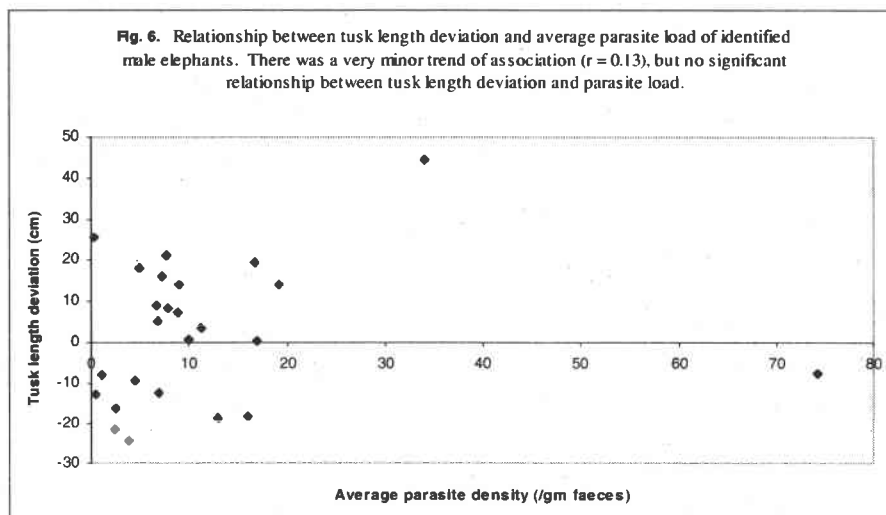


Table 1 Summary data on heights, tusk lengths and tusk circumferences at the level of tusk lip (TCLL) for all identified male elephants. Elephants are grouped into 8 age classes, based on subjective assignment of age in the field (n = number of elephants).

Age class	N	Height (cm)	Tusk length (cm)	TCLL (cm)
		Average ($\pm$ S.E)	Average ($\pm$ S.E)	Average ($\pm$ S.E)
10-15	1	198.7	45	22.7
15-20	3	215.5 ($\pm$ 20.0)	65.1 ($\pm$ 26.9)	22.8 ($\pm$ 3.6)
20-25	5	216.8 ($\pm$ 16.7)	69.7 ($\pm$ 32.8)	24.5 ($\pm$ 11.2)
25-30	7	236.9 ($\pm$ 16.0)	92.4 ($\pm$ 37.0)	29.0 ($\pm$ 8.5)
30-35	3	251.1 ($\pm$ 13.0)	90.3 ($\pm$ 33.0)	30.7 ($\pm$ 4.0)
35-40	4	251.1 ($\pm$ 28.6)	95.7 ($\pm$ 28.3)	31.4 ($\pm$ 3.7)
40-45	1	254.3	111.1	36.1
45-50	1	262.4	88.7	38.9

the case of BCIC, intra-individual variation was relatively low for the 15 individuals that were sampled more than once. It ranged from 0.25 to 6.0, with an average BCIC variation of 2.7 (equivalent to 36% of the average BCIC in the sample population). For all re-sighted individuals, parameter values were averaged when comparing across individuals.

Investigation of age effects on all parameters

The age of an elephant can affect the development of several character traits and is responsible for some proportion of the observed variance across individuals. Since elephant tusks continue to grow throughout the life of an individual (Sukumar, 1989), age is expected to be partially responsible for longer tusks in older males, regardless of their health. In the case of musth, however, the effect of age on the ability of males to attain and sustain musth has not been clearly established. Although captive Asian elephant bulls have been known to exhibit signs of musth in their early to mid teens (Eisenberg *et al.*, 1971; Chandrasekharan *et al.*, 1992) wild African elephant bulls were seen exhibiting signs of musth only after the age of 20 years (Poole 1987, 1989a). It is possible that the intensity of musth is affected by age due to physiological processes not necessarily related to health. Thus, the confounding effects of age on the two secondary sexual characters of interest, as well as on the two chosen health indicators, were examined and eliminated as described below. In all cases, individual's heights were used as proxies for their age.

Age effect on tusk length:

Tusk lengths were significantly correlated with heights (Pearson $r = 0.57$, $df = 23$, $p < 0.005$ and Spearman $r_s = 0.57$, $n = 25$, $p < 0.005$), indicating the strong influence of age on tusk growth. This was an expected relationship and was eliminated before proceeding further with analyses. For

this purpose, a quadratic curve was fitted to the data to obtain the best fit between tusk length and height ($r = 0.764$, Fig 2). This curve gave the following relationship:

$$\text{Tusk length} = -0.732 + (0.114 * \text{Height}) + (0.001 * \text{Height}^2)$$

This curve was used to predict the expected or average tusk lengths for all heights measured. Individual tusk length deviations from this curve were then used instead of actual tusk lengths to investigate relationships between tusk growth and other parameters, as previously done by Watve and Sukumar (1997).

Age effect on musth:

During the study, only males subjectively aged between 25 and 40 years exhibited symptoms of musth. When elephants were grouped into 10-year age classes, the modal class for musth males was the 30-40 year class, containing 67% of all musth males seen, with only 1 out of the 7 males in this class not exhibiting signs of musth during the study interval. There was no correlation between the average MCI (musth composite index) and heights of individuals, and hence no correction for age effects was required.

Age effect on health indicators:

Body condition indexes were checked for correlations with height. Significant correlations were obtained for BCIC (Pearson $r = -0.48$, $df = 23$, $p < 0.01$ and Spearman $r_s = -0.39$, $n = 25$, $p < 0.05$) and BCIB ($r = -0.54$, $df = 23$, $p < 0.005$ and Spearman $r_s = -0.51$, $n = 25$, $p < 0.005$), reflecting a possible improvement in external body condition with increasing age (the r value is negative because lower BCI values indicate better external body condition). However, this was found to be an effect of musth because removal of

Table 2 Summary information of data collected from wild male elephants during the study. For those elephants encountered more than once, average parameter values per individual were used in the calculations below. (n = number of elephants).

Parameter	n	Range	Average	Standard Deviation	C.V.
Height (cm)	25	198.7 - 269.8	234.5	19.0	0.08
Tusk length (cm)	25	45 - 127.8	83.6	20.8	0.25
MCI	10	0.5 - 5.5	3.4	1.60	0.53
BCI(Composite)	28	3.38 - 11	7.6	2.15	0.28
BCI (Body)	28	1 - 7	4.4	1.57	0.36
BCI (Face)	28	1 - 5	3.2	0.98	0.31
Parasite (/gm)	30	0.25 - 74.2	12.0	14.5	1.21

all BCI values belonging to musth males caused reductions in both of the above correlation values ($r = -0.03$ and -0.12 , respectively, non-significant relationships). This indicated that external body condition was not related to age when animals were not in musth, and thus no correction for age effects was required in the case of BCI. Facial depressions, approximated by BCIF, were not correlated with height (or age) in musth and non-musth animals. This contrasted with the common field perception that older animals generally tend to have more prominent facial depressions. There was no significant relationship between heights of individuals and their average parasite loads, and thus no correction for age effects was required.

Investigation of relationships between and among health indicators

Interactions among health indicators

No significant correlations were found between the three body condition indexes and parasite load, in both musth and non-musth animals. This indicated that the two types of health indicators were independent of each other in this study.

Season effect

The effect of different seasons on BCI and parasite load was investigated by testing health indicator data in month-wise pairs. Significant differences in parasite densities were found only between the months of January and April (using Student's t-test for samples with unequal variances, $p < 0.015$). However, the sample size in January was 2, in comparison with a sample size of 23 in April. Thus, it is likely that a few very high values in April were responsible for the significant differences in parasite densities between the two months.

The data set was then divided into Season 1 which included the winter months of December, January and the first half

of February, and Season 2 which included the summer months of the second half of February followed by March, April and early May. There was no significant difference between the means of these groups, and hence no corrections were required for this factor.

Relationship between musth and health status indicators

Musth intensity and age

Data from 9 males in musth were analysed for differences in musth intensities with age. Three males each were estimated to be in the age classes 25 – 30 years, 30 – 35 years and 35 – 40 years, and were tested for the effects of age class on average intensity of musth (using ANOVA). However, there was no significant age class effect, indicating that age did not significantly influence the musth intensity in males in this study.

Musth versus non-musth individuals

Data from individual males were separated into musth and non-musth categories and tested for significant differences between their average parameter values (using Student's t-test for samples with unequal means). For musth individuals, data collected when they were not in musth were not used in this analysis. Some parameters showed significant differences between musth and non-musth males (Table 3). Significant height, tusk circumference (TCLL) and tusk length (TSL) differences between musth and non-musth individuals could be explained on the basis of age, since musth was observed only in animals over 25 years of age in this study. The most interesting finding was the significant difference in average BCIC, BCIB and BCIF between musth and non-musth individuals (Student's t-test, $p < 0.05$. See Table 3), which indicated that musth males were in better physical condition than non-musth males. However, this apparent difference in health between musth and non-musth males was not indicated

Table 3 Comparison of parameter values for non-musth and musth male elephants, with results of Student's t-test for difference of means. n = number of elephants. (* = indicates significance at $p < 0.05$)

Parameter	non-musth average (n)	musth average (n)	t-test p value
Height (cm)	227.1 (16)	247.6 (9)	0.001*
Tusk circumference at lip level, TCLL (cm)	26.6 (16)	31.52 (9)	0.004*
Tusk length, TSL (cm)	78.29 (16)	92.9 (9)	0.044*
Tusk length dev. (cm)	1.23 (16)	3.98 (9)	0.367
Average BCIC	8.67 (19)	5.03 (9)	0.000*
Average BCIB	5.22 (19)	2.51 (9)	0.000*
Average BCIF	3.45 (19)	2.54 (9)	0.014*
Average parasite density (/gm)	12.15 (20)	8.04 (9)	0.157

by the other chosen health indicator, average parasite load per individual.

Health status indicators in relation to musth intensity

Trends in body condition index with changes in musth intensity:

Data obtained from musth individuals were investigated for finer resolution of patterns in health indicators during musth. There was no significant correlation between MCI and BCIC when the data from all musth individuals were pooled (Fig. 3), although there was a minor trend of increasing BCIC (declining body condition) as musth intensity increased. All BCIC values were then split into two groups, early and late musth, based on their respective MCI values. For this, all MCI values between 0.5 and 3.75 ($n = 8$) were considered to be early musth samples, while all MCI values between 4.0 and 5.75 ($n = 7$) were treated as late musth (or closer to peak musth) samples. The BCIC values of these two groups were not significantly different from each other (using Student's t-test for samples with unequal means), indicating that external body condition may not vary with musth intensity. Intra-individual variation may have been responsible for the lack of a consistent trend in the relationship between MCI and BCIC over time. Hence data obtained from repeated sightings of 3 males who remained in musth over considerable periods of time (observed musth intervals ranging from 5 to 22 days) were assessed qualitatively for intra-individual trends. There were marginally increasing values of BCIC (declining health) during the observed musth interval of two males, while the third male showed initially increasing BCIC followed by a decrease. There was no significant association between MCI and BCIC, nor between the number of days in musth and BCIC, in individual males. Thus there was no evidence for a consistent decline in external body condition over time in musth males.

An important, though expected finding, was that early musth BCIC values were significantly different from non-musth BCIC values (Student t test, $n_1 = 8$, $n_2 = 48$, $p < 0.001$). This was an expected result (following from section 3.4.2 above) indicating that significantly better body condition was associated with early musth when compared with the non-musth state.

Trends in parasite load with changes in musth intensity:

Data on musth individuals were similarly studied with regard to parasite loads. However, as with BCIC, there was no clear relationship between parasite load and MCI when all musth data were pooled (Fig. 4). Division of the data into early ($n = 6$) and late ($n = 6$) musth stages based on MCI values as above, revealed no significant difference between the parasite loads of early and late musth groups. In addition, examination of intra-individual trends in the parasite loads of 3 resighted musth males during the course of their period in musth (observed musth intervals ranging from 4 to 22 days) showed no clear trend of increasing parasite loads with increasing intensity and progression of musth. Thus when using parasite loads as the health status indicator, there again appeared to be no decline in health over time in musth males.

However, when early musth data were compared with non-musth individuals, there was a significant difference between early musth parasite densities and non-musth parasite densities (Student t test, $n_1 = 6$, $n_2 = 31$, $p < 0.05$). This result is important when considered in conjunction with the results from the MCI-BCIC analysis above. Significantly lower parasite loads in early musth individuals support the findings above, by indicating that the internal parasite load of individuals in the early musth stage is lower when compared with that of individuals not in musth.

Table 4 Parameter advantages (+) and disadvantages (-) of the dominant male elephant in 9 recorded dyadic interactions. The dominant male was considered to have the parameter advantage if it had greater height, longer tusks, greater tusk length deviation (i.e., deviation from the fitted tusk length curve), lower BCIC value, lower parasite load or was in musth (while the subordinate individual was not in musth). Significance of the association between parameter advantage and dominance, across all dyadic pairs, is given by the binomial test p-value.

(* = indicates significance at $p < 0.05$)

Pair (Dom-Sub)	Height	Tusk length	Tusk dev.	BCIC	Par./gm	Musth
KFI - KUN	-	+	+	+	+	
ERR - IXT	+	-	-	-	+	
LAN - DCR	+	+	+	-	-	
LAN - LKN	+	+	-	-	-	
DAD - PIN	+	+	+	+	-	
KAL - XTT	+	-	-	+	+	+
BAL - LAN	+	+	+	+	+	+
KAL - IXT	+	+	-	+	+	+
BAL - DCR	+	+	+	-	+	+
<i>Propn. positive:</i>	0.89	0.78	0.56	0.56	0.67	1.00
<i>Binom. Test</i>	0.018*	0.070	0.246	0.246	0.164	
<i>p-value:</i>						

Relationship between tusk length and health status indicators

Tusk length and health status indicators
(a) Body condition index

Tusk length deviations were tested for correlative association with BCI. There was a weak but non-significant positive trend when the two parameters were plotted against each other, indicating slightly worsening body condition with increasing positive deviation of tusk length (Fig. 5).

(b) Parasite load

Parasite loads showed no relationship with tusk length deviations (Fig. 6).

Tusk length correction using subjective age classes

The use of height as a proxy for age may have reduced extreme trends of long or short tusks if height is genetically linked to tusk length and if heights vary greatly across ages.

To eliminate this potentially confounding effect, a second standard curve was fitted to the tusk length data, using the subjective age classes assigned in the field (class intervals = 5 years) to rank individuals. This had the effect of collapsing the data into 8 groups and magnifying tusk length deviations from the standard values for each group. Best fit ($r = 0.82$) was achieved by using an exponential association curve with the equation:

$$\text{Tusk length} = 102.37 [1 - e^{-0.474(\text{Age class})}]$$

Tusk length deviations obtained from this correction were then tested for relationships with BCI and parasite densities. However, tusk length deviations obtained from this curve also did not produce significant correlations with BCI or parasite load. These findings indicated that helminth parasite densities and body condition indexes were not related to tusk growth in the elephants used in this study.

Musth-tusk length relationship

There was no significant difference in the average tusk length deviation between animals that exhibited musth and those that did not exhibit musth during the study period (Table 3). There was also no significant relationship between MCI and

tusk length deviation. This indicates that longer tusks are not necessarily related to an individual's ability to attain musth, nor with the intensity of musth exhibited. Thus the two proposed signals appear not to be complementary in signalling the health status of male elephants.

Behaviour analysis

Dominance interactions

Dyadic interaction pairs of male elephants ($n = 9$) were compared to find out which parameter advantages were generally associated with the dominant individuals. The following 6 parameters "advantages" were considered: greater height, longer tusks, greater tusk length deviation (from the quadratic standard curve), lower average parasite density, better average body condition (lower BCI score) and occurrence of musth (Table 4). Simple calculation of the proportions of dominant individuals enjoying a particular parameter advantage over their subordinates showed that the dominant individual had the advantage of musth on every interaction between a musth and non-musth individual (proportion positive = 1.00, $n = 4$). Dominant individuals also had the advantage of greater height in 89% of interactions, while the advantage of longer tusks was associated with the dominant individual in 78% of interactions. Binomial distribution probability tests showed that only the height advantage (in addition to musth) was significantly different from 0.5 (equal probability of having or not having the parameter advantage over the subordinate animal (see Table 4).

From this analysis of dominance behaviours in a small sample of interactions, musth and height advantage appeared highly likely to be associated with dominance in male-male interactions. Other parameters such as tusk length, tusk length deviation, BCI and parasite density were not significantly associated with dominance in male elephants. One cannot, however, rule out the importance of these other factors in dominance, as musth is not always present in either one or both of an interacting pair of males, and there was a single case recorded, of domination by the shorter individual of an interacting pair.

Discussion

Musth as a signal of health and genetic quality

Probably the most important finding of this study was the relationship between musth and health status. Male elephants which exhibited external signs of musth of all stages, had significantly lower average BCI scores (indicating better health) than males which did not attain musth during the study. Early musth males had slightly lower BCI scores, though not significantly different scores, than late musth males. This indicated that throughout the periods of musth monitored in this study, males did not show significant deterioration of external body condition as musth progressed. It may imply that maintaining good external body condition is important throughout an episode of musth. It is also

possible that a highly productive environment such as Nagarahole is able to provide nutrition to sustain reasonably good health in musth males despite the physiological burden imposed by this condition.

Inter-individual parasite loads did not show any significant difference when all musth males were compared against all non-musth males. However, early musth males were found to have significantly lower average parasite loads than males that did not achieve musth. This supports the conclusion above that in order to attain musth, males may need to be capable of achieving a state of health that is significantly better than the average health condition of non-musth individuals. Better health may correspond to a lower internal parasite load and to better external body condition, among other qualities, and thus the exhibition of musth may serve as an honest signal of good health and genetic quality in those males that can attain this physically costly condition. However, it must be cautioned that due to the low sample sizes and the inability to repeatedly sample all musth animals over their entire musth period these significant findings require further data collection and verification before they can be generalised or extrapolated to other areas.

Tusk length as a signal of health and genetic quality

During this study there was no evidence to show that tusk lengths were negatively correlated with average BCI and parasite loads. Consequently, there is no evidence from this study that tusk length may serve as an honest indicator of good health in male Asian elephants.

The results of this study appear to contradict those of Watve & Sukumar (1997). There are several possible reasons why this difference occurred:

(1) Intra-individual variation was not controlled for adequately in either of the two studies. A better understanding of intra-individual variation is required before any conclusions can be drawn. Watve & Sukumar (1997) did, however, control for seasonal variation in parasite loads, which was not possible in this study due to limited background data on parasite load variations across seasons. This is a possible source of intra-individual variation, especially since the study extended through the hot dry summer, which may have stressed some animals more than others and exaggerated the differences in their average parasite loads and BCIs.

(2) Host-parasite interactions between elephants and their helminth parasites may show variations in different habitats. Fluke and spirorid nematode ova were detected in the Nagarahole samples, which were not reported from the Mudumalai population. There may be some variations in host-parasite ecology between these two study areas that may need to be considered.

Thus, although tusk lengths did not appear to signal good quality in male elephants in this short study, the use of tusk length as a signal cannot be completely rejected because longer tusks were associated with dominance in 78% of

interactions. They may thus marginally influence female choice. Longer time periods may be required to assess the role of tusk lengths in sexual signalling and dominance, and a more appropriate health indicator may be required, as external body condition and helminth parasite loads may fluctuate greatly over short intervals of time. These short-term fluctuations would not be reflected immediately in tusk length growth, and hence may lead to incorrect conclusions about their value as sexual signals.

It is possible that tusk length may serve as an indicator of long term or cumulative adaptation to environmental resources, whereas musth, being expressed for short terms on a regular basis, may provide a more immediate reference on an individual's ability to cope with current environmental fluctuations. This may explain why patterns associated with musth were better reflected in the two chosen health indicators while differences in tusk lengths failed to show correlations with the same health indicators.

Musth, tusk length and signal-based sexual selection

Several mate selection theories have been based on the use of extreme character development as effective sexual signals by males. Of these, the handicap principle (Zahavi, 1975) and the theory of heritable true fitness (Hamilton & Zuk, 1982) were considered most relevant to the current study, as they emphasise the costs associated with producing exaggerated signals. In the case of the handicap principle, the cost is expected to be so high as to prevent unhealthy males from being able to produce the signal (Zahavi, 1977).

This study provided evidence in support of musth as an honest signal of quality and of heritable true fitness in resisting chronic parasite infections to female elephants. However, since there was no clear trend in the health indicator values with increasing musth intensity or duration, it was not clear how much of a burden or handicap is imposed on males that attain and sustain their musth over long periods of time. Given that there is no clear evidence of ways in which musth increases the survival chances of males displaying this condition, it can still be speculated that musth may have evolved by female choice and sexual selection, rather than by natural selection, in Asian elephants.

There was little evidence from this study that relatively longer tusks may serve as honest signals of health or resistance to chronic parasite infections. In addition, elephants that exhibited musth during the study interval did not have significantly better developed tusks than those that did not exhibit musth. However, more information is required from a larger sample of males and over a longer time interval, before conclusions can be drawn with regard to the use of tusks as sexual signals by male Asian elephants. Although extremely long and crossed tusks could potentially serve as a signal of handicap, medium-sized and uncrossed tusks can increase the survival of the individual by functioning as digging implements for minerals, for debarking trees, for resting the heavy trunk and as a weapon of offence and defence. Thus it appears unlikely that tusk lengths would serve as effective signals of handicap, whereas musth, which

appears to serve few survival purposes, seems a more likely candidate as a handicap signal. Instead, long tusks may serve as a signal of long-term adaptation to the local environment, a possibility that was not explored in the current study.

Even if tusks are relatively unimportant sexual signals, it cannot be concluded that tusks have no role to play in mate selection and reproductive success. Behavioural analysis showed that musth could potentially increase a male's mating success in another way: by allowing it to dominate over other males. Similarly, longer tusks were associated with dominance in 78% of the social interactions recorded. Since dominance can promote access to females as well as prevent other males from coming near receptive females, males with longer tusks may be able to "influence" females to choose them. In this way, relatively longer tusks may indirectly increase male reproductive fitness.

In general, females are likely to use information from several signals when exercising their choice over males (Zahavi, 1975). This study has provided evidence in favour of one such signal, musth. Previous studies suggest that female African elephants in oestrus preferred musth males to non-musth males (Poole, 1989b). However, while the occurrence and mechanisms of female choice have not been scientifically studied in Asian elephants, there is anecdotal evidence of females consorting with musth males (de Launey, 1938; Eisenberg *et al.*, 1971; Eisenberg & Lockhart, 1972) as well as occasionally rejecting musth males (Stracey, 1963). Clearly the complementary aspect of sexual selection, female choice, needs to be studied in detail before the existence of sexual signalling in Asian elephants can be confirmed. Further studies are also required to understand whether other visual, chemical or vocal signals are used for signalling between the sexes in elephants.

Further research and applications

All interpretations of the results reported above are subject to verification in future studies, due to the small sample sizes obtained in this study. Despite this limitation the study can be of value to conservationists interested in promoting long term viability of the species and of small and threatened elephants populations. The following are possible applications of the findings of this study, and suggestions for further research:

- (1) A simple non-invasive method of assessing the health of elephant populations over regular intervals may be developed by using a combination of BCI and parasite density values. As seen in the case of musth versus non-musth individuals, there are significant measurable differences in these two health indicators over short intervals, which could also serve as sensitive indicators of declining or improving health trends in individuals and populations over different seasons and years.
- (2) Studies on crop raiding by elephants have shown that male elephants are often responsible for most of the damage (Sukumar, 1989; Thouless & Sakwa, 1995; Bhima, 1998; Hoare, 1999). Sukumar & Gadgil (1988) had suggested that

this could be viewed as an adaptive strategy of "high-risk, high-gain" followed by male elephants, in order to attain better body condition, increase their chances of attaining the musth condition and thus increasing breeding success. The current study lends support to this speculation, by demonstrating the relationship between musth (especially early musth) and better health.

(3) The suggestion was put forward to selectively remove the most frequent crop raiding bulls from raiding elephant populations, as this might alleviate human-elephant conflict and reduce a serious conservation problem (Sukumar, 1991). However, if the local pool of male elephants is small, capturing the most persistent male crop raiders might remove the most healthy and reproductively successful males and may adversely affect the genetic fitness of the local breeding population in the long term.

4) The importance of musth and height in determining dominance may have important implications for reproductive success of makhanas (tuskless male Asian elephants). In light of the changing ratios of tusked to tuskless males due to poaching, if the most healthy tusked individuals are removed from a population, makhanas may gain selective reproductive advantage over less fit tusked males. If musth is an important sexual signal and makhanas tend to produce and sustain an intense musth phase over longer periods of time, this could cause a further skew in favour of makhanas in the future. This may be an interesting topic of investigation in future scientific studies of Asian elephants.

References

- Alva, U.T. (1994) *Project elephant report*, Karnataka Forest Department, Bangalore.
- Bhima, R. (1998) Elephant status and conflict with humans on the western bank of Liwonde National Park, Malawi. *Pachyderm*, **25**: 74-80.
- Chandrasekharan, K., Radhakrishnan, K., Cheeran, J.V., Nair, K.N.M., Prabhakaran, T. (1982) Some observations on musth in captive elephants in Kerala (India). In *The Asian Elephant: Ecology, Biology, Diseases, Conservation and Management*. (eds. E.G. Silas, M. K. Nair, & G. Nirmalan) pp. 71-75. Kerala Agricultural University, Trichur, Kerala, India.
- Darwin, C. (1871) *The Descent of Man and Selection in Relation to Sex*. London.
- De Launey, P. (1938) The Mating of Elephants. *J. Bombay Nat. Hist. Soc.*, **40**: 323-324.
- Douglas-Hamilton, I & O. (1975) *Among the elephants*. Viking Press, New York.
- Eisenberg, J.F., McKay, G.M., & Jainudeen, M.R. (1971) Reproductive Behaviour of the Asiatic elephant (*Elephas maximus maximus* L.). *Behaviour*, **38**: 193-224.
- Eisenberg, J.F. & Lockhart, M. (1972) *An ecological reconnaissance of Wilpattu National Park, Ceylon*. Smithsonian Contributions to Zoology, No. **101**. Smithsonian Institution Press, Washington, D.C., USA
- Emlen, S.T. & Oring, L.W. (1977) Ecology, sexual selection, and the evolution of mating systems. *Science*, **197**: 215-223.
- Fisher, R.A. (1930) *The Genetical Theory of Natural selection*. Oxford.
- Folstad, I. & Karter, A.J. (1992) Parasites, bright males and the immunocompetence handicap. *Am. Nat.*, **139**: 603-622.
- Goss, R.J. (1983) *Deer antlers: regeneration, function and evolution*. Academic Press, New York.
- Grafen, A. (1990) Sexual selection unhandicapped by the Fisher process. *Journal of Theoretical Biology*, **144**: 473-516.
- Hamilton, W.D. & Zuk, M. (1982) Heritable true fitness and bright birds: a role for parasites? *Science*, **218**: 384-387.
- Harmel, D. (1983) The effect of genetics on antler quality in white-tailed deer (*Odocoileus virginianus*), In *Antler development in Cervidae* (ed. R.D. Brown), Caesar Kleberg Wildlife Research Institute, Kingsville, Texas, USA.
- Hess, D.L., Schmidt, A.M. & Schmidt, M.J. (1983) Reproductive cycle of the Asian elephant (*Elephas maximus*) in captivity. *Biology of Reproduction*, **28**: 767-773.
- Hoare, R.E. (1999) Determinants of human-elephant conflict in a land-use mosaic. *Journal of Applied Ecology*, **36**: 689-700.
- Karanth, K.U. & Sunquist, M. (1992) Population structure, density and biomass of large herbivores in the tropical forests of Nagarhole, India. *Journal of Tropical Ecology*, **8**: 21-35.
- Kirkpatrick, M. (1982) Sexual selection and the evolution of female choice. *Evolution*, **36**: 1-12.
- Kirkpatrick, M. & Ryan, M.J. (1991) The evolution of mating preferences and the paradox of the lek. *Nature*, **350**: 33-38.
- Krishnan, M. (1972) An ecological survey of the larger mammals of peninsular India. The Indian elephant. *Journal of the Bombay Natural History Society*, **69**: 297-315.
- Maynard Smith, J. (1991) Theories of sexual selection. *TREE*, **6**: 146-151.
- Mayr, E. (1972) Sexual selection and natural selection, In *Sexual selection and the descent of man* (ed. B. Campbell) pp. 1871-1971. Aldine Publ. Co.
- Moller, A.P. (1994) *Sexual selection and the barn swallow*. Oxford series in ecology and evolution, (eds. R.M. May & P.H. Harvey), Oxford University Press, Oxford.

- Moss, C. (1988) *Elephant memories: 13 years in the life of an elephant family*. William Morrow and Company, Inc., New York.
- Poole, J.H. (1987) Rutting behaviour in African elephants: the phenomenon of musth. *Behaviour* **102**: 283-316.
- Poole, J.H. (1989a) Announcing intent: the aggressive state of musth in African elephants. *Animal Behavior*, **37**: 140-157.
- Poole, J.H. (1989b) Mate guarding, reproductive success and female choice in African elephants. *Animal Behavior*, **37**: 842-849.
- Poole, J.H. & Moss, C.J. (1981) Musth in the African elephant, *Loxodonta africana*. *Nature*, **292**: 830-831.
- Poole, J.H. & Moss, C.J. (1989) Elephant mate searching: group dynamics and vocal and olfactory communication. *Symp. Zool. Soc. Lond.*, **61**: 111-125.
- Poole, J.H., Kasman, L.H., Ramsay, E.C. & Lasley, B.L. (1984) Musth and urinary testosterone concentrations in the African elephant (*Loxodonta africana*). *Journal of Reproductive Fertility*, **70**: 255-260.
- Rasmussen, L.E.L. (1999) Evolution of chemical signals in the Asian elephant, *Elephas maximus*: behavioural and ecological influences. *Journal of Bioscience*, (Indian Academy of Sciences), **24**: 241-251.
- Rasmussen, L.E.L., Hall-Martin, A.J. & Hess, D.L. (1996) Chemical profiles of male African elephants, *Loxodonta africana*: physiological and ecological implications. *Journal of Mammalogy*, **77**: 422-439.
- Rasmussen, L.E., Schmidt, M.J. & Daves, G.D. (1986) Chemical communication among Asian elephants. In *Chemical Signals in Vertebrates 4*. (eds. D. Duvall, D. Muller-Schwarze & R.M. Silverstein) pp. 627-645. Plenum Publishing Corporation, USA.
- Reynolds, J.D. & Harvey, P.H. (1994) Sexual selection and the evolution of sex differences. In *The differences between the sexes* (eds. R.V. Short & E. Balaban), pp. 53-70. Cambridge University Press, Cambridge.
- Scribner, K.T. & Smith, M.H. (1990) Genetic variability and antler development. In *Horns, pronghorns and antlers* (eds. G.A. Bubenik & A.B. Bubenik), Springer-Verlag New York, Inc.
- Short, R. V. (1994) Why sex? In *The differences between the sexes* (eds. R.V. Short & E. Balaban) pp. 3-21. Cambridge University Press, Cambridge.
- Sloss, M.W. & Kemp, R.L. (1978) *Veterinary Clinical Parasitology*. Iowa State University Press, Ames, Iowa.
- Soulsby, E.J.L. (1973) *Helminths, arthropods and protozoa of domesticated animals*. Williams and Wilkins Co., Baltimore.
- Stracey, P.D. (1963) *Elephant Gold*. Natraj Publishers, Dehra Dun, India.
- Sukumar, R. (1989) *The Asian Elephant: ecology and management*. Cambridge Studies in Applied Ecology and Resource Management. Cambridge University Press, Cambridge.
- Sukumar, R. (1991) The management of large mammals in relation to male strategies and conflict with people. *Biological Conservation*, **55**: 93-102.
- Sukumar, R. & Gadgil, M. (1988) Male-female differences in foraging on crops by Asian elephants. *Animal Behaviour*, **36**: 1233-1235.
- Sukumar, R., Joshi, N.V. & Krishnamurthy, V. (1988) Growth in the Asian elephant. *Proc. Indian Acad. Sci. (Anim. Sci.)*, **97**: 561-571.
- Thouless, C.R. & Sakwa, J. (1995) Shocking elephants: fences and crop raiders in Laikipia District, Kenya. *Biological Conservation*, **72**: 99-107.
- Toke Gale, U. (1974) *Burmese timber elephant*. Trade Corporation 9. Yangon, Myanmar.
- Watve, M.G. (1992) *Ecology of host-parasite interactions in a wild mammalian host community in Mudumalai, southern India*. Unpublished Ph.D thesis, Indian Institute of Science, Bangalore.
- Watve, M.G. & Sukumar, R. (1997) Asian elephants with longer tusks have lower parasite loads. *Current Science*, **72**: 885-888.
- Zahavi, A. (1975) Mate selection - a selection for a handicap. *Journal of Theoretical Biology*, **53**: 205-214.
- Zahavi, A. (1977) The cost of honesty (Further remarks on the Handicap Principle). *Journal of Theoretical Biology*, **67**: 603-605.
- Zahavi, A. (1987) The theory of signal selection and some of its implications. *Proc. Inter. Symp. Biol. Evol.* (ed. V.P. Delfino), Adriatica Editrice Bari.
- Zahavi, A. (1991) On the definition of sexual selection, Fisher's model, and the evolution of waste and of signals in general. *Animal Behavior*, **42**: 501-503.
- Zahavi, A. (1993) The fallacy of conventional signalling. *Phil. Trans. R. Soc. Lond. B*, **340**: 227-230.

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Appendix

Ethogram of social behaviours of wild elephants recorded at Nagarhole National Park, November 1998 – May 1999:

Dominance and threats

- Approach by dominant with concomitant or consequent turning away/moving away by subordinate
- Approach by dominant with head swinging (up & down) or with trunk slung over the tusks
- Placement of trunk on face/back/rump/tail of subordinate
- Pushing subordinate with tusks, trunk base, head butt or body side
- Hit subordinate with trunk
- Mount subordinate from behind
- Placement of trunk into mouth of subordinate
- Facing subordinate and throwing mud over the head slowly
- Rubbing or swinging forefoot above the ground while facing subordinate
- Swing trunk out forcefully towards subordinate
- Sensing directly and overtly towards subordinate with trunk
- Lock tusks with subordinate and push him backwards
- Kick subordinate with hind foot
- Approach with head up and tusks pointing forward at subordinate
- Move close to subordinate from further away
- Displacement of subordinate for feeding

Subordination

- Passive receipt of dominance behaviours without retaliation
- Turning away/moving away from dominant elephant's approach
- Penis descends and hangs limp in response to approach by dominant
- Urination or defecation in response to approach by dominant

Musth

- Frequent tests of female genital area
- Stand still & alert >5 seconds
- Dig tusks in shallow water
- Walk with head swinging up and down

Female interest in / preference for male

- Approach male
- Turn around and present posterior to approaching male
- Spread legs when male tests genital area
- Urinate/defecate when male approaches female's posterior
- Passively accept male dominance behaviours (listed above)
- Move along with male when he leaves the female group

Female rejection of male interest

- Walk away when male approaches or attempts to mount
- Run away with/without vocalisation when male approaches persistently

Plate 1 A male elephant in musth. In addition to the temporal gland secretion down the cheek, the hind leg appears wet, probably due to urine dribbling



Plate 2 A musth male with a female herd. Body size dimorphism between adult male and female elephants is evident in this picture



Plate 3 Are longer-tusked males preferentially chosen by female elephants? Long and crossed tusks such as these may be a handicap for the males possessing them

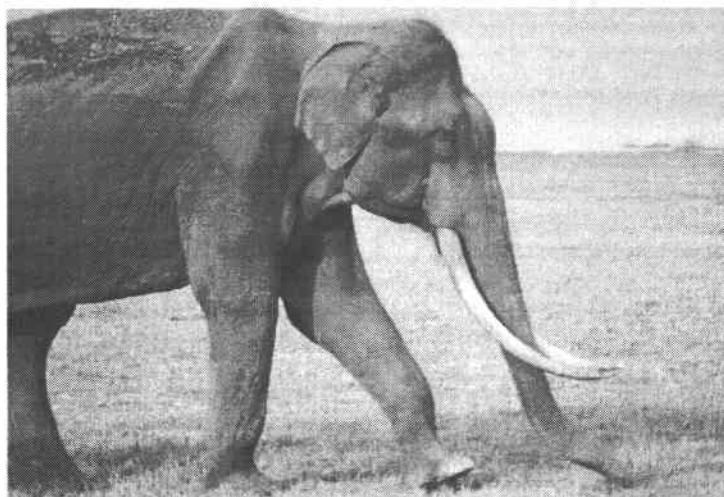


Plate 4 A male elephant showing relatively poor external body condition. The degree of visibility of skeletal components such as pectoral and pelvic girdles, backbone, ribs and cheek bones were used to subjectively score the body condition index

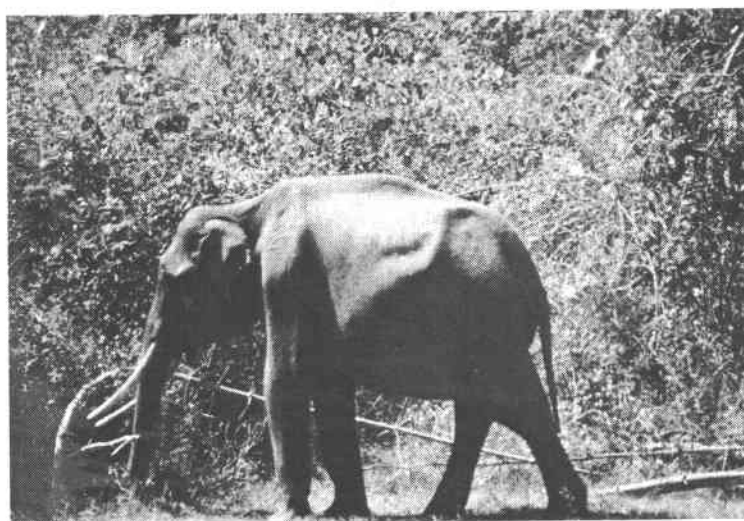


Plate 5 Patterns of holes, cuts and tears in the ears were used to identify elephants. Other features used for individual identification were size and shape of tusks, pattern of ear fold, length and shape of tail, etc.

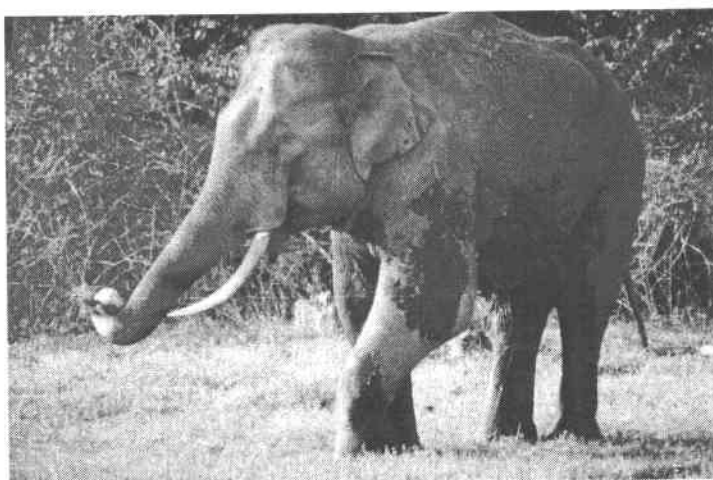


Plate 6 A wild bull elephant crossing the road. Such photos can be used to measure the shoulder height and tusk length.



All photographs were taken at the Nagarhole National Park, South India by Cheryl Nath.

The economic value of conserving the Asian elephant: contingent valuation estimates for Sri Lanka

Ranjith Bandara and Clem Tisdell

Abstract The Asian elephant (*Elephas maximus*) is one of the world's most seriously endangered species of large mammals. However, the economic value of conserving it from a total economic evaluation perspective has been little studied. This paper addresses this matter for Sri Lanka. It summarises the results of a contingent valuation survey of willingness to pay for the conservation of the elephant of a sample of urban residents in Colombo. The majority of respondents favoured the survival of the wild elephants, and were willing to pay (WTP) Rs. 110.16 per month amounting to a total of Rs 1,322 per year on average for a period of five years to support this goal. Extrapolating this value to the other urban centres in Sri Lanka, we found that urban dwellers are WTP Rs. 506.7 million per month, amounting to a Rs 2,713.3 million per annum and Rs. 40248.61 million for a period of five years. The annual return on this capitalised

sum is Rs. 2012.43 million per annum in perpetuity at a 5% real rate of interest. Comparing this amount with our economic estimates of annual total crop and property damage caused by elephants in Sri Lanka (Rs.1121.42 million per annum) shows that urban residents could compensate farmers for these damages and be better off than in the absence of elephants in the country. This suggests that there is a strong economic case for the conservation of the wild elephant population in Sri Lanka, at least at their current population level. The economic value to urban residents of the continued existence of wild elephants in Sri Lanka appears to be about twice the extent of economic damage caused to farmers by elephants.

Keywords Asian elephant, Sri Lanka, contingent valuation method, crop damage, compensation, conservation.

Introduction

In many respects, the survival of the Asian elephant (*Elephas maximus*) is more precarious than that of the African elephant (Bandara & Tisdell, 2002a). IUCN (1996) declared the Asian elephant to be one of the most seriously endangered species of large mammals in the world. At present, it occurs in only thirteen countries in Asia, including Sri Lanka (Kemf & Santiapillai, 2000) and its population has fallen significantly. The Sri Lankan elephant population, for example, underwent a marked reduction starting from the mid-nineteenth century (Santiapillai & Jackson 1990; De Silva, 1998). Fragmentation and loss of natural habitat are the major factors contributing to this decline and these help generate human-elephant conflict (Desai, 1998). This situation largely results from the *ad hoc* development projects carried out during the last fifty years (Weerakoon, 1999), and is exacerbated by the lack of co-ordination between different government departments and wildlife authorities. Moreover, poor integration of economic aspects and lack of attention to public preferences for elephant conservation compounds the problem.

Several techniques are available for measuring the economic value that members of the general public place on the conservation of wildlife and other natural resources. These include the hedonic pricing approach (HPA), the travel cost method (TCM), and the contingent valuation method (CVM) (Carson *et al.*, 1996). However, the HPA and TCM have been criticised by a number of authors for failing to measure the non-use or intangible values of wildlife adequately (see Stevens *et al.*, 1995; Oglethorpe & Miliadou, 2000). The CVM is free from this particular criticism. It is able to elicit types

of benefits that these other methods cannot elicit (Kotchen, 2000). CVM uses survey questions to elicit people's stated preferences for public goods such as conservation of elephants (Ready *et al.*, 1996; Loomis & Ekstrand, 1998; White *et al.*, 2001). However, CVM also has limitations. It can for example, involve errors in estimation of economic value due to strategic, design, part-whole and hypothetical biases (Bateman & Turner, 1993).

Nevertheless, CVM is a widely applied monetary evaluation method. For example, it has been widely applied to the valuation of environmental and natural resource-related goods such as the preservation of wildlife species and outdoor recreational amenities (see Seip & Strand, 1992; Diamond & Hausman, 1994; Jakobsson & Dragan, 1996; Loomis & White, 1996; Wills & Powe, 1998; Witzer & Urfei, 2001; Bandara & Tisdell, 2002b). In CVM, the non-use economic values of a given environmental amenity are generally measured based on the willingness to pay for an improved situation, or using the willingness to accept compensation for a damaged or diminished situation. An appealing aspect of the contingent valuation method is that it allows us to estimate total economic value (Pate & Loomis, 1997). It is widely used. Carson *et al.*, (1994) provide a bibliography of 1,600 CVM studies and related publications.

In economics, the importance of total economic valuation of wildlife and other natural resources is increasingly recognized. Estimates of total economic value combine willingness of stakeholders to pay for their direct interactive use of wildlife for harvesting, tourism or other purposes plus economic values generated by other than direct interactive use such as from the knowledge that a species continues to exist (existence value) or that it will be available to future generations (bequest value). Such willingness to pay can be influenced by feelings of moral obligation towards

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a species (cf. Tisdell, 1997; Etzioni, 1988). CVM is designed to capture all values that influence willingness to pay to conserve (or eradicate) a species. Therefore, it is a considerable advance on those economic techniques that merely measure economic value generated by direct use of a species. As a rule, these only give partial indications of economic value. Nevertheless, economic methods, such as CVM, represent only one philosophical approach to value. One should be clear that despite its wide perspective, CVM does not constitute a complete or exclusive approach to valuation (Tisdell, 1997; cf. Lehman, 1993). Yet, provided this is kept in mind, methods, such as CVM, designed to determine total economic valuation can significantly enhance our appreciation of social choices involving conservation of wildlife. The purpose of this article is to show how analysis using CVM can provide new perspectives on the desirability of conserving Asian elephants in Sri Lanka.

Our study involved first a CVM survey of a sample of urban residents in Colombo, the capital of Sri Lanka, in order to determine their WTP for the conservation of the Asian elephant. This was then used to estimate the willingness of Sri Lankan urban dwellers, as a whole, to pay for conservation of the Asian elephant. A dichotomous choice form of contingent valuation is applied to quantify the conservation value of the wild elephant. An analysis is undertaken to investigate the underlying factors that determine the willingness of urban respondents to pay for the conservation of the elephant. Furthermore, in this analysis we consider whether urban residents' WTP for the conservation of elephants is sufficient to compensate farmers for the damage caused by elephants and to raise farmers' tolerance of the present elephants on their farming fields. The survey procedures are outlined first. This is followed by analysis of the results. The economic losses associated with crop and property damages caused by elephants are then compared with the estimated urban WTP benefits in order to determine whether the urban residents' potential contribution for conservation of elephants would be sufficient to compensate farmers for the crop and property damage caused by elephants and consequently raise farmers' tolerance of the presence of elephants.

Methods

Contingent valuation market to assess the conservation value of the elephants in Sri Lanka

Interviews with urban respondents involved four different steps. In the first step, the respondents were presented with updated information about the present status of the elephant population in Sri Lanka, and the policy and institutional issues that need to be addressed to conserve elephants in the country. Respondents were then told why it is important to adopt new approaches to ensure the survival of the elephant in Sri Lanka in the long-term. They were informed that existing protected areas are inadequate in size to ensure the long-term survival of wild elephants if elephants are confined to these areas. Furthermore, there is little or no prospect of a significant increase in the size of these areas. Thus, the survival of elephants seems to depend on their use of both

protected areas and non-protected areas. Socially acceptable strategies for an appropriate level of co-existence between farmers and elephants are needed. Such co-existence hinges on greater compensation for farmers to tolerate elephants to a greater extent than currently.

In the second step, the survey respondents were presented with an alternative policy designed to address these issues. They were asked to assume that an autonomous body, reputed for its efficient and honest work, would introduce a sound conservation programme so that the current downward trend in elephant population could be halted while addressing other elephant related issues. The respondents were informed that this organisation would initially implement the following measures for the conservation of the elephant: a) Provision of extra protection around existing national parks and protected areas, b) translocation of excess and troublesome elephants, c) domestication of the elephants for local and foreign zoos, tourist establishments, temples, study centers, or for use as work animals, and d) establishment of animal orphanages and recreation centers to promote eco-tourism. Respondents were also informed that this policy alternative was developed based on the assumption of that the conservation of elephants can be achieved through integrated policies involving both public and private landholders in the elephant's range and other interest groups, such as city-dwellers.

In the third step, the respondents were informed about the need to finance the proposed programme and the required support of the general public to establish a 'trust fund' to support the proposed conservation programme. Moreover, they were also told of possible benefits that they would be able to obtain after the successful implementation of this programme. The benefits presented to the respondents were: a) greater possibilities to view more elephants in a single herd in the wild, b) greater opportunities to see elephants in the wild during a short number of visits to a given national park, c) opportunities to domesticate more elephants for the purpose of religious festivals and the local tourism industry, and d) increase in agricultural crop production due to the mitigation of HEC in the main agricultural regions in the dry zone of the country.

Finally in the fourth step, the respondents were presented with the contingent market valuation question: "For the next five years, would you be willing to pay Rs X from the monthly income of your household, that is Rs X per year, starting from January 1st 2002, towards the establishment of the proposed trust fund to implement the above mentioned programs to conserve the elephants in the country". Respondents were offered a set of bid values at four different stages conditioned to their response for the first WTP elicitation question. After survey respondents were presented with WTP elicitation questions, two follow-up questions were asked. These contained categories of reasons for the response to the contingent market and the respondent's preferred method of payment. These questions help to identify protest responses as well as motives for preservation.

Sample, data collection procedure and method of analysis

The surveyed population was purposefully chosen from urban residents in Colombo. The population density, level of urbanisation, living standards and life style of residents were taken into account for the selection of a sample of urban residents. A sample of 300 residents was chosen from three main housing schemes in Colombo, *Jeyanthipura*, *Jayawadanagam*, and *Anderson Flats*. The Urban Development Authority of Sri Lanka (2001) classifies these schemes as upper middle class, middle class and lower middle class housing schemes respectively. This classification is based on the value of the property and other urban facilities in the area where these housing schemes are located i.e. public schooling, shopping centers and recreational sites. A hundred residents from each of these housing schemes were chosen as the sample. A stratified sampling procedure was adopted in selecting this sample.

An interview schedule (IS) was used to gather the information used in the analyses presented in this paper. This consists of five different sections. The first section of the IS contained the personal profile of the respondent. The second contained questions to assess the attitudes of the respondents on 'development' and 'environment'. Section three presented respondents with information about the present status of elephant conservation and the problems that are encountered in conserving elephants in the existing protected area network. Section four of the IS contained the most important questions in the survey, where respondents were presented with dichotomous choice elicitation to assess their WTP for the conservation of elephant. Section five of the IS contained a set of questions for the interviewer. In these questions, interviewers were asked about the level of understanding and sincerity of the respondents. Nine graduate students from the Faculty of Graduate Studies of the University of Colombo were used as interviewers to administer the IS. A face-to-face survey was conducted to gather the information. Hadker (1997) suggests that this is a more useful method

compared to mailed questionnaires and telephonic surveys in developing country contexts.

A non-linear logit regression model was constructed to analyse the respondents' responses to the WTP elicitation questions. Jaibi & Raa (1998) provide a list of economic applications of this model and Pate and Loomis (1997) describe this model as the most commonly used non-linear model in CV studies. Sellar *et al.* (1986) outline the merits of the logit model, and Kanninen & Khawaja (1995) discuss the advantages of use of logit analysis for a contingent valuation survey with dichotomous format. One such advantage is the opportunity to use logit analysis, a non-linear method, to regress a binary (dichotomous) dependent variable on one or more independent variables. McFadden (1974) has also outlined the bases of the dichotomous choice theory corresponding to the logit specification.

In this study, we used the probability of the respondents' responses to principal WTP elicitation questions $\{P_i / (1 - P_i)\}$, where P_i = Probability of yes to the WTP elicitation questions as a dependent variable and considered factors that influence their probable responses. A number of socio-economic, demographic and attitudinal variables were included as independent variables for the preliminary logit analysis. The variables were: the respondent's age (*AGERE*), attitudes to alternative elephant conservation approaches (*ATHEC*), bid value (*BIDVA*), awareness of the current conservation issues (*CONSE*), concern about future generation needs (*FUPRE*), pro-conservation perception (*GREEN*), association with environmental guilds or groups (*MEMBE*), concern about non consumptive use-value of the elephant (*NONUV*), personal income (*PERIN*), pro-development concern (*PRODE*), occupation (*OCCUP*), position in the household (*RPOSF*), total family income (*TOFIN*), and years of schooling (*YRSCH*). The choice of these variables was partly based on choices in several previous

Table 1 The factors influencing respondents' responses for the payment principle questions : The final logit regression results

Variable	Coefficient	t-statistics
CONSTANT	-5.021	-2.098
Respondent's age (<i>AGERE</i>)	-0.872	-3.392
Rupee value from the WTP question (<i>BIDVA</i>)	-1.029	-4.198
Awareness about current conservation issues (<i>CONSE</i>)	1.045	4.685
Opinion on pro-conservation perception (<i>GREEN</i>)	3.322	7.583
Opinion on the non use-value of the elephant (<i>NONUV</i>)	1.284	2.904
Personal income (<i>PERIN</i>)	4.785	9.213
Attitudes towards pro-development activities (<i>PRODE</i>)	-0.043	0.904
Position in the family (<i>RPOSF</i>)	1.224	2.253
Years of schooling (<i>YRSCH</i>)	2.990	5.207

Summary statistics:

Dependent variable = the probability of saying 'yes' to the principle WTP questions, Number of observations = 300; log-likelihood is 73.8654,

F statistic: 31.1846; $\alpha = 0.05$; $df = 9$; $R^2 = 0.06050$; Adjusted $R^2 = 0.5861$.

CVM studies of environmental valuation (see Whitehead, 1992; Miller & Lindsay, 1993; Bateman & Langford, 1997; Witzer & Urfei, 2001).

Results

The preliminary logit regression analysis was undertaken by using the Statistical Package for Social Sciences (SPSS) Version 10.0 to identify the factors associated with respondents' responses for the WTP elicitation question at the $p < 0.05$ significance level. This analysis reveals that some of the independent variables cited above were either statistically not significant, or were highly correlated with other variables at the $r > 0.8$ level. Hence, it was decided to exclude these variables from the final logit regression analysis. Several goodness of fit measures were used to estimate overall statistical performance of the estimated model in this study. These results indicate that the overall ability of the model to yield a correct prediction of urban residents' WTP for the conservation of elephant is significant at the 0.05 level of statistical significance. A summary of the final logit regression results is presented in Table 1.

Discussion

Factors influencing the respondents' response to conservation value questions

As indicated in Table 1, most of the estimated coefficients have a positive influence on the probability of saying 'yes' to the principal conservation value questions by the respondents in the sample. The positive sign for the *CONSE* variable supports the hypothesis that the probability of the respondent saying 'yes' to the WTP question increases with the respondent's awareness of the present status of HEC and the issues involved in the conservation of elephants in Sri Lanka. Loomis & Ekstrand (1998) observe a similar situation in relation to conservation of the Mexican spotted owl. As might be expected, the coefficient for the *NONUV* is positive and significant in the model. This suggests that a respondent who values the non-use values of elephant (such as altruistic bequest and existence values) has a higher probability of answering 'yes' to the WTP question. This is understandable because the elephant in Sri Lanka is closely associated with Sri Lankans, their history, religion, culture, folklore, mythology and ceremony.

The coefficients for the attitudinal variables such as *GREEN*, are positive and significant. The result suggests that respondents with pro-conservation attitudes are likely to contribute more towards the conservation of the elephant. Loomis & Larson (1994) observe a similar situation in a CV survey of the grey whale. On the other hand, the variable *PRODE* was used in the model to assess the response of anti-conservation attitudes on the probability of saying 'yes' to the WTP question. The *PRODE* was not significant. This is understandable because the majority of the respondents in the sample disagreed with development programs that cause environmental problems. In our preliminary discussion when we put the proposition "*Sri Lanka should not encourage development programs such as tobacco cultivation in central highlands*

that cause serious environmental damage", 88.6% respondents agreed, implying that they were rather 'green', and inclined strongly towards environmental protection. Hadker *et al.*, (1997) observe similar attitudes in a CV study in India. In this study, it was found that about 72% of respondents strongly disagreed with development programs that hurt the environment.

BIDV4 had a negative influence on the probability of the respondent saying 'yes' to the WTP question. This means that the larger the bid value presented in the interview to the respondent as a WTP elicitation question, the less willing these respondents were to pay for elephant conservation. Miller & Lindsay (1993) notice a similar relationship in a CV survey which was conducted to analysis WTP for a state gypsy moth control program in New Hampshire. Loomis & White (1996) also observe a similar result in an analysis of economic benefits of rare and endangered species.

Among the socio-economic characteristics, age, personal income, years of schooling, and respondent's position in the family were considered as influences on the probability of respondents being willing to pay for the conservation of the elephant. The positive sign of the coefficient of the *YRSCH* indicates that the probability of saying 'yes' for the WTP question increases with an increase in the number of years of schooling. This is understandable because more years of schooling would arguably increase the knowledge a person has about social, political, economic and environmental happenings. Moreover, the education would help a person comprehend news about environmental effects of economic development. Several CV studies find a similar relationship between level of education and respondent's response towards the WTP elicitation questions. For example, Whitehead (1992) noticed that the level of education is often positively correlated with the WTP amount in an *ex ante* willingness to pay analysis. Pate & Loomis (1997) describe the rationale behind this relationship in a case study of wetland and salmon conservation in California.

The variable *AGERE* is significant with a negative coefficient. This implies that younger respondents were more willing to say 'yes' to the WTP question than their older counterparts in the sample. Heinen (1993) observes a similar situation in a study of people's attitudes towards the wildlife in the *Kosi Tappu* Wildlife Reserve in Nepal. In this study, he found that the positive attitudes towards the preservation of nature could be measured by the individual willingness to pay amounts which correlate highly with the respondents' age, years of schooling and the gender. He also notices an interesting relationship between age and the years of schooling. Younger respondents are found often to have more years of schooling than the older ones in the sample. This is quite similar to the situation found in Sri Lanka.

The variable *PERIN* is significant. The positive sign of it implies that the respondents whose personal income is greater are more willing to pay for the conservation of the elephant than the respondents whose personal income is lower. A number of other CV studies have obtained a similar result. Boyle & Bishop (1987) estimate the effects of the income

on the determination of WTP amount for the conservation of endangered species. Carson *et al.*, (1996) found that the sum individuals are less willing to pay for the preservation of quasi-public goods tends to rise with their income. Loomis & Larson (1994) estimate an individual's WTP for increase in the quantity of an environmental public good in relation to a number of socio-economic factors including household income. Findings of Hadker *et al.*, (1997) suggest that the higher income earners in the metropolitan area of Bombay have a stronger interest in environmental conservation than the lower income earners.

The variable *RPOSF* is significant with a positive contribution to the likelihood of being WTP for conservation of elephants. However, this result may be linked to the traditional Sri Lankan family culture and values. In this setting, families are represented by the head of the household. In most cases, the head of the household is the father (or the mother in the absence of the father) or the oldest child (in the absence of both the father and mother). As a result, in this study over representation of heads of households in the age group of 30 years and above was unavoidable. This cultural situation restricted the opportunities to interview the other members in certain households. In most cases, such opportunities were found only where the head of the household was absent at the time of the interview and he or she permitted another family member (in most cases the most educated person in the family) to represent him or her in the interview.

The aggregation and extrapolation of WTP benefits

Of the 300 respondents, bids of 34 respondents were identified as protest bids. These responses were removed from the sample so that genuine WTP could be analyzed. Therefore, a total of 266 WTP amounts were used in aggregation and extrapolation of WTP benefits. This was carried out at three different levels: a) from the sample to Colombo metropolitan area, b) from the Colombo metropolitan area to other major urban centres, and c) from major urban centres to the entire urban population in Sri Lanka. In this process, the authors, mindful of the sensitivity of sample effects, referred to a study done by the Department of Census and Statistics of Sri Lanka on economic and demographic aspects of the population in the Colombo metropolitan area (Department of Census and Statistics, 1998). It was found that household characteristics of the urban population in Sri Lanka were quite close to the sample of the present study. However, it must be noted that the mean WTP values used to extrapolate from the sample to the population refer to the ones after the removal of protest bids.

In our extrapolation process, we found that urban residents in Colombo metropolitan area were WTP Rs. 166.35 million per month for the conservation of elephant. This amounts to an annual value of Rs 1996.22 million. As the payment will be made over a period of five years, the total net present discounted value of these annual amounts, at a 5% real rate of discount, equals Rs. 9,075.02 million. Extrapolating to these results to all major urban areas in Sri Lanka, it was

estimated that residents in these areas were WTP Rs. 438.48 million per month for the conservation of elephant. This amounts to an annual value of Rs 5,261.17 million. As the payment will be made over a period of five years, the total present discounted value of these annual amounts, at a 5% real rate of discount, equals Rs. 24,554.20 million. Finally, when we extrapolate WTP for the entire urban population in Sri Lanka, using a population size of about 6.67 million (this figure was drawn by deducting 11.3% from the total population of 7.49 million people in urban areas to represent the protest responses based on the findings of the case study presented in this paper), we found it was Rs. 734.83 million per month. This amounts to an annual value of Rs 8818.01 million. As the payments are specified over a period of only five years, the total present discounted value of these annual amounts, at a 5% real rate of discount, equals Rs. 40248.61 million.

We know that urban residents are WTP Rs. 8818.01 million per year for five years but we do not know their WTP beyond that. Damages caused by elephants will, however, continue in perpetuity given current populations of elephants. One possible way to compensate farmers would, in principle, be to invest the urban dwellers' contribution over five years in the capital market to give an estimated return on the capitalised sum of Rs. 2012.43 million per annum at a 5% real rate of interest. This could arguably be considered an indirect indication of the willingness of urban dwellers to pay in principle in perpetuity to conserve wild elephants.

It is also worth mentioning that although in this study, we asked respondents about their WTP for the conservation of elephants for only five years, some (maybe most) respondents certainly would probably be willing to pay beyond this period. Furthermore, this amount could be increased by at least another 100%, if we extended our extrapolation to the population of residents in the rural areas where elephants do not occur or interfere with farming practices.

Urban residents WTP for conservation of elephants exceeds value of crop and property losses of farmers

As mentioned elsewhere in this paper, one of the objectives of this study is to find out whether the urban residents' WTP for conservation of elephants is sufficient to compensate farmers for the crop and property damage caused by elephants, and to raise farmers' tolerance of the presence of elephants. In this analysis, it was assumed that if urban dwellers could compensate farmers for losses associated with crop and property damages caused by elephants, given the current elephant population, and were better off than in the absence of wild elephants, the current population of elephants would be (Kaldor-Hicks) superior to the absence of wild elephants.

According to Bandara & Tisdell (2000b) the total value of the crop and property damage caused by elephants in Sri Lanka is about Rs. 560.71 million per cropping season or Rs. 1121.42 million per annum. These authors have derived this figure by extrapolating the elephant damages estimated in three selected case studies (see Bandara & Tisdell, 2002c; Jayawardene, 1998;

and De Silva, 1998) carried out in three different locations in the elephant's range. However, before we use this figure to reach any conclusions, it must be noted that the crop and property damage calculated in this analysis did not pay much attention to the possible cost that could be associated with elephants other than crop and property damages. Under normal circumstances, the total economic cost should include the cost of control measures undertaken by farmers to scare away the crop-raiding elephants, income foregone by farmers in having to replace some crops with others that are less attractive to elephants, and the management cost borne by government departments to undertake various programs for the conservation of elephants and the mitigation of HEC. Such comprehensive assessments of total losses associated with the elephant are yet to be estimated.

Nevertheless, when we compare the economic estimates of crop and property damage caused by elephants of Bandara & Tisdell (2000b) with above estimated return on the capitalised sum of Rs. 2012.43 million per annum, it shows that urban residents' financial support for the conservation of the elephant significantly exceeds the economic losses caused by the elephant. This means that our estimated return of Rs. 2012.43 million per annum on the capitalised sum in perpetuity is more than sufficient to compensate farmers for their estimated crop losses of Rs. 1,121.41 per annum; in fact almost twice the needed sum.

When compensation is paid, control of elephants by farmers is likely to be much reduced. Furthermore, a lot of their current control costs are ineffective in aggregate, either because elephants have become resistant to control measures or because, in many cases, control measures merely result in elephants moving from one farmed area to another (cf. Rollins & Briggs, 1996, p.369). Consequently, in the latter case, a type of prisoners' dilemma problem exists. If compensation for damage caused by elephants leads to much reduced control of elephants by farmers, they should achieve a net economic benefit because their control costs will be greatly reduced (or in the extreme case, eliminated) and the aggregate damage experienced by them from elephants will increase little or not at all. Nevertheless, there might be a small increase in damage in aggregate, if, for example, elephant populations increase slightly due to less harassment of elephants. Despite this, it is clear that, if compensation were paid to farmers, a sum of less than Rs 1,124.42 million per year would compensate them if allowance were made for the reduced control effort of farmers. The latter will reduce farmers' costs of control.

Conclusion

This study was conducted to survey a sample of urban residents in the Colombo metropolitan area to determine their willingness to pay for the conservation of the Asian elephant in Sri Lanka. The finding of this analysis indicates that there is a strong economic case for ensuring the survival of wild elephants in Sri Lanka. There is strong evidence that the current population of wild elephants in Sri Lanka is economically preferable to their absence considering the interests of all stakeholders, urban residents and farmers.

Gajah 22: (July 2003)

References

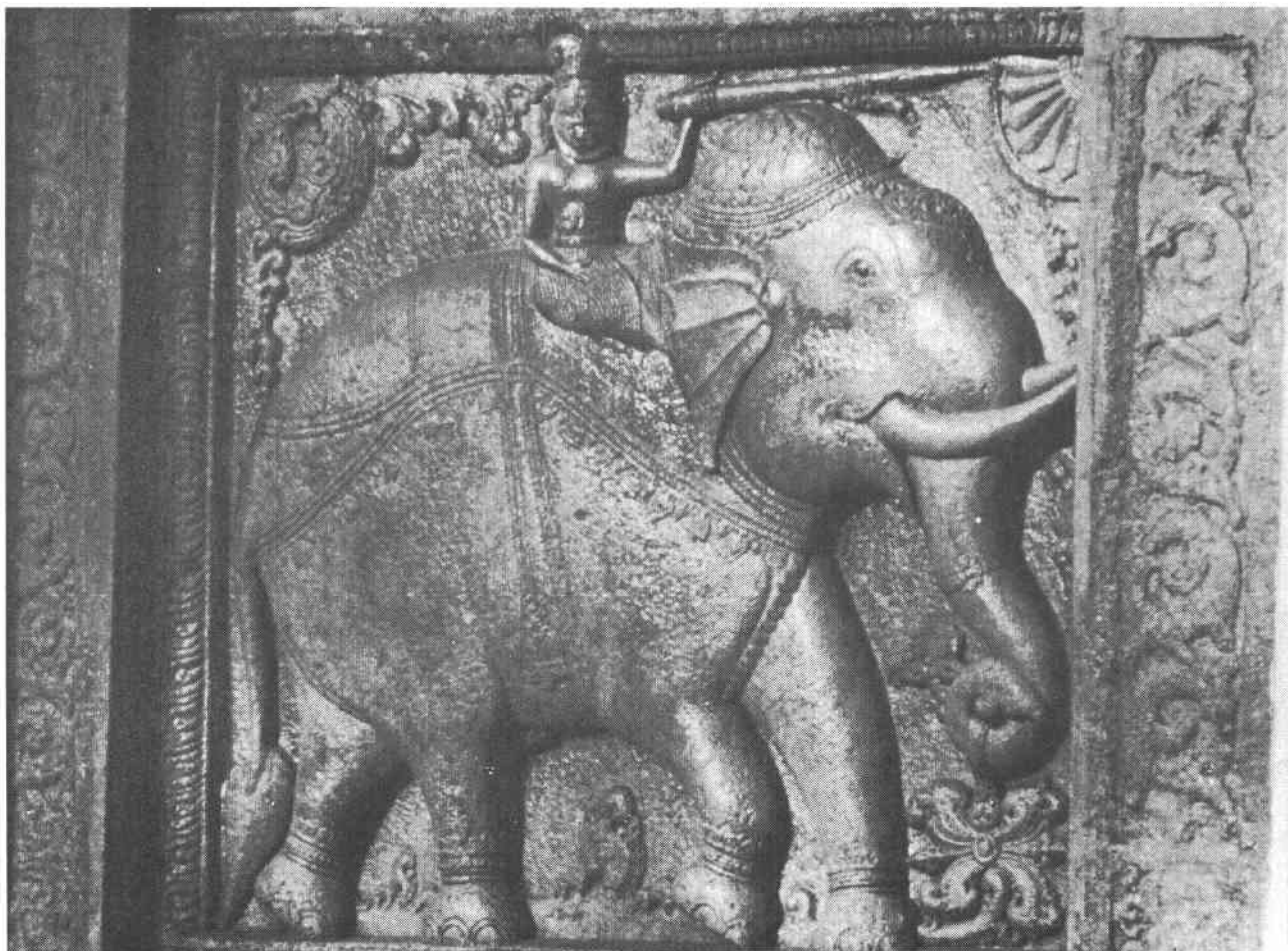
- Bandara, R. & Tisdell, C. (2002a) Conserving Asian Elephants: Economic Issues Illustrated by Sri Lankan Concerns, In *The Economics of Conserving of Wildlife and Natural Areas*. (ed. C.A. Tisdell) pp. 193-211. Edward Elgar, Cheltenham, UK.
- Bandara, R. & Tisdell, C. (2002b) Willingness to Pay for the Conservation of Asian Elephants: Contingent Valuation Study. *Economics, Ecology and the Environment*, Working Paper No. 67, School of Economics, The University of Queensland, Qld 4072, Australia.
- Bandara, R. & Tisdell, C. (2002c) Asian Elephants as Agricultural Pests: Damages, Economics of Control and Compensation in Sri Lanka. *Economics, Ecology and the Environment*, Working Paper No. 65, School of Economics, The University of Queensland, Qld 4072, Australia.
- Bateman, I. J. & Turner, R.K. (1993) Valuation of the Environmental, Methods and Techniques: The Contingent Valuation Method. In *Sustainable Environmental Economics and Management: Principles and Practice*. (ed. R.K. Turner). John Wiley & Sons, Chichester.
- Bateman, I. J. & Langford, I.H. (1997) Non-Users' Willingness to pay for a National Park: An Application and Critique of the Contingent Valuation Method. *Regional Studies*, 31: 571-582.
- Carson, R. T., Wright, J., Alberini, A. Carson, N., & Flores, N. (1994) A Bibliography of Contingent Valuation Studies and Papers. Natural Resource Damage Assessment Inc. La Jolla, CA.
- Carson, T. R. Flores, N. E. Martin, K. M. & Wright, J. L. (1996) Contingent Valuation and Revealed Preference Methodologies: Comparing the Estimates for Quasi-Public Goods. *Land Economics*, 72: 80-99.
- Diamond, P.A. & Hausman, J.A. (1994) Contingent valuation: Is Some Number Better than No Numbers. *Journal of Economic Perspectives*. 8: 45-64.
- Department of Census and Statistics. (1998) *Statistical Pocket Book*, Department of Census and Statistics, Colombo, Sri Lanka.
- De Silva, M. (1998) Status and conservation of the elephant (*Elephas maximus*) and the alleviation of man-elephant conflict in Sri Lanka. *Gajah*, 19: 1-68.
- Desai, A. A. (1998) *Conservation of Elephants and Human-Elephant Conflict*, Unpublished Technical Report, Department of Wildlife Conservation, Colombo, Sri Lanka.
- Etzioni, A. (1988) *The Moral Dimension: Towards a New Economics*. The Free Press, New York.

- Hadker, N., Sharma, S., David, A. & Muraleedharan, T. R. (1997) Willingness to Pay for Borivli National Park: Evidence from a Contingent Valuation. *Ecological Economics*, **21**: 105-122.
- Heinen, J. T. (1993) Park-People Relation in Kosi Tappu Wildlife Reserve, Nepal: A Socio Economic Analysis. *Environmental Conservation*, **20**: 25-34.
- IUCN. (1996) *Red List of Threatened Animals*, IUCN Gland, Switzerland.
- Jaibi, R.M. & Raa, T.T. (1998) An Asymptotic Foundation for Logit Models. *Regional Science and Urban Economics*, **28**: 75-90.
- Jakobsson, K.M. & Dragun, A.K. (1996) *Contingent Valuation and Endangered Species: Methodological Issue and Applications*. Edward Elgar, Cheltenham, UK.
- Jayawardene, J. (1998) Elephant and Mahaweli: A 15-Year Study. *Sri Lanka Nature*, **2**: 45-51.
- Kanninen, B. J. & Khawaja, M. S. (1995) Measuring Goodness of Fit for the Double-Bounded Logit Model. *American Journal of Agricultural Economics*, **77**: 885-890.
- Kemf, E. & Santiapillai, C. (2000) *Asian Elephants in the Wild*. 2000 WWF Species Status Report. WWF-International. Gland, Switzerland.
- Kotchen, M.J. (2000) Environmental Attitudes, Motivation, and Contingent valuation of Non-use Values: A Case Study Involving Endangered Species. *Ecological Economics*, **32**: 93-107.
- Lehman, H. (1993) Values, Ethics, and the Use of Synthetic Pesticides in Agriculture, In *The Pesticide Question: Environment, Economics and Ethics* (eds. D. Pimentel & H. Lehman) pp.347-349. Chapman and Hall, New York.
- Loomis, J. B. & Larson, D. M. (1994) Total Economic Value of Whale Populations: Results from a Contingent Valuation Survey of Visitors and Households. *Marine Resource Economics*, **9**: 275-286.
- Loomis, J. B. & White, D. (1996) Economic Benefits of Rare and Endangered Species: Summary and Meta-Analysis. *Ecological Economics*, **18**: 197-206.
- Loomis, J. B. & Ekstrand, E. (1998) Alternative Approaches for Incorporating Respondent Uncertainty when Estimating Willingness to Pay: The Case of Mexican Spotted Owl. *Ecological Economics*, **27**: 29-41.
- McFadden, D. (1974) Conditional Logit Analysis of Qualitative Choice Behaviour. In *Frontiers in Econometrics*. (ed. P.C. Zarembka), pp.105-142. Academic Press, New York.
- Miller, J. D. & Lindsay, B. E. (1993) Willingness to Pay for a State for a Gypsy Moth Control Program in New Hampshire: A Contingent Valuation Case Study. *Journal of Economic Entomology*, **86**: 829-837.
- Oglethorpe, D.R. & Miliadou, D. (2000) Economic Valuation of the Non-use Attribute of a Wetland: A Case Study for Lake Kerkini. *Journal of Environmental Planning and Management*, **43**: 755-767.
- Pate, J. & Loomis, J. (1997) The Effect of Distance on Willingness to Pay Values: A Case Study of Wetland and Salmon in California. *Ecological Economics*, **20**: 199-207.
- Ready, R. C., Buzby, J. C. & Hu, D. (1996) Difference Between Continuous and Discrete Contingent Valuation Estimates. *Land Economics*, **72**: 397-411.
- Rollins, K. & Briggs III, H. C. (1996) Moral Hazard, Externalities, and Compensation for Crop Damages from Wildlife. *Journal of Environmental Economics and Management*, **31**: 368-386.
- Santiapillai, C. & Jackson, P. (1990) *The Asian Elephant: An Action Plan for Its Conservation*, IUCN, Gland, Switzerland
- Seip, K. & Strand, J. (1992) Willingness to Pay For Environmental Goods in Norway: A Contingent Valuation Study with Real Payment. *Environmental and Resource Economics*, **12**: 91-106.
- Sellar, C., Chavas, J. P. & Stoll, J. R. (1986) Specification of the Logistic Model: The Case of Valuation of Non-market Goods. *Journal of Environmental Economics and Management*, **13**: 382-390.
- Stevens, T.H., Benin, S. & Larson, J.S. (1995) Public Attitudes and Economics Values of Wetland Preservation in New England. *Wetlands*, **15**: 226-231.
- Tisdell, C. A. (1997) Local Communities, Conservation and Sustainability: Institutional Change, Altered Governance and Kant's Social Philosophy. *International Journal of Social Economics*, **24**: 1361-1375.
- Urban Development Authority of Sri Lanka. (2001) *Land Use Planning In Sri Lanka*. Volume 1, Urban Development Authority, Sethsiripaya, Colombo, Sri Lanka.
- Weerakoon, D. K. (1999) *Ecology and Ranging Behaviour of Wild Elephants and Human-Elephant Conflict in Sri Lanka*. (Unpublished Report) Department of Zoology, University of Colombo, Sri Lanka.
- Whitehead, J. (1992) Ex-ante Willingness to Pay with Supply and Demand Uncertainty: Implications for Valuing a Sea Turtle Protection Programme. *Applied Economics*, **24**: 981-988.

White, P. C. L., Bennett, A. C. & Hayes, E. J. V. (2001) The Use of Willingness to Pay Approaches in Mammal Conservation. *Mammal Review*, **31**: 151-167.

Witzer, H. P. & Urfei, G. (2001) Willingness to Pay for Environmental Protection in Germany: Coping with the Regional Dimension. *Regional Studies*, **35**: 207-214.

Wills, K.G. & Powe, N.A. (1998) Contingent Valuation and Real Economic Commitments: A Private Good Experiments. *Journal of Environmental Planning and Management*, **41**: 611-19.



Elephant (18th Century) at the entrance to the Temple of the Tooth Kandy
(Photo: Dr. H. I. E. Katugaha)

Guidelines for the management of captive Asian elephants and the possible role of the IUCN/SSC Asian Elephant Specialist Group

Fred Kurt and Khyne U Mar

Abstract Many reports refer captive Asian elephants as “domesticated” animals. However, most of the elephants living in captivity have been wild-caught and a large number of them are the result of wild bulls mating with females in captivity. Although captive elephants have existed since 3,500 years in close contact with man, yet they have not been the subject of sustained captive breeding, nor have they been selected for particular characteristics as it was, and still is, the case with really domesticated animals such as horses, sheep or dogs. It is therefore inaccurate to refer to the captive Asian elephants as domesticated animals. There could be as many as 14,000 Asian elephants in captivity, with Myanmar accounting for 40%. At least 1,047 Asian elephants are kept world wide in zoos and circuses. Therefore the total captive population includes at least 15,000 elephants. The chances of survival of captive populations are practically zero in intensively kept elephants and very insignificant for those

kept in traditional zoos where mortality rates are extremely high at young ages. But the survival chances are relatively high in the Pinnawela Elephant Orphanage in Sri Lanka, modern zoos as well as in extensive keeping systems with low mortality rates at young ages. Well maintained elephant parks, orphanages, and transit homes allow for the maintenance of elephants free of chains and in social groups, thereby enabling the animals to express their natural behaviour patterns, and provide them with exercise and opportunities to socialize. Elephants kept in such a way make more sense to the visitors than do “dancing” elephants or elephants that are forced to ride bicycles, paint canvas, play football, guitar or mouth-organ.

Keywords Asian elephant, management in captivity, domestication, captive breeding.

Introduction

During the IUCN/Asian Elephant Specialist Group (AsESG) meeting that was held in Phnom Penh, Cambodia in May 2002, the AsESG formed a “Captive Elephant Taskforce”. Some AsESG members met again at the Workshop on Captive Elephant Management in Trichur in October 2002 and again the Chairman of AsESG, Prof. Raman Sukumar, asked for ideas concerning the aims of such a taskforce. In this paper we have drafted a few ideas along the following lines: First of all the AsESG should desist from referring to “domesticated” elephants. Then one should ask what are the aims of IUCN and the IUCN Specialist Groups as compared to the aims of animal welfare organizations and those zoos concerned with management problems of captive elephants. Then very brief overviews are given on existing and forthcoming guidelines on the management as well as on the estimated sizes of captive populations. Different aspects of the significance of captive populations are broadly discussed after keeping systems have been defined. Finally we have made some proposals concerning further activities of AsESG regarding the management of captive elephants.

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Are captive elephants really domesticated?

Numerous reports consider captive Asian elephants as “domesticated” animals (c.f. Lair, 1997). However, most of the elephants living in captivity have been wild-caught and a large number of elephants that have been bred in the range countries are the result of matings between captive females and wild males. Although captive elephants have existed since 3,500 years in close contact with man, yet they have not been the subject of sustained captive breeding, nor have they been selected for particular characteristics as it was, and still is, the case with really domesticated animals such as horses, sheep or dogs. It is therefore inaccurate to refer to the captive Asian elephants as domesticated animals (e.g. Baker & Manwell 1984; Herre & Röhrs, 1990; Stevenson, 2002).

Misuse of the term “domesticated” leads to the fact that many captive elephants were, and still are, treated as cattle and managed accordingly. For example, in old fashioned western zoos and circuses the elephant is the only wild animal still kept more or less permanently in chains. Imagine the reaction of animal welfare organizations, if suddenly zoos would keep rhinos, hippos or tigers in chains! All members of AsESG should consider tamed Asian elephants as what they are, as captive wild animals.

What are the aims of the IUCN, modern Zoos and Animal Welfare Organizations?

The IUCN aims to conserve the biodiversity of the planet earth with particular emphasis on the maintenance of threatened species and their genetic diversity and the

maintenance of ecological processes. The Asian elephant is considered an endangered species. Furthermore *Elephas maximus* must be considered a keystone species as well since it plays an important role in ecological processes (e.g. dispersion of seeds, acceleration of soil fertility in cooperation with insects and other invertebrates) in its habitat. The Asian elephant can also be regarded as a flagship species promoting conservation of numerous less popular plant and animal species surviving in its habitat (Leader-Williams & Dublin, 2000).

In 1993 some modern zoos formulated the "World Zoo Conservation Strategy" and started to take responsibility for the *ex-situ* conservation of certain animal species including the Asian elephant. Accordingly these zoos would like to keep elephants in as natural ecological and social conditions as possible. This means that the environment must be provided to ensure species-specific behaviour patterns, e.g. food preparation or social possibilities for forming a dominance hierarchy, family units and successfully rearing of offspring. The World Zoo Conservation Strategy aims to maintain a natural socio-ecological set-up, refers to results of field research on wild populations and aims by environmental enrichment to reduce the frequencies of abnormal behaviour as well as the increase of behavioural diversity, the range or number of behaviour patterns, the positive utilization of the environment and the ability to cope

with challenges in a more normal way. Elephants kept in near-natural conditions convey more understanding of the species and its requirements to the visitor and provide insight into the necessity to protect the species. Furthermore near-natural conditions promote breeding in captivity and hence, add to the conservation of genetic and behavioural diversities.

During the past few years, animal welfare organizations have helped raise elephant welfare standards. A considerable number of new elephant welfare organizations have been formed. They campaign, train and provide resources to improve living conditions of captive elephants in western zoos as well as several range states including India, Sri Lanka, or Thailand. Animal welfare activities refer mainly to the fitness (e.g. health, body condition) of the individual, but hardly touch on socio-ecological considerations to maintain captive populations living in near-natural conditions. In traditional elephant keeping establishments the captive animals are not able to enjoy what Webster (1984) terms "the five freedoms" (freedom from malnutrition, from thermal and physical discomfort, from injury and disease, from fear and stress, as well as freedom to express most normal patterns of behaviour). Nevertheless assessment of the fundamentals of animal welfare organizations is the fundamental basis of the maintenance of the Asian elephant in captivity.

Table 1 Estimated numbers of captive Asian elephants in range countries, zoos and circuses (worldwide), population trends and employment (+ occurs, ++ occurs often, - not found).
CRM = ceremonies; BEG = begging shows; ECO = ecotourism.

country	total	population trend	used for				source
			logging monitor	CRM	BEG	ECO	
Bangladesh	50	decrease	+	+	-	-	Islam (1996)
Cambodia	144	decrease	+	+	+	-	Ratanakorn (2002)
India	3600	stable	+	++	+	+	Bist <i>et al.</i> , (2002)
Indonesia	400	decrease?	(+)	(+)	++	+	Mikota (2002)
Lao PDR	920	decrease	++	?	?	?	Ratanakorn (2002)
Malaysia	8	?	+	-	-	-	Daim (1996)
Myanmar	5700	stable	++	+	-	-	Mar (2002)
Nepal	127	stable?	-	(+)	-	++	Dhakal (2002)
Sri Lanka	186	decrease	-	++	++	(+)	Jayewardene (2002)
Thailand	2568	decrease	+	(+)	++	(+)	Ratanakorn (2002)
Vietnam	225	decrease	+	?	?	+	Sawson (1996)
Total	13928						
Zoos/circus	c.1094	decrease					Koehl (2001)
Grand Total	c.14975						

Taking the above-mentioned definitions into consideration, AsESG has to assist all serious animal welfare activities, but according to the aims of the IUCN, the AsESG has to promote the aims formulated by the World Zoo Conservation Strategy as well. The goals of the strategy should accordingly be valid for any conservation-minded facility keeping captive Asian elephants.

Existing guidelines for the management of captive Asian elephants

The earliest work concerning the care of captive elephants was decidedly the *Hastayurveda* which appears to have been written in the 5th or 4th century BC. The *Arthashastra* of Kautiliya (300 BC – 300 AD) deals, in two chapters, with capture, keeping, care and training of elephants. The *Matangalila* of Nilakantha, another ancient source, may go back to a thousand years or even to a much earlier date. Next to these three standard texts are a number of other old Buddhist and Hindu sources referring to the management of captive elephants such as the *Tanjore Manuscript* (a compilation of several older texts), the *Gajanirupana*, the *Gajacikitsa*, the *Gajalakshana*, or the *Brhat-Sarnhita* of Varahamihira (c.f. Edgerton, 1931). All the rules and regulations given in these texts formed the basis for the management of captive elephants in areas under the control of Buddhist and Hindu rulers in South Asia.

In the 19th and early 20th centuries, the British civil servants recorded many local practices, improving them if necessary, and formulated a number of guidelines to regulate the capture, care, daily food rations, work schedules and working loads of timber and army elephants in India and Myanmar (e.g. Sanderson, 1879; Evans, 1912; Milroy, 1922 or Ferrier, 1947; Krishnamurthy & Wemmer 1995a; 1995 b). State-run elephant establishments had guidelines on elephant husbandry which were later prescribed as Department Standing Orders and are still implemented (Khyne U Mar pers. comm.). A system of record keeping right from the early days of elephant management under colonial rule provides valuable data on the performance of individual animals. Several forms of reportage are routinely practiced. These records also provide guidelines, particularly to the new entrants to the administrative set-up, in the proper usage of working elephants under their custody (Khyne U Mar pers. comm.).

In India, the Central Zoo Authority has prescribed standards and norms for all zoos in the Recognition of Zoo Rules (1992). But no such standards and norms exist for the care of hundreds of privately owned elephants. In the last seven years "*Standard and Norms for Elephant Owners*" has been drafted (Bist, 1996) and for Kerala, the "*Captive Elephant Management Rules 2002*" have been drawn up by Dr. V. Cheeran and his colleagues. These new guidelines are paramount in improving the living conditions of captive elephants. However, the fact that only few captive elephants are breeding and that few live in a social and ecological environment and are in physical and psychological conditions conducive to breeding, has hardly been recognized.

In North America and Europe a considerable number of management guidelines have been formulated by governmental and non-governmental organizations. Many of them are rightly criticized by elephant experts or welfare organizations as being not strict enough to guarantee a minimum of species-specific requirements. However, most of these guidelines consider the Asian elephant as a species with highly evolved social behaviour and therefore recommend the keeping of the species in groups. In Europe for example, a radical change came with the "EEP Management for Elephants in EAZA Institutions" (2000). Among many other points, it was suggested that "matriarchal family units are developed and kept together, i.e. the intention to keep female offspring within their family group during their life" (Dorrestyn, 2001).

In 2002, the "*Review of the Welfare of Zoo Elephants in Europe*" was commissioned by RSPCA and carried out by Ross Clubb and Georgia Mason of the Oxford University, which summarized results from a few rather traditional zoos and found poor welfare of most zoo elephants and demanded improvement of the elephants' social and physical environments. They concluded: "The factors responsible for the poor welfare of zoo elephants should be empirically investigated as a matter of urgency. The zoo elephant population should be frozen, i.e. breeding and importation should be ceased until these factors have been identified. Only zoos that then solve these problems should be allowed to keep elephants in the future."

In her "*Management Guidelines for the Welfare of Elephants*", Miranda F. Stevenson (2002) has compiled all the requirements for a near-natural keeping of elephants in modern zoos and the *Elephant Management Policy Statement of Federation of Zoos in Great Britain and Ireland* stipulates that "Elephants must only be kept in zoos as part of an overriding conservation mission so that they are in actively managed breeding programmes.... Their presence must enable progressive educational activities and demonstrate links with field conservation projects and benign scientific research, leading to continuous improvements in breeding and welfare standards. Zoos must exercise a duty of care so that standards of husbandry practices, housing, health and welfare management are humane and appropriate to the intelligence, social behaviour, longevity and size of elephants..."

How many Asian elephants live in captivity?

Accurate numbers of captive Asian elephants in the range states are not known. According to most recent estimates their total population numbers about 14,000 animals (Table 1). The largest population is found in Myanmar (40% of the total population from the range states), followed by India (26%) and Thailand (19%). At least 1,047 Asian elephants are kept world wide in zoos and circuses. Therefore the total captive population includes at least 15,000 elephants. But the captive population is dwindling rapidly as a result of many factors such as low reproduction and high (juvenile) mortality, restriction of capturing operations, or lack of employment opportunities as logging was banned in many south Asian countries.

Table 2 Definitions of management systems

Examples	Extensive Jungle-based timber and wildlife camps	Intensive Temples, urban tourist centers	Alternative Modern zoos elephant parks
Mainly used for:	Riding, transport, hauling, heaving	Parades, circus tricks, begging	Display, reproduction, research
<i>Daily activities, food:</i>			
- Free movements:	Forefeet hobbled but free in nearby forest ± Determined by elephants	12 – 22 h/day chained in stands or stables Determined by man	Chains and hobbles exceptionally ± Determined by elephants
- Activity centers:	Divers ± By elephants, except prepared ration	Monotonous By man	Divers By man
- Quality of food:	± Permanently except when bathing, sleeping		Several feeding periods/d
- Choice of food:	By man and elephants	1-3 feeding periods/d	By elephants
- Food intake:	Determined by elephants	By man	Determined by elephants
- Bath, skin care:		Determined by man	
- Place for sleep:			
<i>Social behaviour:</i>			
- Pop structure:	Heterogeneous	± Homogeneous	Heterogeneous
- Social contacts:	Permitted	Hindered	Permitted
<i>Reproduction:</i>			
- Reprod. rate:	Relatively high	Very low	Relatively high
- Neonate mort.:	Relatively low	Very high	Relatively low
- Rate of raising:	Relatively high	Very low	Relatively high
- Role of "aunts"	Important	Not existent	Important
<i>Musth</i>			
- Musth bulls kept:	Permanently in chains	Permanently in chains	In bull enclosure
- Social contacts:	Not permitted	Not permitted	Permitted
- Musth period	Relatively short	Relatively long	Relatively long
<i>Owners & mahouts:</i>			
- Ownership:	Mainly government	Mainly private	Private
- Soc. status owner	High	High	High
- Soc. status keeper	Relatively high	Increasingly very low	Relatively high
- Skill of keeper	High	Increasingly low	High
- Fluctuations of mahouts/keepers	Low	High	Low
- Tool used:	Stick or rod, blunt pointed ankus	Stick or rod, blunt pointed ankus, sharply pointed knife and ankus, poles, spears	Blunt pointed ankus
- Accidents:	Rare	Increasingly common	Very rare

Nevertheless there are exceptions. In India, Myanmar and Nepal the populations of captive elephants appear to be stable.

In all the range states considerable shifts of captive elephants from forest to urban areas have been reported. In India for example, restriction of logging operations in the north-east and the Andaman Islands imposed by the Supreme Court in 1996 resulted in a great exodus of captive elephants from these regions, while their number has increased in Kerala from about 250 in 1983 to more than 700 with a male-biased population structure at present (Fig.1). The city of Jaipur (Rajasthan) has about 100 captive elephants with a female-biased population structure (Fig.1) and has become a major elephant center. Captive elephants all over Thailand suddenly became unemployed after the government banned logging in 1989. Now most of them are involved in illegal logging, and many are given amphetamines to speed up work. Unworkable elephants are sent to slaughter houses and their meat sold (Mahasavangkul, 2002).

Keeping systems

The multiple and diverse deployment of captive Asian elephants requires various keeping systems (Kurt, 1995) whose extremes can be defined as follows (Table 2): Working elephants in jungle villages live in extensive keeping systems.

They are used as riding, carrying and towing animals. During their rest periods they live, with hobbled front feet, in the nearby forest, where they find food and meet their tame and wild conspecifics. In South India, depending on tradition, additional fodder is given. Examples are the timber elephants of the Myanma Timber Enterprise (MTE) of Myanmar or those under the care of forestry authorities in Assam, Tamil Nadu, Karnataka or Kerala where captive elephants are increasingly used as riding animals for wildlife patrolling, conservation research and tourism.

In Myanmar most of the elephants are maintained for work, particularly logging, and a definite schedule of work is allocated. Work hours are adjusted according to the seasons thereby avoiding the hottest part of the day. A working elephant is able to work six hours a day over a period of eight months in a year. After the work hours, elephants are allowed to forage at nights with front limbs loosely hobbled to restrict their movement. Elephants can move distances of 8-15 km per night. The amount of work that an elephant can do in a day depends on the sex and age of the animal, its general body condition, size of timber, the state of drag paths, nature of terrain, quantity and quality of food available in the vicinity of the forest and the ambient temperature of the season. Pregnant elephants and female elephants with suckling calves are given rest until the neonate reaches the

Table 3 Significance of captive Asian elephants according to keeping systems
(0 = not significant; 1 = low; 2 = medium; and 3 = relatively high).

Keeping System	economical owner mahout		religion social	urban tourism	education	ecological forestry keystone		total (T1)
Intensive								
Temple	3	1	3	3	1	0	0	11
Tourist Co.	2	1	0	3	1	0	0	7
Circus	3	1	0	1	1	0	0	7
Intermediate								
Trad. Zoos	3	2	0	1	2	0	0	8
Pinnawala	3	2	0	3	3	0	0	11
Extensive								
Timber Co.	2	2	0	0	2	3	3	12
Tourist Co.	2	2	0	0	3	3	3	13
Alternative								
Modern Zoos	3	3	0	2	3	0	0	11
Transit House	1	2	0	0	0	0	0	3

age of one year. Bulls in musth are not allowed to be put in the work force and are given rest at secluded areas. However, during the pre-musth period, when most of the mating takes place, captive bulls can roam freely during the night.

During the hottest period of the year, when food quality is at a minimum, the animals are shifted to a new camping ground and given complete rest. In Myanmar, working elephants will continue to play a vital role in the timber operations of the MTE for the foreseeable future (Mar & Win, 1997; Mar, 2001; 2002).

Intensive keeping systems (Table 2) are those in which animals are kept in temples or by private owners more or less individually, fed exclusively on prepared fodder and at night or if idle, shackled with longer or shorter chains to a hind foot or to both one hind and one front foot. Contact with captive conspecifics is avoided. Contact with wild conspecifics is unlikely because intensive keeping is concentrated in urban regions. Today intensively kept elephants are rarely employed for work (e.g. sawmills), but increasingly used in religious processions, political demonstrations or wedding ceremonies. Restricted movements and the practical absence of contacts with conspecifics has led to extreme aggressive behaviour towards mahouts or elephant handlers and to the evolution of stereotypic behaviour (e.g. Kurt & Garai, 2002). The intensive keeping system has been adopted by western circuses today, and in the former times, zoological gardens too followed it. The keeping system in traditional zoos as well as in the Elephant Orphanage at Pinnawala, Sri Lanka can be considered as intermediate between extensive and intensive systems. For example, during the day the elephants are kept free in their paddocks but in the night, they are shackled or otherwise kept solitary in small cages.

In very modern zoos alternative keeping systems (Table 2) are evolving now very fast according to the guidelines of the *World Zoo Conservation Strategy*. In these systems elephants live in appropriate family groups which are paramount for the process of learning and socialization (Garai, 2002a; Kurt, 2001; 2002; Clubb & Mason, 2002; Stevenson, 2002) and only subadult and adult bulls are kept singly if necessary (e.g. during musth). A further alternative keeping system is found in Elephant Transit Homes situated in the Uda Walawe National Park in Sri Lanka, where young elephants are kept in a semi-natural environment with minimal contacts with humans (e.g. bottle-feeding) to avoid imprinting processes which could later complicate the release of the captive animals into the wild.

Significance of captive Asian elephants

Captive elephants have an economical significance for owner, keeper or mahout. They may be important as a motive force for forestry operations. Furthermore they may have a religious significance (mainly in Buddhist and Hindu countries) or a social significance for non-religious ceremonies. Captive elephants can be an attraction in urban tourism, they can be paramount for education (including eco-tourism) concerning life sciences and conservation. Last but not least, captive Asian elephants can still have an ecological significance in selective timber harvesting and as keystone species in the maintenance of biodiversity and ecological processes (Santiapillai & Widodo, 1992).

For each of these above categories the degree of significance has been crudely estimated and given 4 scores: 0: insignificant; 1: low; 2: medium and 3: high significance. Relative low total significance (total less than 10 points) is found in elephants kept in transit homes, urban tourist centers, circuses or traditional zoos (Table 3). Relative high

Table 4 Living conditions and population dynamics of captive Asian elephants according to keeping systems (0 = not present; 1 = low; 2 = medium; and 3 = relatively high)

keeping system	individual fitness		food	population dynamics			reproduction	total (T2)
	vet care	body condition		activity	social behavior	social structure		
<i>Intensive</i>								
Temple	2	2	1	1	0	0	0	6
Tourist Co.	1	1	1	1	0	0	0	4
Circus	1	1	1	1	0	0	0	4
<i>Intermediate</i>								
Trad. Zoos	2	2	1	1	1	1	1	9
Pinnawala	2	2	2	3	3	3	3	18
<i>Extensive</i>								
Timber Co.	2	2	3	2	3	3	3	18
Tourist Co.	2	2	3	2	3	3	3	18
<i>Alternative</i>								
Mod. Zoos	3	3	2	3	3	3	3	20
Transit House	1	1	1	1	1	1	0	6

significance (total ≥ 10 points) is found in elephants kept in temples, the Pinnawela Elephant Orphanage (Sri Lanka), modern zoos, timber and tourist camps (Table 3). It must be stressed that relative high significance has different reasons. Those living in jungle camps reach high values mainly due to their value for local people, education and ecology, while those living in temples reach a relative high significance due to their economical, religious and tourist value.

Living conditions and population dynamics of captive Asian elephants

Living conditions can be defined by the individual fitness, the food offered, the daily activity as well as aspects of population dynamics such as social behaviour, social structure of the population and reproductive performance (Table 4). Individual fitness depends on the degree of care by veterinarians and keepers/mahouts and becomes apparent in the body condition of the animals. Both aspects have been assigned scores: 1: low, 2: medium, and 3: high. The food offered to elephants can be monotonous (1), diverse (3) or intermediate (2). Monotonous food consisting of the leaves, branches and stems of one to three plant species is common for elephants kept in temples and urban tourist centers. But also in most of the traditional zoos and circuses food can be considered as monotonous (Schwammer, pers. com.). The same applies to the baby elephants kept at the Transit Home in Uda Walawe National Park (Sri Lanka). Beside the daily portion of milk, the animals survive on only a few wild growing species of grass. Elephants living in jungle or forest-

based extensive systems find a most diverse diet. In modern zoos as well as in the Pinnawela Elephant Orphanage the diversity of food must be considered as intermediate.

For elephants kept in extensive systems daily life includes, besides work, the search for food, skin care, socializing and sleeping at a species-specific place. There are no or at least hardly any stereotypes. Their daily species-specific activity is considered as medium (2). Elephants kept in extensive and intensive systems are brought twice a day to certain watering areas by their mahouts, where they are scrubbed and massaged with the husk of the coconut or the skin of the bread-fruit, or stones or bark. Elephants kept in intensive systems are fed once a day or repeatedly with prepared food. When they are not working they often remain idle. Stereotypes occur regularly. The daily species-specific activity is considered as low (1). The same applies to elephants kept in traditional zoos, circuses and in the Transit Home at Uda Walawe. However, a high degree (3) of diverse daily activities is found in modern zoos and in the Pinnawela Elephant Orphanage.

Species-specific social behaviour is very rare or practically absent (0) in elephants kept in intensive systems. But it is relatively high (3) in the Pinnawela Elephant Orphanage, in extensively kept elephants as well as in modern zoos. Low social activities (1) are found in traditional zoos as well as in the Transit Home. Low or even an absence of social behaviour is due to the respective management systems, where intraspecific interactions are either not allowed by owners

Table 5 Significance of captive Asian elephant populations for conservation
(0 = not significant; 1 = low; 2 = medium; & 3 = relatively high)

keeping system	total T1+T2	promoting conservation	reproductive potential	chances of pop. survival	natural biodiversity	Total
<i>Intensive</i>	17	1	0	0	0	18
Temple	11	1	0	0	0	12
Tourist Co.	11	0	0	0	0	11
Circus						
<i>Intermediate</i>						
Trad. Zoos	17	1	1	0	0	19
Pinnawala	28	3	3	3	0	37
<i>Extensive</i>						
Timber Co.	30	2	3	2	3	40
Tourist Co.	31	3	3	3	3	43
<i>Alternative</i>						
Mod. Zoos	31	3	3	3	0	40
Transit House	9	3	?	?	3	>15

and keepers/mahouts or hardly possible because of a monotonous social structure of the captive groups concerned (Fig.1).

In most intensively kept populations social structures can hardly be recognized (0) since only members of certain age and sex classes are kept (e.g. mainly subadult and adult bulls in temples, or older females in circuses, or juveniles in many urban tourist resorts). Groups in traditional zoos consist mainly of middle aged or old females and rarely include bulls or younger members (Fig.1). Therefore their social structure can be considered as being comparatively low (1). The same applies to elephants in the Transit Home at Uda Walawe, where only orphaned neonates, infants and juveniles are kept. The populations in the Pinnawela Elephant Orphanage, as well as those in jungle based camps are socially well structured (3).

Reproduction is practically absent in intensive keeping systems and – of course – in the Transit Home. But reproductive performances are relatively high at the Pinnwela Elephant Orphanage and in extensively kept populations. The sum total of crude evaluations of different parameters of living conditions and population dynamics is low (<10 points) in intensive keeping systems as well as in traditional zoos and the Transit Home, but is significantly higher in the Pinnawela Elephant Orphanage, in modern zoos as well as extensive keeping systems (Table 4).

The significance of captive Asian elephant populations for conservation

The significance of captive elephants for the economy, religious education as well as for the natural environment are the root-causes for the *ex-situ* conservation of the species. The same applies to parameters of living conditions and population dynamics (t1 and t2 in Table 5). To assess crudely the significance of captive elephants for the conservation of the species it must also be taken into consideration that captive elephants can promote conservation efforts, that some of the populations can add to the natural biodiversity and that captive propagation is possible in some populations.

There is a wide variety of ways in which captive Asian elephants can promote conservation efforts. Riding elephants enable researchers to carry out ecological and behavioural studies in wild areas. Zoo elephants living under near-natural conditions are paramount for fundraising as well as conservation orientated education in urban areas. And in protected areas, riding elephants are an important asset for wildlife and conservation research as well as eco-tourism. It must be stressed, however, that more and more captive elephants are being misused in spectator shows which have little or nothing to do with the species-specific behaviour or good taste and aim to entertain the crowds in a very questionable way. Often such shows owe their existence to some of the most cruel training methods.

Several captive populations reproduce on a more or less regular basis. It must be stressed, however, that there is no self-

sustainable captive population at present due to a lack of well managed breeding programs. Nevertheless there are smaller populations with a high (3) potential for reproduction as can be seen in the Pinnawela Elephant Orphanage, modern zoos and extensive keeping systems. In intensive keeping systems, reproduction is practically absent (0), due to several reasons, the most important being the lack of economical incentives for the owners to breed elephants. But many intensively kept elephants are neither physiologically nor psychologically able to reproduce. They show serious retardation in body growth (Kurt & Kumarasighe, 1998; Weihs *et al.*, 2002); they never went through a species-specific socialization process (Garai, 2002a) and tend to practice infanticide (Kurt & Mar, 1996), or they are kept under such tremendous physical and psychological suppression by their keepers/mahouts that neither their sexual organs nor their sexual behaviour can develop normally (Hildebrandt *et al.*, 2000; 2001). Many females kept in traditional zoos become so obese that reproduction is impossible after an age of 30 years (Hildebrandt & Göritz, 1995; Kurt & Mar, 1996).

The chances of survival of captive populations are practically zero in intensively kept elephants and very insignificant for those kept in traditional zoos where mortality rate is extremely high at young ages (Fig. 2). But the survival chances are relatively high in the Pinnawela Elephant Orphanage, modern zoos as well as in extensive keeping systems (Sukumar *et al.*, 1997) with low mortality rates at young ages (Fig. 2). Finally the significance of captive populations increases when they add to the natural biodiversity of the species habitat. Summarizing the single values of qualifications for different keeping systems (Table 4), the following conclusions can be drawn: Elephants living in intensive keeping systems, circuses or traditional zoos have low significance for conservation of the species (total < 20 points). But elephants living in the Elephant Orphanage at Pinnawala (Sri Lanka), modern zoos and extensive keeping systems have a relative high significance for conservation. The same may apply to Transit Homes (see below).

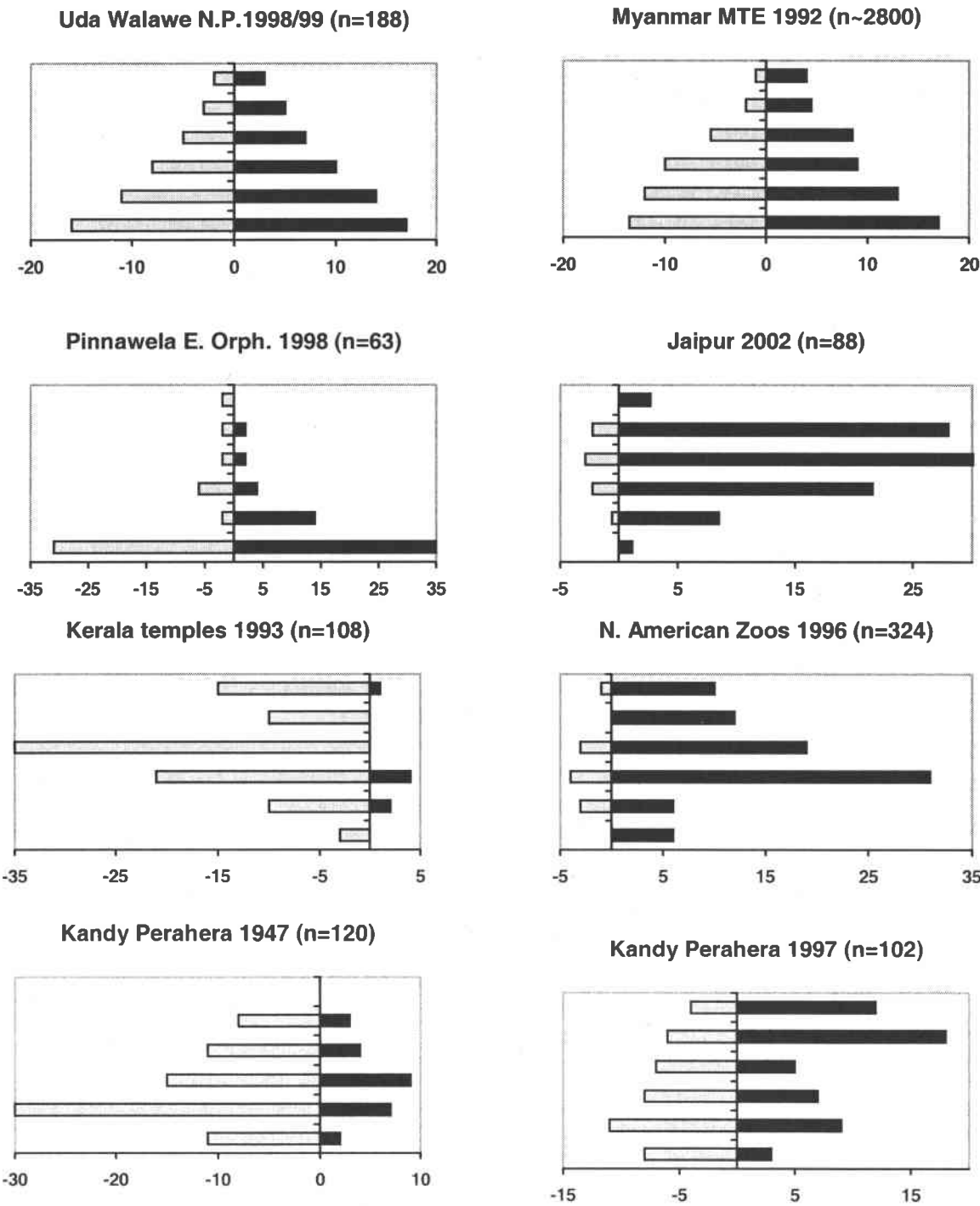
The role of the AsESG in the management of captive Asian elephants

The adequate management of captive Asian elephants can only be reached by coming together of people with varied talents such as wildlife experts, veterinarians, elephant owners, and managers and every effort must be made to ensure that all captive Asian elephants meet the maximum welfare requirements. The authors would like to highlight the following reasons why the AsESG ought to become involved in the conservation orientated management of captive Asian elephants:

1. The relative high number of Asian elephants living at present in captivity which is estimated to include some 25-33% of the total population of *Elephas maximus* living today.
2. The importance of traditional knowledge on elephants and biodiversity of the natural elephant habitat by local, often tribal, elephant people. Regional AsESG members need to identify individuals who keep traditional medical and other knowledge of elephants (capturing, taming etc.) and document their

Fig.1. The population structures of wild (Uda Walawe N.P.) and captive Asian elephants presented as a % of the size of the total population (n).

In the ordinate six age classes are distinguished:
Bottom: 0-10 years, followed by 11-20, 21-30, 31-40, 41-50, and >50 years (top).
Males: grey, females: black. (Sources: Kurt, 2001; Mar, 2001; 2002, pers. com.)



knowledge before it is lost. The employment of these traditional specialists in jungle or forest-based captive elephant establishments can be a great boost for conservation, applied research and local politics. In collaboration with local NGOs, the AsESG should play a leading role in the setting up of vocational training programs for the families of the mahouts in order to supplement the mahouts' income (e.g. integrated farming, weaving traditional fabrics etc.). This would hinder the emigration of the mahouts and their families to the urban areas.

3. The importance of AsESG as a data base on species-specific ecological and

3. behavioural characteristics which are important to alter unsuitable keeping systems and to improve living conditions of captive elephants. Furthermore, the AsESG should encourage the formation of data bases and studbooks by regions. The AsESG/IUCN/SSC can monitor the demography of captive elephants only after a proper registration of captive elephants, owners and elephant holding facilities is made.

4. The international prestige of the AsESG must be used to set up an International Veterinary Consultancy Group to give free advice and medical care in the range countries. Each range country should sign a memorandum of understanding (MoU) to share elephant database. Appropriate software should be created to enable each country to maintain a computerized registration database and to exchange data with neighbouring countries.

4.

5. The AsESG should establish a network that could lobby the respective governments of elephant range countries to strengthen and improve existing national laws in order to enforce at least the Prevention of Cruelty to Animals Act and thereby help

Prevent the misuse or abuse of elephants in captivity.

It is doubtlessly more important for species conservation to maintain large wild populations in their natural habitat than considerable captive populations. However, the pressures on a number of wild populations by human elephant conflicts, poaching of young elephants and other disturbances by man (e.g. destructive agricultural practices, fuel wood extraction etc.) seem to be the reasons that cause continuous inflow of wild elephants into captive populations in the years to come. Taking this fact into consideration government and non-government conservation agencies have to fight for relevant elephant keeping facilities where elephants are kept under modern welfare guidelines but also under the considerations of conservation, such as captive propagation of genetic and behavioural diversities, conservation minded education and promotion. This goal is best reached by:

1. Maintenance of jungle based establishments and, where selective logging had to be stopped, local people and

captive elephants working in these stations should be employed in research, eco-tourism and education.

2. In urban areas zoological gardens should be improved so that they reach the standards defined by the International Zoo Conservation Strategy.

3. For elephants living in establishments for religious and other traditional ceremonies (intensive keeping systems) AsESG should encourage the improvement of elephant welfare and, if necessary, restrict or reduce the size of these populations.

4. AsESG should find ways to update the scientific knowledge on elephants of range officers, managers and representatives of animal welfare organizations. The life of elephants in their natural habitat must be the model for conservation minded keeping systems.

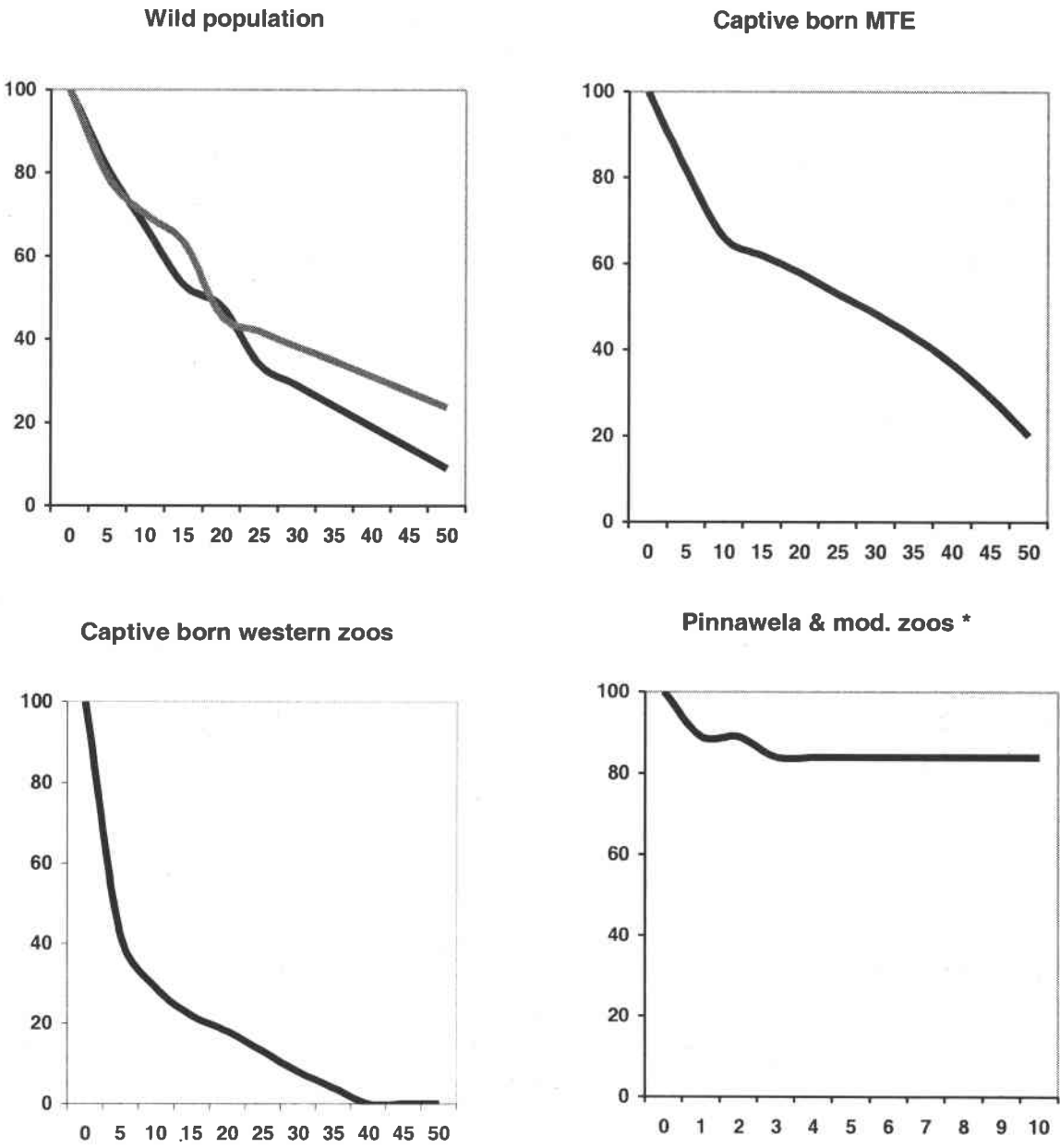
5. AsESG could assist all agencies concerned with captive elephants to find alternative keeping systems where the animals can be kept under near natural conditions, where genetic and behavioural diversity is maintained and, if suitable, where a release into natural habitat is possible. Remarks on such alternatives are made in the following:

Alternative keeping systems: Elephant Parks and Transit Homes

2000 years ago Kautiliya's *Arthashastra* proposed the establishment of a Mrgavana, a fenced park for (tamed) elephants and other wild animals. Such a recommendation needs to be adopted today. Large areas of at least a quarter of a km² could be fenced and furnished with adequate water, shade etc. to become a home for orphaned and otherwise problematic (e.g. dangerous, surplus) elephants. Elephants kept in such an elephant park have to be fed and regularly checked by veterinarians. But otherwise contacts between men and elephants should be reduced to a minimum. The Pinnawala Elephant Orphanage may become a good example of such an elephant park after renovation although the area is relative small. In Spain a large park is currently being established for surplus of zoo born Asian elephant bulls. There are already two large parks in the country for problematic African elephants (Cabarceno and Reserva Natural el Castillo de las Guardas). There is a tremendous experience in South Africa on elephants kept in fenced range areas and it would be worthwhile to learn from South African experts (see Garai, 1997; 2001; 2002).

In addition to the Elephant Orphanage in Pinnawala, Sri Lanka there are several other, more or less similar establishments, where orphaned neonate, infant, and juvenile elephants are cared for (e.g. in Thailand, in Assam or in Malaysia). As known from the studies in Pinnawala, many orphans show retarded body growth, their daily food intake is significantly lower than that in young elephants growing up with their mothers and/or allomothers, they are not familiar with efficient methods to prepare the food and they are socially not fully integrated (c.f.

Fig.2. (Survival rate according to age of wild (adapted from Sukumar 1991 and Kurt 2001) and captive populations (Kurt 2001, Mar 2001, 2002). Males or total: black; females: red lines. * data from Emmen (Holland) and Hagenbeck (Germany).



Kurt, 2001; 2002; Garai, 2002a, Weihs *et al.*, 2002). The fact that many orphans are kept socially more or less isolated, i.e. lack of "aunts" and other subadult and adult helpers, may be *inter alia*, a reason for the extreme high mortality at young ages, as often seems to be the case. It is well known that certain adult females are extremely altruistic and therefore willing and capable of nursing the orphans (even females that have not reproduced before). Such allomothers should be available in all orphanages as well as in all transit homes. They would guarantee that behavioural diversity is preserved.

As it is well known from translocated juvenile orphans in African elephants (Garai, 1997; 2001; 2002b; Garai & Carr, 2001) socially non-integrated elephants may face later difficulties in mating (bulls killing females or even buffaloes and rhinos) or parturition (killing of newborns, as it is also very well known from Asian elephants kept in western zoos). Such observations must be taken seriously, since they teach us that survival of reintroduced juvenile elephants may only be a short-term success. Success of reintroduction can only be measured long term, once we know that the elephants are capable of fending for themselves, remain healthy, are integrated into a social organization, can reproduce and do not cause problems. Accordingly all released orphans should be marked, not necessarily with radio-collars but with easily visible optical marks as well as with chips, and they should be monitored continuously from the moment of release. This is also important from the point of view of animal welfare. If monitoring is not carried out properly certain animals may escape and later end up dead when the radio-collar tightens round the neck with the growth of the elephant, slowly choking the animal.

Well maintained elephant parks, orphanages, and transit homes allow the keeping of elephants free of chains and in social groups in appropriately furnished paddocks. This allows the elephants to express their natural behaviour patterns, and provides them with exercise and opportunities to socialize. Elephants kept in such a way convey more understanding of the species and its requirement to the visitor and insight into the necessity to protect the species than "dancing" elephants or elephants that are forced to ride bicycles, paint canvas, play football, guitar or mouth-organ.

References

- Baker, C.M.A. & Manwell, C. (1983) Man and elephant. The "dare theory" of domestication and the origin of the breeds. *Z. Tierzücht./Züchtungsbiol.* **100**: 55-75.
- Bist, S.S. (1996) Standards and norms for elephant owners (draft for comments). *Zoo's Print*, **11**: 52-54.
- Bist, S.S. (2002) The status of the domesticated elephants in India. *J. Indian Vet. Ass. Kerala*: 4-8.
- Clubb, R. & Mason, G. (2002) *A Review of the Welfare of Zoo Elephants in Europe*. University of Oxford, Oxford.
- Daim, M. S. (1996) Elephant translocation: The Malaysian approach. *Gajah*, **14**: 43-48.
- Gajah* **22**: (July 2003)
- Dawson, S. (1996) *Vietnam's Vanishing Elephants: A Species Survival Strategy*. FFI and Forest Prot. Progr. Hanoi, Vietnam.
- Dhakal, N. (2002) Role of domestic elephants (*Elephas maximus*) in park management: Nepal's experiences. In *A Research Update on Elephants and Rhinos* (eds. H.M. Schwammer, T.J. Foose, M. Fouraker, & D. Olson) pp. 255-257. Schöling, Münster.
- Dorresteyn, A. (2001) Forward planning and EEP Management for elephants in EAZA institutions. In *Eitäge zur Elefantenhaltung in Europa* (eds. H.M. Schwammer, & S. de Vries), pp. 13-16. Schöling, Münster
- Ferrier, A.J. (1947) *The Care and Management of Elephants in Burma*. Steel Brothers & Co., Ltd., London.
- Edgerton, F. (1931) *The Elephant-Lore of the Hindu*. New Haven, USA.
- Evans, G.H. (1910) *Elephants and their Diseases*. Government Printing, Rangoon.
- Garai, M.E. (1997) *The Development of Social Behaviour in translocated juvenile African Elephants Loxodonta africana Blumenbach*. Ph.D thesis University of Pretoria, South Africa.
- Garai, M.E. (2001) Are elephants suitable as game ranch animals? In *Proc. Intern. Wildlife Ranching Symp.* (eds. H. Ebedes, B. Reilly, W. van Hoven, & B. Penzhorn). South African Game Rangers' Association, Pretoria.
- Garai, M.E. (2002a) Social behaviour of the elephants at Pinnawela Elephant Orphanage, Sri Lanka. In *A Research Update on Elephants and Rhinos* (eds. H.M. Schwammer, T.J. Foose, M. Fouraker, & D. Olson), pp. 32-40. Schöling Münster.
- Garai, M.E. (2002b) *Managing African Elephants. Guidelines for Introduction and Management of African Elephants on Game Reserves*. 2nd rev. edition. EMOA.
- Garai, M.E., & Carr, R.D. (2001) Unsuccessful introduction of adult elephant bulls to confined areas in South Africa. *Pachyderm*, **31**: 52-57.
- Herre, W. & Röhrs, M. (1990) *Haustiere – zoologisch gesehen*. Paul Parey, Stuttgart & New York.
- Hildebrandt, T.B., Göritz, F., Pratt, N., Brown, J.L., Montali, R.L., Schmitt, D.L., Fritsch, G. & Hermes, R. (2000) Ultrasonography of the urogenital tract in elephants (*Loxodonta africana* and *Elephas maximus*): An important tool for assessing female reproductive function. *Zoo Biology*, **19**: 321-332.
- Hildebrandt, T.B., Hermes, R., Pratt, N.C., Fritsch G., Blottner, S., Schmitt, D.L., Ratanakorn, Brown, J.L., Rietschel, W. & Göritz, F. (2000) Ultrasonography of the urogenital tract in elephants (*Loxodonta africana* and *Elephas maximus*): An

- important tool for assessing male reproductive function. *Zoo Biology*, **19**: 333-345.
- Jayewardene, J. (2002) The status of captive elephants in Sri Lanka: In: *Proc. Workshop on Captive Elephant Management* (ed. J. Cheeran). In press.
- Koehl, D. (2001) Captive elephant database. Elefant-Consult. at <http://elephant.se/main.htm>.
- Krishnamurthy, V. & Wemmer, C. (1995a) Timber elephant management in British India (1844-1947) with special emphasis on the Madras Presidency. In *A Week with Elephants* (eds. J.C. Daniel & H. Datye). pp. 456-472. Bombay Nat. Hist. Soc. Bombay.
- Krishnamurthy, V. & Wemmer, C. (1995b) Veterinary care of Asian timber elephants in India: Historical accounts and current observations. *Zoo Biology*, **14**: 123-133.
- Kurt, F. (1995) The preservation of Asian elephants in human care – a comparison between the different keeping systems in South Asia and Europe. *Animal Research and Development*, **41**: 38-60.
- Kurt, F. (2001) *Elefant in Menschenhand*. Filander, Fürth Kurt, F., 2002: Physical and social development in captive born and orphaned Asian elephants at the Pinnawela Elephant Orphanage, Sri Lanka. In *Proc. Workshop on Captive Elephant Management* (ed. J. Cheeran). In press.
- Kurt, F. & Garai, M.E. (2002) Stereotypies in captive Asian elephants – a symptom of social isolation. In *A Research Update on Elephants and Rhinos* (eds. H.M. Schwammer, T.J. Foose, M. Fouraker, & D. Olson), pp. 57-63. Schöling, Münster.
- Kurt, F. & Kumarasinghe J.C. (1998) Remarks on body growths and phenotypes in Asian elephant *Elephas maximus*. *Acta Theriologica*, Suppl., **5**: 135-153.
- Kurt, F. & Mar, K.U. (1996) Neonate mortality in captive Asian elephants (*Elephas maximus*). *Z. Säugetierk.* **61**: 155-164.
- Lair, R.C. (1997) Gone Astray – the care and management of the Asian elephant in domesticity. FAO Regional Office for Asia and the Pacific (RAP), Thailand, RAP Publ. Nr. 1997/16.
- Leader-Williams, N. & Dublin, H.T. (2000) Charismatic megafauna as “flagship species”. In: *Priorities for the Conservation of Mammalian Diversity*. Cambridge University press, Cambridge.
- Mar, K. U. (2001) The Studbook of Timber Elephants of Myanmar with special reference to survivorship analysis. *International Workshop on Domesticated Elephants*, organized by FAO/RAPA. Bangkok/Chaingmai, 5.-10. February, 2001.
- Mar, K.U. (2002) The Status of Elephants in Myanmar. *IUCN/SSC Asian Specialist Group Meeting*, Phnom Penh, Cambodia, 25.-28. May, 2002
- Mar, K.U. & Win, S. (1997) Working elephants for the Timber Extraction of Myanmar. *Draught Animal News*, **2**: 6-13.
- Mahasavangkul, S. (2002) Domestic elephant status and management in Thailand. In *A Research Update on Elephants and Rhinos* (eds. H.M. Schwammer, T.J. Foose, M. Fouraker, & D. Olson), pp. 71-82. Schöling, Münster.
- Mikota, S.K. & Hammatt, H. (2002) Elephant Care International: An independent program devoted to elephant healthcare and conservation. In *A Research Update on Elephants and Rhinos* (eds. H.M. Schwammer, T.J. Foose, M. Fouraker, D. Olson), pp. 272-275. Schöling, Münster.
- Milroy, A.J. (1922) *A Short Treatise on the Management of Elephants*. Government Printer, Shillong, Assam.
- Ratanakorn, P. (2002) Elephant health problems and management in Cambodia, Lao and Thailand. In *A Research Update on Elephants and Rhinos* (eds. H.M. Schwammer, T.J. Foose, M. Fouraker, & D. Olson), pp. 111-114. Schöling, Münster.
- Sanderson, G.P. (1897) *Thirteen Years amongst the wild Beast of India*. John Grant, Edingburgh.
- Santiapillai, C. & Widodo, S.R. (1992) Jungle four-wheel drive. *Geographical*, **LXIV**: 10-14
- Stevenson, M. F. (2002) *Management Guidelines for the Welfare of Elephants*. The Federation of Zoological Gardens of Great Britain and Ireland.
- Sukumar, R. (1992) *The Asian elephant – ecology and management*. Cambridge Studies in Applied Ecology and Resource Management. Cambridge University Press, Cambridge.
- Sukumar, R., Krishnamurthy, V., Wemmer, C. & Rodden, M. (1997) Demography of captive Asian elephants (*Elephas maximus*) in southern India. *Zoo Biology*, **16**. 263-272.
- Webster, F. (1984) *Calf Husbandry, Health and Welfare*. Collins, London.
- Weih, W., Weisz I., Wüstenhagen, A. & Kurt, F. (2002) Body growth and food intake in a herd of captive Asian elephants at the Pinnawela Elephant Orphanage (Sri Lanka). In *A Research Update on Elephants and Rhinos* (eds. H.M. Schwammer, T.J. Foose, M. Fouraker & D. Olson), pp. 141-145. Schöling, Münster.

The Asian elephant (*Elephas maximus*): its habitat, status and distribution in Arunachal Pradesh, India

Bharath Sundaram, Surendra Varma, Arun Venkataraman and Raman Sukumar

Abstract The survey assessed forest contiguity, distribution and status of elephants in some areas of Arunachal Pradesh to identify likely gaps in the protected area network. The survey also examined changes seen in elephant distribution between 1984 and the present. The study was carried out through field and questionnaire surveys in the administrative districts of the state. Elephant habitat maps with vegetation types and elephant distribution information were produced. The encounter rates of elephant signs per kilometre were calculated to ascertain specific zones of high, medium and low elephant abundance. Based on the results, East Kameng,

Tirap and Papam-Pare had high, medium and low abundance areas respectively. Qualitative information on district wise elephant status, distribution and conservation is also presented. The survey found very patchy habitat in many areas and many areas that are important for elephants do not fall under the protected area network. The paper also discusses specific recommendations for conserving the species and its habitat.

Keywords Elephant, Assam, Arunachal Pradesh, Human-elephant conflict.

Introduction

Arunachal Pradesh, the largest state in the north-east India, covers an area of 83,743 km² between 26° 28'–29° 30' N and 91° 30'–97° 30' E. Lying in the Eastern Himalayan region of the Himalayan biogeographic zone, Arunachal Pradesh is located at the junction of the Palaearctic and Oriental (Indo-Malayan) realms (Rodgers & Panwar, 1988). Arunachal Pradesh comprises mountains that ring eastern Assam, terrain thrown up by the sharp twisting of the Himalayan ranges as they turn suddenly from a southeastern to a southerly direction. These mountains drop precipitously into the tropical lowland evergreen forests of the region. Because of the wide gradients in elevation (50 m–7,000 m asl) and annual rainfall (1,000 mm–5,750 mm), an array of forest types, ranging from tropical evergreen forests, tropical semi-evergreen forests, riverine semi-evergreen forests, subtropical pine forests, temperate broadleaved forests, temperate coniferous forests, alpine forests, and high montane grasslands are seen. Such a diversity of habitats harbouring rich plant and animal life, packed into a relatively small area, makes Arunachal Pradesh a hotspot of global biodiversity. It is also home to over 5,000 species of plants (including 600 species of orchids), 500 species of birds and 29 species of mammals listed under Schedule I of the Indian Wildlife Protection Act. These include 4 species of large cats, 7 species of primates, and 3 species of goat antelopes.

There are over 100 species of amphibians and reptiles recorded from the region (Anon. 1994).

Arunachal Pradesh shares international borders with Bhutan in the west (border length 160 km), China to the north and northeast (1,080 km), and Myanmar to the east (440 km). Culturally diverse, Arunachal Pradesh, with a population under 10 lakh (of which 70% are tribal people), has 21 major tribal groups with over 100 ethnically distinct subgroups and over 50 distinct languages and dialects. Spread over 14 districts, the people of Arunachal Pradesh practice semi-nomadic swidden agriculture (also called *jhoom* cultivation), terraced wet agriculture, high montane pastoralism, and traditional trade and barter. Arunachal Pradesh is a land of mighty rivers such as Siang, Dibang, Lohit, and Kameng, all of which join the Brahmaputra in the Assam valley. Over 70% of Arunachal Pradesh is forested, and 11.8% of the total land area falls under the protected area network (Fig. 1), with one Biosphere Reserve (BR) (Dibang-Dihang Biosphere reserve), one Tiger Reserve (TR) (Namdapha Tiger Reserve), one National Park (NP) (Moulung National Park), 10 Wildlife Sanctuaries (WLS) and one Orchid Sanctuary (Sessa Orchid Sanctuary). Eighty-six Reserved Forests (RF's) account for an additional 12.7% of the total area. The rest of the forested areas come under the purview of the 3,649 villages in Arunachal Pradesh and are classified as Village Forest Reserves (VFR's) or Unclassed State Forests (USF's).

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At least two populations of the Asian elephant (*Elephas maximus*) extend along the Himalayan foothills and plains from northern West Bengal eastwards through Assam, Bhutan and Arunachal Pradesh (Sukumar, 1989). It has also been estimated that 10,000 km² of hilly habitat may be available for elephants in Arunachal Pradesh alone. The Arunachal Pradesh Forest Department estimates the population of elephants in the state at 4,000, which is twice that of an earlier estimate (Lahiri-Choudhury, 1980). This discrepancy

could be due to the fact that elephants moving into Arunachal from Assam were also counted (AESG Report, 1981). In collaboration with the Forest Department, the Task Force of the IUCN/Asian Elephant Specialist Group (Lahiri-Choudhury, 1980) mapped the distribution of elephants in northeast India (Lahiri-Choudhury *et al.*, 1984). However, widespread destruction of foothill forests through developmental and other anthropogenic activities have shrunk the range of the elephant, consequently restricting it to smaller landscapes having very little connectivity. An increase of encroachment in forested areas has also led to an increase in elephant-human conflict.

The prime objectives of this survey were to assess the forest contiguity and status of elephants, to identify possible gaps in the protected area network in some areas of Arunachal Pradesh, to examine the changes seen in elephant distribution between the 1984 study and the present one, and to project all the data on maps that could be used by both the Forest Department and researchers for better management and further research.

Methods

The status and habitat available for elephants were determined through field surveys and questionnaire surveys. Field surveys were undertaken in East Kameng, West Kameng, Papum-Pare, Lower Subansiri, Dibang Valley, Lohit, Tirap and Changlang districts of Arunachal Pradesh. Survey of India toposheets were used to assess forest contiguity in the low- and mid- elevation (100-900m) areas. Information regarding the area was first gathered from the Divisional Forest Office, after which animal trails in the forest were identified. These trails were then traversed on foot, and data on elephant signs, i.e. dung, pad marks, scratch marks, and feeding signs were collected. GPS locations were taken at kilometre intervals, and the habitat at that point was classified by noting geographical features, and the four species of trees characteristic of the vegetation in the nearest vicinity were noted. Direct sightings of elephants were also recorded as

and when they occurred. Proximity to the closest human settlements was also noted. In addition to field data collection, secondary information was gathered through questionnaire surveys in villages and Divisional Forest Offices. This included information on distribution, movement patterns, and numbers of elephants. Since very few elephants in Arunachal Pradesh are resident, data on seasonality of sightings/movement were also collected. Fieldwork was carried out during the dry periods of 2001.

Encounter rates (frequency of sighting elephant signs per kilometre traveled on foot) were calculated (Table 1). From these encounter rates it was possible to determine, within the study area, specific zones of high (encounter rate in the range 4 and above), medium (encounter rate in the range 2.5 to 4), and low (encounter rate in the range 1 to 2.5) elephant abundance.

Maps were created using MapInfo Professional, ArcView GIS, and GMView. Layers of political boundaries, protected area network, forest cover were created using VMap Level 0 data (the data set was derived from 1-km resolution Advanced Very High Resolution Radiometer (AVHRR) data spanning a 12 month period, from April 1992 to March 1993), and Global Land Cover Characterization datasets obtained from the International Steering Committee for Global Mapping, Geographical Survey Institute, Japan. The GPS survey points were overlaid on the forest cover map (Fig. 2), and inferred elephant distribution (from secondary information) was plotted (Fig. 3).

Results

The elephant ranges in Arunachal are mainly distributed along the foothills adjacent to Assam. Elephants are found usually between the altitudinal range from 2,000 to 6,000 m asl but there is some evidence to show that they could migrate to higher levels in search of food and other resources especially during winter months. A total of 1,600 elephants were estimated for the state during 2001 elephant census (Forest

Table 1 List of areas where ground surveys for dung were carried out, with encounter rates for each area

Area	District	Forest Division	Protection Level	Distance walked (km)	Number of signs	Encounter rate/km
Chessa	Papum-Pare	Bandardewa	RF, USF	12	28	2.33
Chessa	Papum-Pare	Bandardewa	RF, USF	8	15	1.88
Kimin	Papum-Pare	Bandardewa	RF, USF	15	24	1.6
Deomali	Tirap	Deomali	RF, VFR	15	79	5.27
Deomali	Tirap	Deomali	RF, VFR	7	29	4.14
D' Ering	East Siang	Pasighat	WLS	16	88	5.5
Tipi	East Kameng	Khellong	WLS	12	78	6.5
Seijosa	East Kameng	Khellong	WLS	15	89	5.93

Department, unpublished report). Within Arunachal Pradesh, elephants occur in Papum-pare, Lower Subansiri, East Siang, East & West Kameng, Lohit Dibang Valley, Tirap & Changlang districts.

East and West Kameng districts

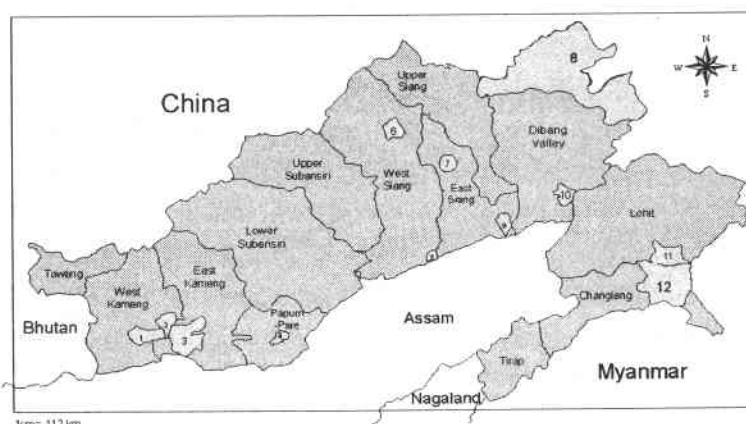
Areas surveyed in these two districts include Pakhui WLS and Khellong Forest Division, both of which support abundant elephants and experience severe human-elephant conflict. The high abundance may be due to these areas bordering Nameri NP and Sonitpur RF in Assam, from where elephants tend to move out. While the forest types in Pakhui WLS range from semi-evergreen to evergreen with patches of secondary *jhoom* forests, the forests in the Bhalukpong side (Khellong Forest Division- Amartala, Doimara and Papum RF's) are mostly degraded, with some patches of evergreen forest still existing due to their inaccessibility. Elephants range right from the foothills of the Dhansiri river (at the Bhutan border), to Papum RF east of Pakhui WLS. A specific area of high human-elephant conflict is Tipi (a town close to Bhalukpong). The position of the Tipi Orchid Research Centre (situated in a natural elephant pathway), increased levels of human encroachment, and the construction of a Territorial Range Office on an elephant path have been the reasons for increasing levels of human elephant conflict. Project Elephant has recognised the Kameng -Sonitpur interstate area (ca 4,300 km²) as an Elephant reserve (National Elephant Conservation Action plan, 1992), but this area experiences a lot of pressure in

Assam due to the large-scale transformation of land for cultivation.

Papum-Pare and Lower Subansiri Districts

The areas surveyed in these two districts include the Itanagar WLS and Bandardewa Forest Division, which had medium elephant abundance, with highly migrant animals. These areas are also highly fragmented and degraded due to human encroachment and illegal deforestation. Areas such as Poma, Jote, Kimin, Hoj, Tarajuli, Chessa, Hollongi, Changmara, Kokila, Tengabari, and Balijan have a matrix of habitats composed of semi-evergreen forest, evergreen forest, and cultivation. Unplanned development in the Itanagar area has also destroyed much of the habitat and has been identified as an issue of concern in 1984 (Lahiri-Choudhury, 1985). An elephant reserve has been planned in Papum-Pare district, but the success of this plan depends entirely on how effectively encroachers can be removed. This area shows very little influx of elephants from Assam because the areas on the Assam side are completely under cultivation.

In the Subansiri range of Panir RF (Bandardewa Forest Division) disturbance affecting elephants has been observed. Dolunmukh is a village bordering Panir RF, which has not reported the presence of elephants for the past 10 years due to such disturbance. Though the disturbance has ceased a few years ago, elephants are yet to return. These areas have large patches of semi-evergreen and evergreen forests. More interestingly, Dolunmukh was reported to have been an area of high human-elephant conflict (Lahiri-Choudhury *et al.*,



1. Eagles Nest WLS
2. Sessa Orchid Sanctuary
3. Pakhui WLS
4. Itanagar WLS
5. Kane WLS
6. Yordi Rabe Supse WLS
7. Mouling NP
8. Dihang-Dibang BR
9. D' Ering Memorial WLS
10. Mehao WLS
11. Kamlang WLS
12. Namdapha TR

WLS- Wildlife Sanctuary
NP- National Park
BR- Biosphere Reserve
TR- Tiger Reserve

1984). A major hydroelectric project involving the construction of a dam across the Subansiri is also being planned.

Lohit District

The floodplain areas of the Lohit River, such as the Paya and Digaru Ranges, were surveyed in the Lohit Forest Division within this district. Of the 7 ranges here 2 showed seasonal presence of elephants. Dung encounter rates indicate that these areas have medium elephant abundance. Affected heavily by flood, the landscape in these areas is highly amorphous. Struck by a major earthquake in 1950, many of the natural forests of this area were destroyed due to inundation and the changing of the course of the Lohit River. The habitat in this area is a combination of secondary riverine forest, *Saccharum* grasslands and plantations. Plantations were established following the earthquake to restore some of the original forest. In providing fresh herbage for elephants after the first rains, this area assumes immediate importance and hence it is necessary to bring these areas under the protected area network. This area is also heavily disturbed due to the presence of '*khutis*' (herds of unproductive cattle). Overgrazing was seen the Digaru area. The Paya and Digaru areas are approximately 300 km² in size, and this area supposedly has at least 10-12 *khutis* (ca. 2500-3000 heads of cattle). Such large number of cattle is bound to put undue pressure on the grassland ecosystem, and should be brought under control. Choudhury (1999) has also cited illegal capture of elephants to be common in this district, but no such instances were observed during this study.

Dibang Valley District

The areas in and around Mehao WLS were surveyed. Mehao WLS (281.5 km²) lies along an elevational gradient and evergreen forests are found up to 900 m (an area of around 100 km²). This area shows medium elephant abundance, and appears to be highly disturbed with a high degree of encroachment (especially in the Koronu and Ippipaani areas), where the people are not aware that they are living in the midst of a wildlife sanctuary. Elephants that use the Dibru-Deomali elephant corridor sometimes visit this area.

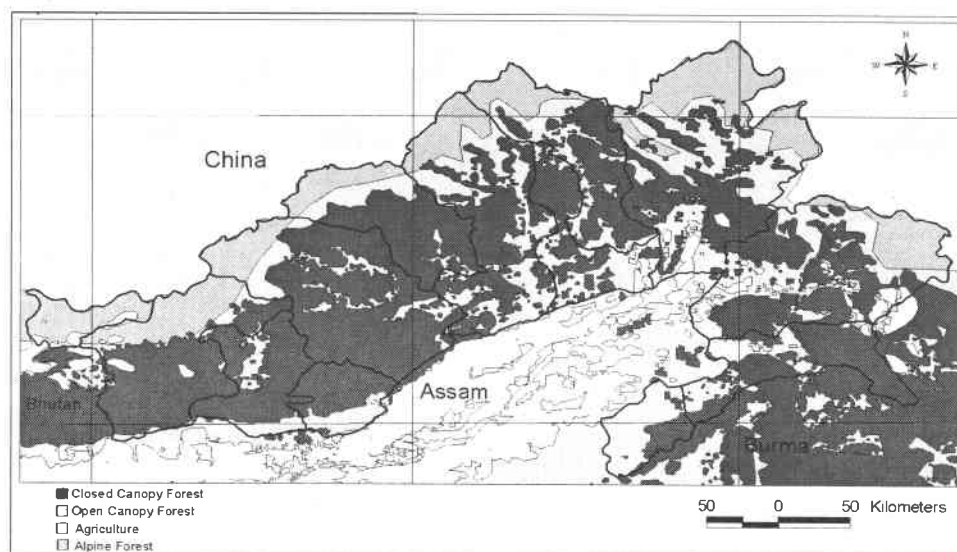
Changlang District

Namdapha TR (1985 km²) is located on the Myanmar border, and movement of elephants to and from Myanmar cannot be totally ruled out. This area was found to have low elephant abundance. A survey by our team in 1999 also yielded very poor results as far as elephants were concerned. The forest types in Namdapha TR range from semi-evergreen to evergreen on the lower reaches. Evergreen forest habitat has been found to be sub-optimal for elephants and this may be the reason for their low abundance.

Tirap District

In this district, the Deomali Forest Division (286 km²) was surveyed. The Arunachal Pradesh Forest Corporation used this area for timber operations until 1997 and selectively felled patches are recuperating. This is an area of high elephant abundance, with elephant influx from Nagaland in the west, as

Fig. 2 Extent of forest cover in Arunachal Pradesh



well as movement of elephants from neighbouring Joypur RF in Assam. A large number of natural salt licks (*pungs*) were found in the Namsangmukh area. These areas are classified as VFR's and RF's, and must be incorporated into the protected area network, taking into account their value for elephants. Elephants also frequently move from Tinsukhia and Digboi areas (especially around Dibru-Saikhowa NP) to this area and vice-versa

East Siang District

The D'Ering Memorial WLS was surveyed in this district. The D'Ering WLS (184 km²) is composed mainly of *Vetiveria* grasslands and plantations of *Dalbergia* and *Bombax*. It is another area of high elephant abundance and is used seasonally by elephants (before and during the monsoons). The area is also flood prone and is rendered a virtual island during heavy rains and flood. Heavy siltation occurs in the areas affected by flood. Elephants frequently cross over from Jonai and Kobo Chapori in Assam to this area. Cited as an important movement path for elephants (Choudhury, 1999), the Dibru-Deomali elephant corridor includes D'Ering WLS, Jonai and Kobo Chapori areas (Assam), Dibru-Saikhowa NP, Joypur RF and Deomali Forest Division. Consequently, this whole area (ca 4000 km²) is under the Dibru-Deomali Elephant Reserve. Presently D'Ering WLS is not protected effectively due to the shortage of manpower and resources. As a result many people from Pasighat and Mebo use it as a hunting ground. Frequent burning of the grassland also occurs.

Discussion

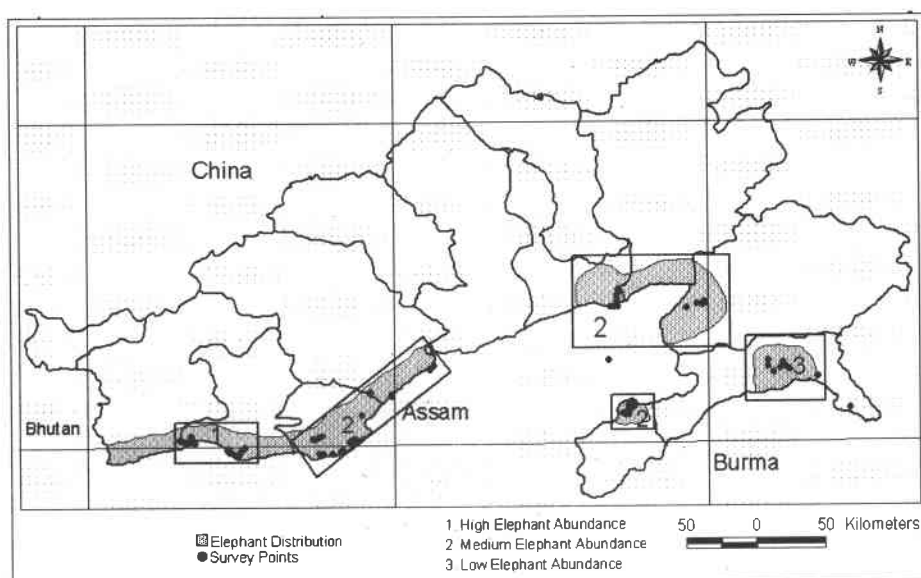
Habitat patchiness and Elephant-Human Conflict

Most of the areas surveyed, excepting a few, showed very patchy habitat. Mosaics of forest types such as semi-evergreen, degraded *jhoomed* forests, degraded grasslands and degraded riverine forest are interspersed with cultivated lands. During their attempts at maintaining normal ranging pattern, elephants encounter an increased interface between natural vegetation types and cultivation. Elephant-human conflict was a common problem in most of the areas surveyed. The people of Arunachal Pradesh have always been living in close proximity to their forests, but uncontrolled development has already destroyed many prime elephant areas, such as the foothill forests in Papum-Pare district and Lower Subansiri. The problem of elephant-human conflict is compounded by the fact that a large proportion of agriculture in Arunachal Pradesh is subsistence agriculture. Crop depredation affects the subsistence agriculturist very hard, and the existing system is not equipped to deal with this problem. The formulation and implementation of a compensation scheme will greatly help improve relations between the common people and the governmental agencies involved.

Gaps in the protected area network

Many areas that are important for elephants do not fall under the protected area network. The Deomali area in Tirap district is one such example. An important link in the Dibru-Deomali corridor, this area is presently classified as a VFR. It is not only important to bring some areas under the protected area network, but existing parks and sanctuaries must be well protected as well. The D'Ering Memorial Wildlife Sanctuary is a very important area for elephants as they use the grasslands extensively for feeding. Limitations of manpower and resources make the job of protection difficult, and a solution to the problem lies in finding a cost-effective remedy to ensure

Fig. 3 Distribution of Asian elephants in Arunachal Pradesh based on a questionnaire survey



protection by involving the local communities. Since the elephant populations in the northeastern region know no political boundaries, it is necessary to ensure their protection in the neighbouring states of Assam, Meghalaya and Nagaland. Unprecedented levels of deforestation in Assam often cause problems in the areas where cross-border movement of elephants is common, as for example in the Kameng (bordering with the Sonitpur and Balipara forests of Assam) and East Siang-Tirap (bordering with Dibrugarh-Digboi areas) zones. The Forest Department in these states must work out a common strategy for the protection of elephants on a region-wise scale by identifying these key areas.

Preservation of key habitats

Habitats such as the riverine semi-evergreen forests and grasslands are extremely important for elephants, as they are a ready source of forage, especially following the first rains. These habitats are constantly under threat due to possible conversion to cultivated land. A viable alternative to livestock grazing is stall-feeding and this must be promoted in a large scale in order to reduce the pressure on forest resources. It is very clear that there can be no long-term solution without the combined effort of the Forest Department and the indigenous people of the area.

Fig. 4 The location of Kameng Sonitpur area in the Arunachal Pradesh and Assam

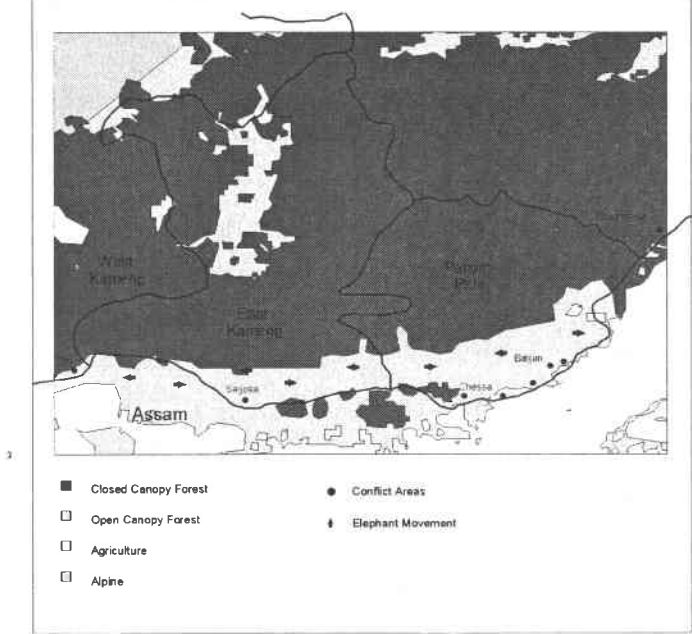
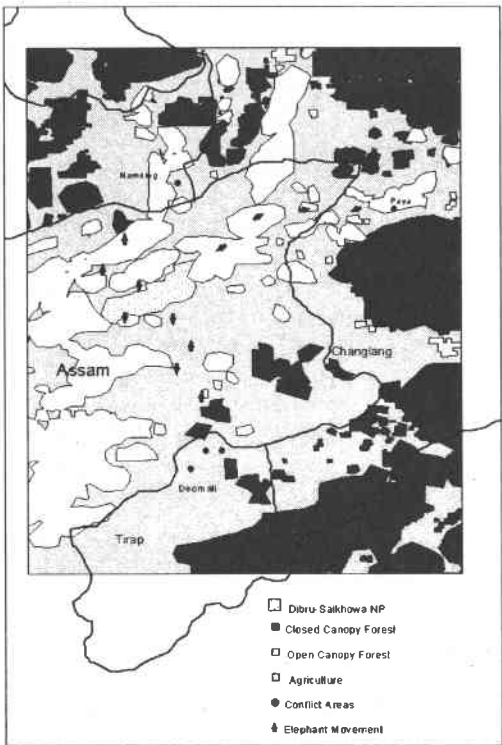


Fig. 5 Map of the Dibru-Deomali area of Arunachal Pradesh and Assam



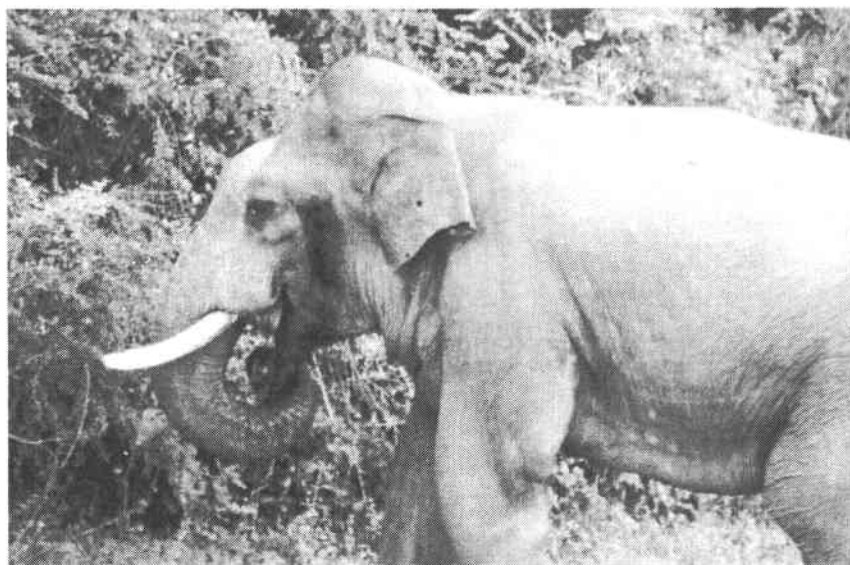
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References

- Asian Elephant Specialist Group. 1981. *Proceedings of the First meeting of North-East Task Force, Asian Elephant Specialist Group*, IUCN/SSC. 64 pp.
- Anonymous. 1994. The Wildlife (Protection) Act 1972. (2nd Edition). Natraj Publishers, Dehra Dun, India.
- Choudhury, A. 1999. Status and conservation of the Asian Elephant *Elephas maximus* in north- eastern India. *Mammal Review* 29: 141-173.
- Lahiri-Choudhury, D. K. 1980. *An interim report on the status and distribution of elephants in northeast India*. IUCN-SSC Report. 16 pp.
- Lahiri-Choudhury, D. K., Dey, B., Sar, C., & Mukherjee, A. 1984. *Summarised report on Elephant Habitat Survey in Arunachal Pradesh*. IUCN/WWF Report. 21 pp.
- Lahiri-Choudhury, D. K. 1985. *Distribution, population estimate, and status of elephant in North-East India*. IUCN-SSC Report. 10 pp.
- Ministry of Environment and Forests, Government of India. 1992. *National Elephant Conservation Action Plan- Executive Summary*. 22 pp.
- Rodgers, W.A. & Panwar, H.S. 1988. *Planning a wildlife protected area network in India*. 2 vols. Project FO: IND/82/003. FAO, Dehra Dun.
- Sukumar, R. 1989. *The Asian Elephant: Ecology and Management*. Cambridge University Press, Cambridge.



A bull in musth. (photo: courtesy Dr. H.I.E. Katugaha)

Man-elephant conflict in Assam, India : is there any solution?

Bibhab Kumar Talukdar and Rathin Barman

Abstract Assam is one of the important states in India that have had the legacy of conserving elephants in the wild for centuries. However in recent times, due to gradual shrinkage, fragmentation and deterioration of habitats, and increase in human population around elephant habitats, the conflict between man-elephant conflict has increased in Assam. Fragmentation in elephant habitats has enhanced the level of elephant depredations in crop fields, further worsening the already tenuous interface system. Due to the increased

conflict between man and elephant, mutual intolerance and animosity has also increased resulting in man killing elephant and elephant killing man. This is indeed a crucial and most critical management issue, which needs to be addressed through the adoption of innovative approaches.

Keywords man-elephant conflict, habitat, poison, management, conservation, Assam.

Introduction

The state of Assam occupies a special place in the context of the elephant conservation in India (Stracy, 1963; Gee, 1964; Lahiri-Choudhury, 1980; Santiapillai & Jackson, 1990; Choudhury, 1991, 1997 & 1999; Bist, 2002). Around 20% of India's elephant population are found in Assam. In fact, Assam alone accounts for more elephants than Myanmar, Thailand, Indonesia or other South East Asian countries. However in recent times, as a result of unabated shrinkage, fragmentation and deterioration of habitats, elephant depredation on cultivated crops has increased in various parts of Assam, leading to conflict with man. There has been an increase in the number of incidents of man-elephant conflict in Assam in recent times (Talukdar, 1996) and a number of elephants have also been poisoned in the Sonitpur district of Assam during the later part of the year 2001. This represents an extreme example of man's intolerant attitude towards the elephant, which has now raised widespread concern from wildlife conservationists, NGOs, general public and the mass media.

In this paper, we address the history of elephant conservation in Assam, the gradual changes in habitat and the current trend and people's perception towards elephant conservation. We have also tried to analyze the factors responsible for the mutual intolerance between man and elephant in the context of the recent conflict, and at the end, based on the study, we offer a few suggestions to minimize the man-elephant conflict in Assam.

Elephant population and conservation

The gloomy aspect of elephant conservation in Assam is that from 1993 to 1997, the population of elephants decreased from about 5,524 to about 5,312 (Table 1). Serious decline in elephant numbers has been recorded in the central part of Assam, while the elephant population in the southern part of Assam has virtually gone astray. While fragmentation of habitats has isolated elephant populations, poaching has reduced them to levels below the minimum viable population size, thereby making them extinction prone, as has been the case in southern Assam. There is a need for us to understand the ecological requirements of the elephant for its long-term survival in the wild, and its impact on the flora and fauna.

The protected area network in Assam today comprises some 2,860 km², which represents 14% of the managed forests and 3.6% of the total geographical area of Assam. The reduction of elephant population is mainly due to deaths of elephants from poaching, poisoning, diseases, electrocution and unknown factors besides natural mortality from old age. However the adult male:female sex ratio of elephants in Assam remains healthy at 1:1.29 (in 1997), although reduced somewhat compared to the situation 1993 where the adult male:female sex ratio was 1:1.58 (Table 2).

One of the major concerns about elephant conservation has been the almost total extinction of the elephant population from the Barak valley, located in southern part of Assam. Sukumar (1989) referred to the presence of 100-150 elephant in this area. However this population had been gradually decreasing and by 1993, when the Assam Forest Department carried out a census, there were only 18 elephants. By 1997 the population was reduced to just 5 individuals, which is not viable at all. During 1993-94, almost a dozen elephants were reported from the Barak valley, of which two were declared rouges and subsequently killed by the government in 1996, and poachers are believed to have wiped out the rest. This might be the likely fate awaiting other elephant populations in parts of Assam in the near future if corrective steps are not taken.

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Cultural affinity with the elephant

The cultural influence of the elephant on the people of Assam is unique which could be hardly experienced in other parts of the country. The elephant happens to be the part of the Assamese culture and ethos. Nowhere in India are there are so many folk tales as well as folksongs about elephants as in Assam. Assamese have grown up watching elephants and listening to the stories and songs about elephants, which highlight the amazing bond that exists between man and elephant. The region has also contributed towards the knowledge about elephants, especially that concerning their capture and management. Elephants are used on different auspicious occasions and in cultural processions and pageants. Furthermore, the words of command used to train and handle elephants throughout the country are similar to those used in Assam.

Loss of elephant habitats

Recent studies carried out by the Indian Institute of Remote Sensing, using the techniques of remote sensing, Geographic Information Service (GIS) and phytogeographical analysis have shown that biodiversity is at great risk in Assam as a result of the age-old practice of jhum cultivation. A continuous belt of dense evergreen forest is now being fragmented. Patches of evergreen forest are gradually being converted to secondary forest and degraded in many areas. Karbi-Anglong and North Cachar Hills have been identified

as the worst affected areas. Such degradation and fragmentation have led to the loss of prime elephant habitat in Assam and have become the main factors contributing to the current intense man-elephant conflict. Between 1991 and 1999, the Forest Survey of India recorded a decrease of about 600 km² in the forest cover. On the north bank of the mighty Brahmaputra River alone, more than 1,500-km² forest area has come under human encroachment. A number of Reserved Forests in Assam such as Nanoi RF, Rowta RF, Majbat RF, Dhekiajuli RF, Batasipur RF, Sonai-Rupai Sanctuary, Chariduar RF, Balipara RF, Nameri NP, Pabhoi RF, Biswanath RF, Naduar RF and Behali RF, that form a continuous Bhutan-Assam-Arunachal Pradesh elephant belt is under severe threat.

Current studies carried out by various remote-sensing agencies have also shown the reduction in total forests to be more in Sonitpur District of Assam between 1999 and 2000 than recorded between 1994 and 1999. More than 86.75 km² (about 1.7%) of the forest area has changed from 1994 to 1999, while 145.44 km² (about 2.86%) has changed from 1999 to 2001 (Srivastava *et al.*, 2002). Moist deciduous forest totaling an area of 229.64 km² has been lost between 1994 and 2001 and the decline has been more acute from 1999 to 2001 where some 143.40 km² of moist deciduous forest were lost. Between 1994 and 2001 encroachers damaged an area of 2.55 km² semi-evergreen forest in the district. Much of the forest cover loss in these parts can be attributed to the large-scale encroachment, aided and abetted by politicians, for subsequent conversion to agricultural land. Well-organized

Table 1 Number of elephants recorded in the Forest Divisions of Assam between 1993-1997

Forest Division Elephants	District	Elephants	
		N (1993)	N (1997)
Goalpara	Goalpara	0	0
North Kamrup	Nalbari	32	0
Kachugaon	Kokrajhar	83	215
Haltugaon	Kokrajhar	93	85
Aie Valley ⁽¹⁾	Bongaigaon	-	70
Dhuburi	Dhuburi	0	0
East Kamrup	Kamrup	403	116
West Kamrup	Kamrup	143	67
East Sonitpur	Sonitpur	174	186
West Sonitpur	Sonitpur	161	305
Darrang ⁽²⁾	Darrang	-	148
Lakhimpur	Lakhimpur	55	128
Orang NP & Barnadi S	Darrang	10	11
Nameri NP	Sonitpur	305	230
Nagaon	Nagaon	896	464
South Nagaon	Nagaon	243	233
Laokhowa WS ⁽³⁾	Nagaon	-	24
Golaphat	Golaphat	54	109
Jorhat	Jorhat	49	37
Sibsagar ⁽⁴⁾	Sibsagar	-	24
Dibrugarh	Dibrugarh	35	49
Digboi	Tinsukia	157	137
Doomdooma	Tinsukia	13	30
Dibru-saikhowa NP	Tinsukia	131	238
Silchar	Cachar	21	4
Karimganj	Karimganj	0	0
Hailakandi	Hailakandi	0	1
East Karbi-Anglong	Karbi-Anglong	378	189
West Karbi-Anglong	Karbi-Anglong	294	76
North Cachar Hills	N. Cachar Hills	25	15
Hamren	N. Cachar Hills	74	385
Manas NP	Barpeta/Golaphat	522	289
Kaziranga	Nagaon	1092	945
Total		5524	5312

Source: Forest Department, Assam. (Note: in 1993 ⁽¹⁾ Aie Valley was within Haltugaon Division; ⁽²⁾ Darrang was within Sonitpur Division; ⁽³⁾ Laokhowa WLS was within Nagaon Division; ⁽⁴⁾ Sibsaagar was within Jorhat Division. NP = National Park; WLS = Wildlife Sanctuary, S = Sanctuary)

encroachers with the support from political leaders are destroying the forest cover in the Sonitpur District. They are well armed and prepared to foil eviction at the risk of life. On one occasion, on 28 April 2002, when the forest officials accompanied by police started the eviction drive against encroachers in Nameri National Park of Sonitpur District, a local member of legislative Assembly (MLA) of Assam and his supporters set ablaze the Rangajan Chapori anti-poaching camp inside the national park to halt the eviction drive. A case was registered against him in Rangapara Police Station for violating Sections 147/148/149/353/436/447 and 506 of the Indian Penal Code. The MLA has been interfering in the eviction drive against encroachers for a long time, ever since he was elected as MLA. Such political interference has led to further degradation of present elephant habitat. Hence, it is inevitable that ordinary people will suffer along with elephant from the intense man-elephant conflict in the district.

The forest area management for the elephant and other animals has suffered greatly from an acute scarcity of funds. The forest staff has not been paid salaries for months. Lack of funds has also curtailed anti-poaching and forest protection activities. The flow of funds is either belated or uncertain given the lack of priority at the State government level. This has led to a shortage of manpower, equipment, and poor infrastructure development. The plight of the forest staff working in far-flung areas goes unnoticed by the government. However, Mr. S.S. Bist, Director, Project Elephant of the Government of India, has revealed that the north-eastern states currently receive a large amount of financial assistance from the Ministry of Environment and Forests for conservation of forests and wildlife, including special fund for conservation of the elephant under the Project Elephant of the Government of India. Nevertheless, the situation in the field remains rather gloomy in view of the general insensitivity and lack of vision on the part of the state government. As a result the state government of Assam finds it difficult to utilize fully the funds earmarked for wildlife conservation or elephant conservation. This problem needs both political and administrative solutions. The finance secretary of Government of India should be informed well in advance about the anticipated central government funds earmarked for the state government for elephant or other wildlife conservation initiatives, so that the same provision is made in the state annual budget. It is mainly due to the non-provision of the allocated money in the state budget, that problems get worse and the central funds hardly reach the field to deal with the situation effectively.

Man-elephant conflict

It appears that areas where the maximum deforestation has taken place are the areas where the man-elephant conflict is intense. Large-scale destruction of forest in the Golaghat, Sonitpur, Darrang, Tinsukia, Dibrugarh and Lakhimpur Districts has resulted in intense man-elephant conflict here. The Gohpur RF in the Sonitpur District is now totally encroached with no sign of the forest evident. Similarly other Reserved Forests such as Balipara, Chariduar, Naduar, Biswanath, Behali, and Singri in the Sonitpur District are under heavy encroachment and forest destruction is on full swing due to political patronage given to the encroachers. In the Golaghat District, which is one of the prime elephant habitat and migratory route from Kaziranga NP to Nagaland, has been badly affected because of forest destruction and subsequent encroachment by tea plantations in some areas. RFs in Rengma and Doyang are merely on paper, since in reality tea gardens and other crops and development activities have taken over. The Nambor RF in Golaghat is also threatened with forest destruction, timber extraction and subsequent encroachment. In the eastern Assam, RFs in the Upper Dihing and Lower Dihing are also degraded from timber felling and other developmental activities including the oil refineries, thereby forcing the elephant to move out of the forest in search of its basic necessities and in the process causing man-elephant conflict as well. This is seen as a consequence of the destruction of the elephant habitat.

Elephant collects highway toll

As a result of the large-scale destruction of forest cover in the Golaghat District in the past two decades, elephants moved to the National Highway 39 (which goes to Dimapur in Nagaland from Kumarbandha) in their search for food from the trucks, buses and other vehicles passing using the highway and a few accidents have taken place. The highway bisects the Nambor RF, which is one of the oldest RF in Assam and had dense forest cover until two decades ago. At present, about 40% of the northern side of Nambor RF have almost been encroached, thus putting immense pressure on elephants on their way to seek food. However, elephants have also learnt the art of stopping vehicles on the highway during food crisis, and only after they are provided with some fruits, do they allow the vehicles to pass through the highway. This may appear fanciful but it is true. In a stretch from Rangamati in Golaghat District to Silanijan in Karbi-Anglong

Table 2 Changes in the population composition of elephants in Assam (1993-1997)

Year	Adult	Subadult	Juvenile	Cow : Calf	Makhna : Tusker	
	M : F	M : F	M : F		Adult	Subadult
1993	1:1.58	1:1.47	1:1.52	1:0.55	1:0.54	1:0.77
1997	1:1.29	1:1.05	1:1.12	1:0.63	1:0.59	1:0.42

District of Assam on the highway 39, elephants often block the road for vehicular traffic and ask for 'tax' in the form of food. Transporters use this highway to haul sugarcane from Nagaland to Assam and other parts of India. Some truck drivers started the habit of providing sugarcane to elephants on the road as a gesture of goodwill. But subsequently, this has habituated the elephant to expect food from all the vehicles going down the highway! Elephants would stop vehicles for food. It is still unclear when elephants in Nambor developed this peculiar habit, but Choudhury (1993) reported an observation dated 14 March 1982, when a forest range officer saw a herd of 18 elephants stopping a truck carrying sugarcane and pulling out the canes from the loaded truck and disappearing into the forest. This phenomenon can still be seen especially between November to April. Local people and even the drivers passing along the highway have become so familiar with this type of 'toll' collection by the elephant that they often carry with them food such as bananas, sugar cane or biscuits. Such phenomenon has also been reported from Digboi area of eastern Assam where the elephant herds block the vehicular traffic for a long time during April-May and November-February.

Crop damage by elephants

The main season of depredation by wild elephants is from October to January, which is also the main harvesting time in Assam. This is also the time when elephants find it increasingly difficult to find food inside the forest since the condition of forest itself has deteriorated substantially in the past few years due to over exploitation and encroachment. In order to save the crops from the marauding wild elephants, there has been a direct conflict of interest between the cultivator and the wild elephant. Every year wild elephants in Assam damage a sizeable area of cropland. However the exact area of crop damage has not been calculated through lack of verifiability on the part of the concerned agencies. In order to protect the standing crop of the cultivators residing close to

forest areas or illegally settled in the forest areas, so far, no schemes have been implemented for providing compensation for the loss of revenue. Even cases of human deaths and injuries are not properly attended with *ex-gratia* payments. This has eroded much of the public sympathy towards the elephant in areas where the human-elephant conflict is severe.

Elephant mortality

According to the Forest Department of Assam, from 1989 to 1997, poachers killed 41 elephants. From 1998 to 2001, some 147 elephants died from various causes (Table 3). Poaching, electrocution and poisoning have been identified as the major threats to elephants in Assam. Some elephants have died of diseases, which needs to be studied in-depth studies if elephants are to be secure against outbreaks of such contagious diseases as anthrax or Foot and Mouth Disease (FMD). During the same period, 37 elephants died from unknown causes which may be concerned with diseases. Deaths due to unknown causes must be investigated scientists of the veterinary department. They should also be reported to these scientists as early as possible so that they get have time to visit the spot, examine the carcasses, and perform postmortems to determine the exact cause of death.

Mass poisoning of elephants

Poisoning of elephants by culprits in Sonitpur District of Assam has dented the age-old bond between the elephant and man. It is related to the encroachment of forests. Assam currently accounts for about 90% of the cases of poisoning of elephants, about 25% of the cases of electrocution and about 50% of the cases of elephants being run over by trains in the country. Indeed nothing has defamed the elephant management in Assam more than probably the mass poisoning of elephants in 2001. Mr. S.S. Bist, the Inspector General of Forests and also the Director, Project Elephant of the Government of India, has commented that the incident of

Table 3 Causes of elephant mortality from 1998 to 2001 in Assam. (Source: Forest Department)

Causes of death	1998	1999	2000	2001	Total
Gunshot	3	1	3	3	10
Poisoning	1	-	1	17	19
Old age	4	7	6	7	24
Electrocution	4	5	3	5	17
Train accident	-	-	2	7	9
Tiger predation	4	2	-	-	6
Infighting	4	-	-	-	4
Diseases	2	7	2	3	14
Injury	3	1	-	3	7
Unknown	8	18	3	8	37
Total	33	41	20	53	147

mass poisoning of elephants provides a case study of the insensitivity and technical handicap that generally characterizes the forest administration in the North East India. Although the first carcass of poisoned elephant was detected in Nameri on 2 July 2001, yet it was not before the mid-August that the state forest department took notice of the incidents and sent senior officers to visit the site of mass poisoning of elephants. By the time the senior officials visited the site, considerable damage has already been done to elephant. Lack of technical competence has been a major disadvantage of the forest department in taking stock of the crisis.

There were reports from the villagers and forest staff that about 8-10 elephants were found dead in the reserved forest and village areas outside the Nameri National Park since May 2001. In fact we found a dead elephant just outside the Nameri NP on 3 June 2001 on way to Sejusa in Arunachal Pradesh, which is adjacent to Pakhui wildlife Sanctuary. However no forest officials found it necessary to examine the cause of death or alert their counterparts in other forest areas. It seems everyone is just concerned on what happened within his area of jurisdiction. If the elephant died just one meter outside his area of jurisdiction, he hardly attends the case. The territorial division of forest department often thinks that the wildlife matters, even within its territorial jurisdiction, will be taken care of by the wildlife wing, whose office may be located 100 km from the site where the elephant died. Shifting of the responsibility for protecting and dealing with poisoning has been responsible to some extent for the forest department inability to control the mass poison of elephants in the district of Sonitpur. Even the role of the police in nabbing the culprits involved in this heinous crime has been a disappointment. Over 17 elephants were reportedly poisoned to death, and police could arrest only one person!

Furthermore, the forest staff was also confused on the cause of elephant deaths once the carcasses were detected. At first they claimed the elephant deaths were the result of infection by liver fluke, followed by anthrax and only then identifying the cause as poison using chemicals called "DEMECRON". Identification of causes of elephant deaths should be left to the scientists from veterinary department. Forest staff should not pretend to be veterinarians. What the forest staff should have done was to call the veterinary expert from the College of Veterinary Science, based at Guwahati to visit the site and discern the cause of death as soon as possible. These experts, if informed on time, could have investigated the cause and offered possible preventive measures for the future. The seriousness of this kind of crisis, whether epidemic or man-made problem, needs to be understood and realized. Of course everyone learns from mistakes, but it should not take too long to rectify such mistakes. It is a good sign that the press in Assam has helped publicize the tragedy, as a result of which the state government became more serious about the plight of the elephants. Even the Chief Minister of Assam has convened a meeting of forest officials to discuss the problem and expressed his deep concern.

The current study found that the rampant and uncontrolled use of pesticides, mainly by the tea estates, has become a major threat to elephants as far as poisoning is concerned. It

has been found that the labourers of various tea estates around the elephant habitat have easy access to these pesticides, which they often use to kill fishes in lakes and ponds. They also sell these pesticides to villagers. Thus most of the water bodies are affected with these poisonous chemicals and much of the fish population has suffered by their accumulation in their tissues (bio-amplification). A few culprits have used these pesticides inside fruits preferred by elephants, which die as a consequence of eating them. What is more disturbing is that the elephant being the largest mammal received much publicity from the poisoning cases, but the same process has killed numerous fishes, insects, reptiles and other animals inhabiting these water bodies with no attention being directed towards their plight. The government should monitor the easy access of the tea plantation workers to such pesticides, and to the culprits intent on killing elephants.

On October 2002, five more wild elephants were poisoned to death in areas of tea plantations in the Sonitpur District suggesting that the poisons were used either within the estates or in their vicinity. The use of pesticide by tea growers needs to be monitored strictly, and legal action should be taken against them if they are guilty. It appears that the organophosphate pesticides used to kill elephants were from the tea gardens.

Human casualties

Between 1990 and 2001, wild elephants killed more than 450 people across Assam. On average some 38 people lost their lives (range 15-52), which translates roughly into a human death once every 9.6 days. According to Choudhury (1999) between 1980 and 1994, some 670 elephant related human deaths occurred in Assam. He further adds that in 1985 alone, 85 persons died in the conflict in Assam. Some of the state government officials are of the view that elephants have increased in number and hence human casualty at the hand of elephant is on the rise, which is not true. On the contrary, elephant numbers have gone down in Assam from 5,524 in 1993 to 5,312 in 1997. Some state government officials are of the view that more elephants need to be captured from the wild to minimize the man-elephant conflict in Sonitpur and elsewhere.

However, it is unlikely to solve the conflict since no one has seriously addressed the issue of people straying into habitats occupied by elephants, which in fact is the crux of the problem. Most of the administrators and politicians in Assam overlooked the fact that capture of wild elephants in Sonitpur and elsewhere in Assam had failed to give desired result. This due to the fact that the contractors, who get the permit to capture wild elephants often target the calves or juveniles which are easier to capture and train. This has not helped minimize the man-elephant conflict. Even the electric fences erected in parts of Sonitpur district have not offered any respite owing to poor design and management coupled with the lack of goodwill of the local people. It is high time we evaluated the past efforts and develop a sensible strategy that could reduce the man-elephant conflict in Assam. If only when problematic elephants are identified and captured, that villagers around the affected areas may get some relief.

Inter-state Elephant Reserves

There are four inter-state elephant reserves in Assam, and they too have experienced great disturbances due to human interference, as a result of which elephant depredation has become a cause for concern among the forest managers, especially those directly involved with elephant management. The frequency of elephant depredation is given in Table 4.

ARANAYAK, a Society for Biodiversity Conservation in North East India, started an education-awareness programme in the Assam part of the Kaman-Sonitpur Elephant Reserve in March 2002 with the support from the U.S. Fish and Wildlife Service. As part of the project, ARANAYAK has been working closely with the district administration, police and forest officials along with all the village heads of the fringe villagers living around the Assam part of Sonitpur-Sonitpur Interstate elephant reserve. Already five villager-level meeting and more than 20 educational cum awareness programmes have been organized in various parts of the Sonitpur District in collaboration with other NGOs and Police and Forest departments. Such effort has paid dividends since no case of elephant poisoning was recorded since March 2002 in the district. Once this awareness cum education programme proves effective, ARANAYAK will initiate a similar programme in other interstate elephant reserves in Assam.

Recommendations

The recommendations can be divided into two categories: (a) those that are feasible, and (b) those that are challenging. The feasible recommendations are those that can be implemented by the government and the people, while the challenging recommendations, as can be inferred, are difficult but not impossible to implement, provided the government and the people are determined to solve the problem of man-elephant conflict in Assam.

(a) So far the construction of elephant-proof trenches, establishment of electric fences and adopting other measures to prevent crop degradation had been the responsibility of the forest department. Such initiatives need to be taken at individual level too so that the people living along the periphery of elephant habitats can look after the maintenance of the barriers. Eco-development initiatives need to be taken up in the fringe villages to encourage the villagers to adopt alternative livelihoods such as horticulture, poultry, pig farming, bee-keeping and fisheries instead of expanding traditional agricultural practices by encroaching into more forest areas. Anti-elephant depredation squads involving the villagers need to be set up especially in those few months when elephant depredation is known to escalate. Furthermore, awareness programmes for the villagers must be carried out by the NGOs and government agencies to enlist the support and participation of the people in protecting elephants and minimizing the conflict. Compensation as *ex-gratia* should be paid to the affected families within the shortest possible time to minimize their suffering, otherwise they would be further antagonized. In addition, we realize that it may not be practical to stop jhum cultivation, as it is a way of life among the villagers in Assam. However, some effective measures should be taken along the fringe areas of elephant habitats and elephant corridors in order to reduce such agricultural practices. Furthermore, commercial timber extraction in the remaining patches of elephant habitat should be stopped immediately. Power lines passing through prime elephant habitat and corridors should be relocated. It has also been observed during the study that the digging of ditches by oil companies often become death traps for many calves and juveniles. These ditches must be filled to minimize the death of elephants.

(b) It is only through the adoption of a coordinated and balanced effort for overall forest management and rural development can the present trend in man-elephant conflict be reversed. Since Assam still has more than 16% of forest cover,

Table 4 Intensity of elephant depredation in the four inter-state reserves

Name	area (km ²)	elephant number (N)	no. of protected areas	frequency of depredation
Manas-Buxa-Jaldapara	2,622	504	12	low
Kameng-Sonitpur	1,265	670	6	very high
Dibru-Deomali	1,498	336	38	high
Kaziranga-Karbi Angolung-Intanki	4,316	1,828	37	high

the state budget should provide at least 8% of the total annual budget for forest conservation initiatives. Such a provision of financial assistance may go a long way to reduce the man-elephant conflict and save the lives and properties of the people.

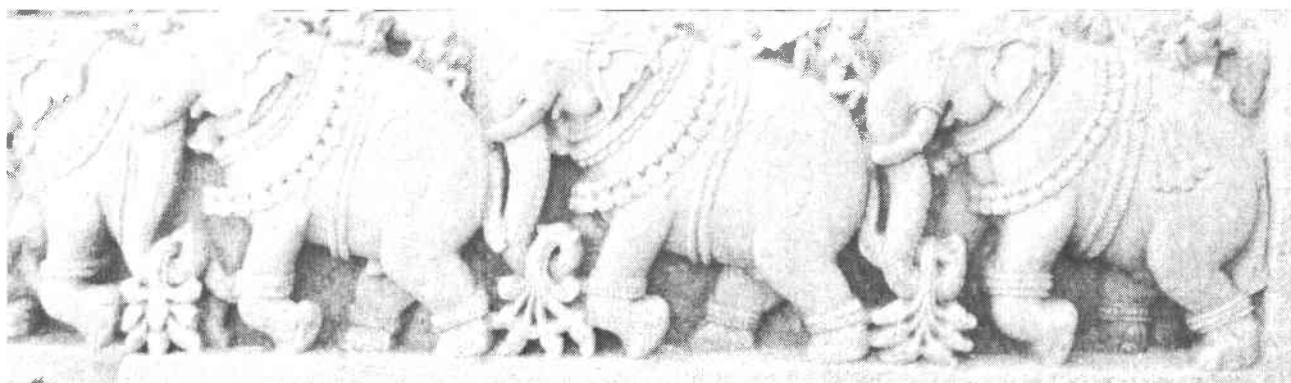
Planners and economists must realize the need to enhance allocations to ensure not only the protection of elephants, but also to ensure the overall ecological security of the habitat. This would be a wise investment and one that would certainly improve the quality of life of the poor, even as it strengthens the economy in the long run. Furthermore in important elephant corridors where human encroachment is a problem, measures must be taken to evict the encroachers so that the elephants can follow their traditional migratory routes. This will minimize the conflict between man and elephant to a great extent, but in order to evict the encroachers strong political and administrative will is needed. In fact legal protection should be given to all the elephant corridors under the Wildlife Protection Act, 1972 to arrest further encroachment into the corridors. Uncontrolled and unsustainable over harvesting of bamboo from the forests must be checked. Some railway lines and national highways need to be diverted as they pass through the prime elephant habitat in Assam resulting in increased mortality of elephants caused by accidents with trains and vehicles.

Conclusion

Man-elephant conflict situations need urgent amelioration to prevent them from becoming a launching pad of retaliatory action against elephants by the people affected, and subsequently foci of illegal trade in elephant products. There are many lessons learnt and few yet to be learnt from managing elephants in the wild in Assam in recent times. It will be foolish if we do not learn from these lessons and remain indifferent to the conflict and its causes. The efficiency of forest staff needs to be improved, followed by the adoption of massive public awareness campaigns against forest encroachment and the wanton slaughter of wild elephants. The people of the area who bear the brunt of elephant depredation must be made aware of those aspects of their farming systems which make them particularly susceptible to crop-raiding by elephants.

References

- Bist, S.S. (2002) Conservation of Elephants in NE India: Past, Present and Future. *Newsletter of the Rhino Foundation for Nature in NE India*, **4**: 7-10.
- Choudhury, A.U. (1991) Status of Wildlife elephants in Cachar and N.C. Hills, Assam - a preliminary investigation. *J. Bombay nat. Hist. Soc.* **88**: 512-221.
- Choudhury, A.U. (1993) *A Naturalist in Karbi Anglong*. Gibbon Books, Guwahati.
- Choudhury, A.U. (1997) *Checklist of the mammals of Assam*. (Revised 2nd edn). Gibbon Books & ASTEC, Guwahati.
- Choudhury, A.U. (1999) Status and conservation of the Asian elephant *Elephas maximus* in north-eastern India. *Mammal Review*, **29**: 141-173.
- Gee, E.P. (1964) *The wild life of India*. St. James Place, Collins, London.
- Lahiri-Choudhury, D.K. (1980) An interim report on the status and distribution of elephants in north-east India. In: *The status of the Asian elephant in the Indian sub-continent* (ed. J.C. Daniel), pp. 43-58. IUCN/SSC report, BNHS, Bombay.
- Santiapillai, C. & Jackson, P. (1990) *The Asian elephant: an action plan for its conservation*. IUCN/SSC, Gland.
- Srivastava, S., Singh, T.P., Singh, H., Kushwaha, S.P.S., & Roy, P.S. (2002) Assessment of large-scale deforestation in Sonitpur district of Assam. *Current Science*, **82**: 1479-1484.
- Stracey, P.D. (1963) *Elephant gold*. Weidenfeld and Nicolson, London.
- Sukumar, R. (1989) *The Asian Elephant: ecology and management*. Cambridge University Press, Cambridge.
- Talukdar, B.K. (1996) Conflict between Man and Elephants in Assam. *Zoos' Print*, **11**: 29.



Elephants from the Channakeshara temple at Somanathpur, Karnataka, India (photo: courtesy S. Wijeyamohan)

Short Communication

Are captive elephants important to conservation?

Heidi S. Riddle, Bets Rasmussen and Dennis L. Schmitt

We dedicate this article to one of the most forward-thinking Asian scientists, Dr. V. Krishnamurthy. Dr. K was deeply committed to elephants, and grasped the importance of the recent captive and wild studies described below, as significant for the salvation of elephants. We are privileged to have worked with him.

Introduction

The value of captive elephants

Currently in North America, there are about 280 captive Asian elephants. The question is often asked: "Do captive elephants truly benefit their wild counterparts?"

We feel that the answer is yes and will present evidence from specific areas to reinforce our answer.

Captive elephants serve as good will ambassadors for their wild counterparts. Elephants capture human attention in multifaceted ways. The public and young potential scientists, are drawn to this charismatic mammal. Every day, elephants in facilities of all kinds plant important seeds of conservation in fertile minds, creating concern and raising consciousness of the world's greatest land animal. If we are to teach people the importance of conservation, we have to reach them in as many ways as possible.

Captive elephants provide an opportunity for people to learn more about elephants. Education serves conservation, and that education takes many forms. Ultimately, the more people know about elephants the more likely they are to care about what happens to them as a species. Elephants are a keystone species with important ecological interactions with other fauna and flora. The study and conservation of a keystone species allows many other smaller species to be helped.

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Detailed knowledge of inter-species interactions is useful to conservation efforts.

Captive elephants provide opportunities for conservation. Captive elephants raise public awareness — whether it is about the animal itself, or about the challenges facing wild elephants such as human-elephant conflict and the need to identify and support protected areas. Public awareness, in turn, helps drive important public policies on conservation and habitat protection, and also provides important opportunities for fundraising.

Financial support for conservation comes not only from people who experience captive wildlife exhibits, but also from the organizations who exhibit captive elephants. Zoos, circuses, wildlife parks and private exhibitors are uniquely able not only to communicate important conservation messages, but also to raise funds for conservation through special fundraisers, gate proceeds and even from general revenues. Member organizations from groups like the International Elephant Foundation, which comprise both commercial and non-commercial exhibitors, come together to support important conservation and scientific study projects.

Captive elephants aid in scientific study which can be applied in the field. Captive elephants help validate field techniques used in conservation. For instance, in a carefully controlled experiment using captive elephants, dung extracted DNA was compared to blood extracted DNA. These paired samples showed that dung is a source of DNA that allows reliable and noninvasive genotyping (Fernando *et al.*, 2003). Dung extracted DNA from wild elephants is a useful and important tool to answer some conservation questions, such as genetic diversity in small or isolated populations.

Captive elephants offer unique opportunities to intimately understand how these animals function. Much has been learned about elephant physiology, biology and communication by the ability to be close to captive elephants. This body of knowledge, as it increases, continues to assist with conservation management decisions.

Communication

Elephants use multimodalities of sensory information to solve their life problems. For humans to be able to decipher this

communication it is often necessary to study one sensory modality at a time in an up-close context. Thus captive elephants allow a starting point for collecting basic information about how elephants communicate. A substantial amount of our understanding about the details of elephant communication originates from captive elephants. For example, to demonstrate that infrasound is produced by Asian elephants, it was necessary to use the sound-friendly environment of a zoo and the close proximity of a single elephant at that zoo (Payne *et al.*, 1996). Recordings proving such elephant-emitted noises opened the way for years of field research about how elephants utilize these sounds.

Olfaction is an important sense driving mammalian behavior. Our ongoing research into elephant olfaction has shown that elephants behaviorally demonstrate the extensive and precise use of their olfactory systems in complex life situations. Thus a fundamental biology question, "how do animals cope with their environment?" can be partially answered by linking specific elephant-emitted chemical compounds with elephant behaviors. For example, chemical signal mediated behaviors have been demonstrated to be female-to-female, male-to-male, female-to-male, mother-to-offspring and male-to-female (Rasmussen & Krishnamurthy, 2000).

Our understanding of how elephant olfaction works is improved by easily collecting excretions such as urine and breath, as well as secretions such as temporal gland and mucus, from living captive elephants to allow biochemical and molecular analyses. Armed with the identity of active chemical signals, we can figure out how they work, which signals are ephemeral and which ones are long lasting. In captivity we can easily and rapidly confirm these biochemical results by bioassays with living elephants at each step. Indeed, elephants exhibit observable and measurable responses to pheromones, facilitating the correlation of biochemical and behavioral events (Rasmussen *et al.*, 2003).

Our ability to link behavior and biochemistry allows more rapid understanding of the results in the real world of the animal. Two outstanding examples exist for the Asian elephant. The pre-ovulatory pheromone of the female Asian elephant was identified through work on captive elephants in North America, and was subsequently validated in the wild (Myanmar and India) through behavioral observations and biochemical analyses (Rasmussen *et al.*, 1996). A pheromone of musth male temporal gland secretion that sends varying messages to both sexes of elephant society was first identified in captive North American elephants, as was the discovery of the "honey" musth of teenage Asian males and the chemical explanation of moda musth (Rasmussen *et al.*, 2002).

In order to have the tools for better managing this endangered species, it is imperative to understand the extent of their use of chemical communication through the translation of the chemical signaling function. How pheromones work, how they affect behavior between conspecifics and how they can be used to possibly modulate elephant behavior directly begins to address some conservation issues such as crop raiding and human-elephant conflict. For instance, crop raiding by elephants is not necessarily a population problem,

but might be an individual elephant problem which may be dependent on that individual's gender or hormonal state, or even the time of year. Such detailed knowledge is important if specific biochemical information, such as the identity of individual pheromones, is to be utilized in the management of wild elephants — for example in developing deterrents between cropland and crop raiding elephants. Most importantly, information about chemical communication needs to be utilized now, not twenty years from now, if it is to effectively benefit wild populations of elephants.

Physiology and Reproduction

Elephants, both wild and captive, are a challenging animal to manage due to their great size, strength and intelligence. Carrying out detailed research into physiological parameters is simply not possible to do safely in the wild. It would be unrealistic to think about easily collecting blood samples daily, or even weekly, from a wild elephant. However, by intensely studying captive elephants to further our knowledge about biology and physiology, these captive animals do effectively contribute to conservation.

With elephants, many medical diagnostic methods, including radiography, have been limited in their scope because of the size of the animal. Since 1995, a new procedure, ultrasonography, is revolutionizing our understanding of elephant biology (Hildebrandt *et al.*, 1995, 1997). Ultrasonography offers a clear view of many internal organs of elephants therefore providing us with previously unknown intimate knowledge about elephant biology. Through ultrasonography scientists have a better understanding of important biological issues in elephants such as the timeline of ovulation, and internal physical changes that occur as elephants mature and during musth. The knowledge gained by closely studying numerous captive elephants in facilities in the West is being shared in elephant range states every year.

To successfully preserve any species, a detailed understanding of the reproductive process of the particular animal is essential. Ultrasound technology has made a significant difference to elephants by contributing new information, and this knowledge has recently allowed successful assisted reproduction techniques. While the number of elephant calves produced through Artificial Insemination (AI) may not yet be enough to significantly contribute to conservation of the species, by working toward successful and repeatable AI, our understanding of the physiological reproductive process of elephants has been, and continues to be, greatly enhanced.

Captive reproductive studies clearly help conservation decisions. For example, studies of the captive population have shown that although females may have 'normal' hormonal estrous cycles as measured in blood serum or fecal samples, some have reproductive tract pathological conditions reducing their fecundity (i.e. making them poor breeding candidates). Interestingly, these captive assessments demonstrate that these reproductive tract changes usually occur when a female has not had an opportunity to be

pregnant very often. These abnormalities can only be detected by a detailed internal assessment, primarily ultrasonography (Hildebrandt *et al.*, 2000). Such information is useful in making conservation decisions on how to best preserve wild elephant populations with disproportionately high numbers of females. For instance, in an almost exclusively female population, if most of the females are older and have not had an opportunity to conceive for some time, these females may experience similar reproductive tract pathologies as seen in captive animals, thereby reducing even further the potential for pregnancy. These populations would therefore benefit from a relocation infusion of both males as well as younger reproductively active females as the best way to ensure future population growth.

Another example of our basic understanding of elephant biology being enhanced by captive elephants is in the field of endocrinology. It was discovered that elephants have two luteinizing hormone surges; one is anovulatory and occurs about 21 days prior to the second ovulatory surge. In elephants, ovulation occurs about 24 hours after the second or ovulatory luteinizing hormone surge. Elephants are the only mammal known to have this unique double luteinizing hormone surge. This significant physiological finding was possible through an intense study of captive animals, as it was discovered only by closely monitoring captive elephants by daily blood sampling throughout the estrous cycle to determine the most fertile period for AI (Brown *et al.*, 1999).

In regards to diseases, particularly those which may be shared by humans and elephants, such as tuberculosis, much has been learned from captive elephants. Captive elephants are known to contract the same strain of tuberculosis as humans (*Mycobacterium tuberculosis*), and as cattle (*M. bovis*). These various strains have been diagnosed in captive elephants, and, where necessary, effective treatment protocols have been formulated and implemented (Mikota *et al.*, 2000). These types of illnesses may also affect wild elephants and more studies are needed to understand this possibility. Having well established diagnosis and treatment plans, as studied in captive populations, will assist in any possible detection and therefore resolutions of such problems occurring in the wild. Focused studies of captive elephant pathology have also identified an elephant specific herpes virus. Although the virus is highly fatal to young, captive born Asian elephants (Richman *et al.*, 1999), it is unknown at this time how prevalent this virus is in the wild elephant populations in Asia, and what possible impact it may have on the conservation of these populations.

As the elephants' world shrinks, and the humans' world increases, such zoonotic diseases may expand. Elephants, as well as humans, may be increasingly and more quickly exposed to new virus and bacteria that jump from other species. If this were to occur, the information gleaned by years of close study of captive elephant populations in

detection and treatment of diseases will be invaluable in helping to preserve wild populations of Asian elephants.

Conclusion

Helping Conservation

Elephants are centerpieces of many conservation issues. They are charismatic ecosystem engineers of economic importance yet their needs often conflict with those of humans (Sukumar, 1991). Humans, as the dominant species, have the responsibility to decide who gets what resource, when, and how much. Elephants help call attention not only to their needs, but to the requirements of other species. Therefore, an intimate knowledge about elephant habits and needs, including communicative, physiological and reproductive, is important for long-term conservation decisions.

The translation and exchange of information from captive to wild is important and needs to be rapid as time is running out for the Asian elephant. Recent exchanges of information between elephant managers, mahouts, veterinarians and research scientists from Asia and from the West have escalated, and the elephants can only benefit from such educational interactions.

Western exhibitors of captive elephants are providing increasing support of conservation projects and issues in elephant range states. In the U.S., a group of commercial and non-commercial exhibitors as well as wildlife organizations, worked for legislation to provide federal funds for Asian elephant conservation. This was the creation of the U.S. Fish and Wildlife Service administered Asian Elephant Conservation Fund which was signed into law in 1997 and continues to financially support many important elephant projects all over Asia through the use of government funds and private matching donations, many of which are provided by western exhibitors of captive elephants.

Wild areas available for elephants are shrinking daily. Due to a lack of habitat in most range states, elephants may face death or captivity as their only options. Some wild areas are in reality captive sanctuaries. As elephants around the world become more intensely managed by humans, captivity will have to expand.

Captive elephant facilities in Asia and in the West have a responsibility to promote and support elephant conservation by sharing information, by creating awareness of problems and issues facing wild elephants, and by raising financial support where possible. These facilities must also promote and support public education of these same issues. Of equal significance is the continued study of elephant biology through a variety of projects, such as the development of

technology to preserve the genetic diversity of the highly endangered Asian elephant.

Captive elephants are indeed important to conservation, and to the survival of all elephants.

Acknowledgements

In the spirit of this article we acknowledge Joan Galvin whose ongoing "behind the scenes" support for captive elephants helping conservation is largely unnoticed, and who spearheaded the effort to make the U.S. Fish and Wildlife Service's Asian Elephant Conservation Fund a reality.

References

- Brown, J., Schmitt, D.L., Bellem, A., Graham, L.H. & Lehnhardt, J. (1999) Hormone Secretion in the Asian Elephant (*Elephas maximus*): Characterization of Ovulatory and Anovulatory Surges. *Biology of Reproduction* **61**: 1294-1299
- Fernando, P., Vidya, T.N.C., Rajapakse, C., Dangolla, A. & Melnick, D.J. (2003) Reliable Noninvasive Genotyping: Fantasy or Reality? *Journal of Heredity* **94**: 115-125
- Hildebrandt, T.B. & Goeritz, F. (1995) Ultrasonography as a Tool in Zoo Animal Management. In: *Zoological Library – Research and Captive Propagation*. (eds. U. Ganzloser, J.K. Hodges & W. Kaumanns), pp. 49-58. Filander Verlag GmbH, Furth, Germany.
- Hildebrandt T.B., Goeritz, F., Pratt, N.C., Schmitt, D.L., Lehnhardt, J., Hermes, R., Quandt, S., Raath, J., West, G., & Montali, R.J. (1997) Assessment of Health and Reproductive Status in African and Asian Elephants by Transrectal Ultrasonography. *Proceedings of the American Association of Zoo Veterinarians Annual Meeting*. pp. 207-212
- Hildebrandt T.B., Goeritz, F., Pratt, N.C., Brown, J.L., Montali, R.J., Schmitt, D.L., Fritsch, G. & Hermes, R. (2000) Ultrasonography of the Urogenital Tract in Elephants (*Loxodonta Africana* and *Elephas maximus*): An Important Tool for Assessing Female Reproductive Function. *Zoo Biology* **19**: 321-332
- Mikota S.K., Larsen, R.S. & Montali, R.J. (2000) Tuberculosis in Elephants in North America. *Zoo Biology* **19**: 393-403
- Payne K.B., Langbauer Jr, W.R. & Thomas, E.M. (1986) Infrasonic Calls of the Asian Elephant (*Elephas maximus*). *Behavioral Ecology and Sociobiology*, **18**: 297-301
- Rasmussen L.E.L., Lazar, J. & Greenwood, D.R. (2003) Olfactory Adventures of Elephantine Pheromones. *Biochem Soc.Trans.* **31**: 137-141.
- Rasmussen L.E.L., Riddle, H.S. & Krishnamurthy, V. (2002) Mellifluous Matures to Malodorous in Musth. *Nature, Lond.*, **415**: 975-76.
- Rasmussen L.E.L. & Krishnamurthy, V. (2000) How Chemical Signals Integrate Asian Elephant Society: The Known and the Unknown. *Zoo Biology* **19**: 405-423.
- Rasmussen L.E.L., Lee, T.D., Roelofs, W.L., Zhang, A. & Daves, G.D. (1996) Insect Pheromone in Elephants. *Nature, Lond.*, **379**: 684.
- Richman L.K., Montali, R.J., Garber, R.L., Kennedy, M.A., Lehnhardt, J., Hildebrandt, T., Schmitt, D., Hardy, D., Alcendor, D.J. & Hayward, G.S. (1999) Novel Endotheliotropic Herpesvirus Fatal to Asian and African Elephants. *Science* **283**: 1171-1176
- Sukumar R. (1991) The Management of Large Mammals in Relation to Male Strategies and Conflict with People. *Biological Conservation*, **55**: 93-102



Plate 1 Demonstrating ultrasound in Kerala

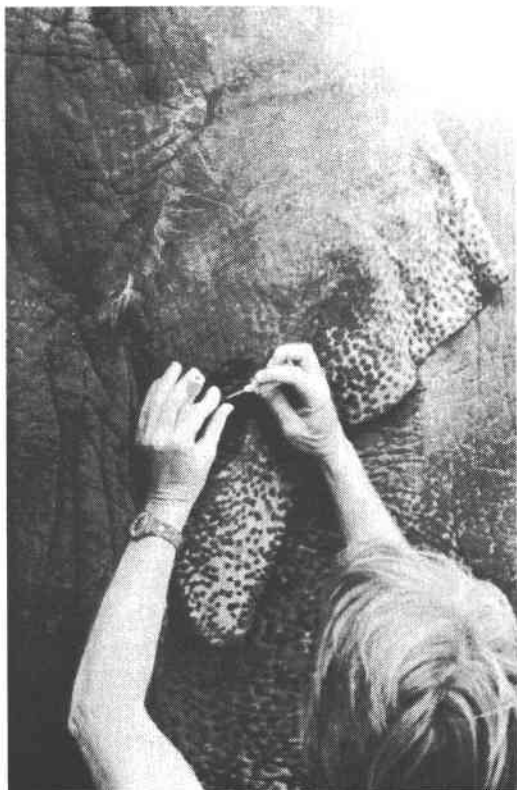


Plate 2 Collecting blood sample from an elephant's ear



Plate 4 Demonstrating the use of ultrasound in Kerala

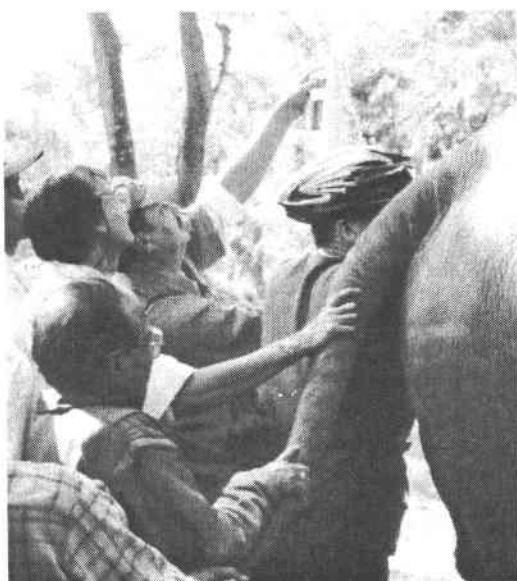


Plate 3 Collecting interdigital gland volatiles

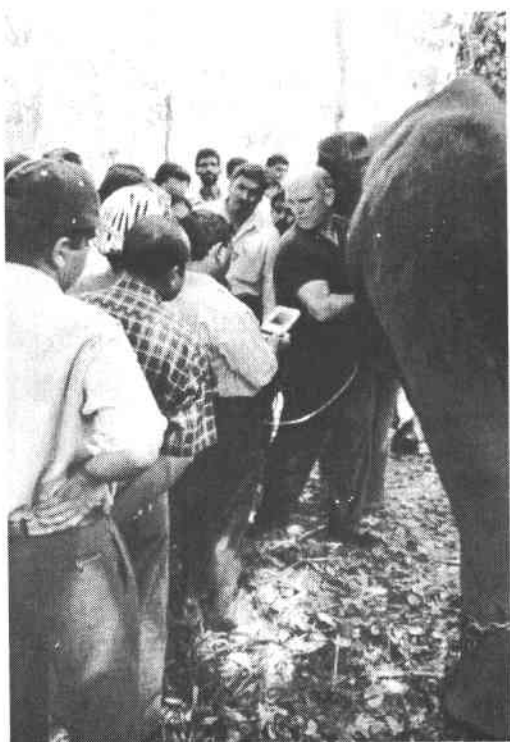


Plate 5 Demonstrating the use of ultrasound in Assam

Biogas from elephant dung: a means of mitigating human-elephant conflict

S. Wijeyamohan

Introduction

The human-elephant conflict (HEC) is one of the longest unresolved problems in Sri Lanka. This paper attempts to provide a solution to the HEC using the biogas produced from elephant dung. Biogas is not something new. It has been known as early as the 18th and 19th centuries (Garg, 1980). It was introduced to Sri Lanka by the Industrial Development Board in 1979 (Amarakone, 1981). Although further development and work has been done by the Agriculture Department, the Ceylon Electricity Board, the National Engineering Research and Development Center, and the Ceylon Institute of Scientific and Industrial Research (Amarakone, 1981), biogas has never been very popular in Sri Lanka. However during the past 100 years, especially after the second world war biogas production techniques have improved and highly sophisticated methods have been evolved in other parts of the world, namely in the USA, India, and China. Many of these methods are very expensive and highly technical.

Characteristics of biogas

Biogas is also known as natural gas. It is colourless, odourless, and smokeless when it burns. It is a mixture of gases: methane, carbon dioxide, hydrogen, nitrogen, carbon monoxide, oxygen, hydrogen sulphide and water vapour. The major proportion of the mixture consists of 60-70% methane and 30-40% CO₂ (Hansen, 2001). Other gases are found in trace amounts. It is methane that burns and gives off heat. One molecule of methane has one carbon and four hydrogen atoms. Chemists often write it as CH₄. Biogas contains 65% methane and yields 650 British Thermal Units (Btu) or 5,857 k. cals of heat per cu. ft or 0.028 cu. m., whereas gasoline yields 120,000 Btu per gallon (Hansen, 2001). Biogas is produced by certain groups of bacteria and protozoa as a byproduct, when they digest cellulose containing organic materials, under anaerobic conditions. Thus practically, biogas can be produced by fermenting cellulose using these organisms under controlled anaerobic conditions. As a tradition, cow dung (cattle dung) is used as the source to produce biogas, but it is true that biogas can also be produced from the faeces of any herbivore or omnivore which contains cellulose material. However the faeces of various other animals including that of man, other plant materials, and a

mixture of animal faeces and plant material have been used to produce biogas (Hansen, 2001; Ameratunga, 1980; Garg, 1980; Amarakone, 1981). However, it is the first time that elephant dung has been used in the production of biogas in Sri Lanka.

Biogas from elephant dung

There are several types of biogas plants around the world. Nevertheless, a newly designed prototype biogas plant using elephant dung has been set up in Puttalam, Sri Lanka. The cost of production was Rs. 5,000 (= US\$ 50). The volume of the plant is between 375 to 400 litres and about 50 kg of dry elephant dung was used. After a week the plant started to produce biogas. The maximum yield was 50 litres per day under ambient pressure, which meets the level of biogas production levels achieved by Amarakone *et al.* Under current estimation, 400-500 litres of biogas under ambient atmospheric pressure at sea level is enough to cook a meal of rice and 3 curries for a family of five. This would require 500 kg of dry elephant dung, but does not mean that such an amount is needed every day. The 500 kg of elephant dung would produce 500 litres of biogas daily for at least 14 days. After this peak activity, the production rate will decrease. However, biogas production is spontaneous and it can go on for a few months.

An adult elephant, on average, defaecates at least 100 kg of dung per day. This may be equivalent to a minimum of 50 kg of dry dung per day. Therefore 500 kg of dry elephant dung can be collected either from droppings of one elephant during ten days or droppings of ten elephants during one day. Furthermore, using the present prototype gas plant, 500 kg of dung can be used to produce sufficient biogas for a family of five at least for two weeks. Therefore, these ten elephants can continuously supply dung for 14 five-member families in rotation. Studies show that about 70% of the estimated population of 3,000 elephants in Sri Lanka are to be found outside the system of protected areas (Karyawasan *et al.*, 2002). They may produce a minimum of 105,000 kg of dry dung per day, which can be used to provide biogas to around 7,500 five-member families in rotation every two weeks. Since the newly designed gas plant is being improved, the values give above must be considered the minimum. Once the production and retention times are improved, higher targets can be reached.

Why use elephant dung?

The rationale behind the use of elephant dung in the production of biogas is to change the perceptions of the farmers who often shoot elephants in the wild as they are regarded simply as a dangerous pest. If elephant is to survive outside the protected areas in Sri Lanka, some ways must be

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found to reconcile the needs of the species with the legitimate aspirations of the local people. As Eltringham (1994) argues, one solution is to give the wildlife a value so that local people will want to conserve it. The production of biogas and its use by the villagers living in areas frequented by elephants would give an economic value to the elephant.

As mentioned earlier, biogas production is mainly by the fermentation of cellulose found in the cell components of plants by certain groups of bacteria and protozoa. Cattle being ruminants, their dung has very little plant fibre content. Various plant materials can be added to cow dung to increase biogas production. By contrast, elephant being a non-ruminant, its dung has considerably more fibres. The cow is a fore-gut feeder while the elephant is a hind-gut feeder. In the cow, the digestion and absorption of cellulose is almost complete and the excreta contains very little plant fibres, whereas in elephants, the process being incomplete, the dung contains a high percentage of undigested plant materials. As a result, comparatively more biogas can be produced from elephant dung than from cowpats without additional plant materials. Furthermore one of the reasons for the failure of biogas production in Sri Lanka vis-à-vis the situation in India, is that people in general do not like to handle cow dung in Sri Lanka. It may have something to do with the texture, pastiness and the strong smell associated with cow dung. But by contrast, handling dry elephant dung is much easier as it is not as pasty and smelly as cow dung. Therefore people would like to make use of elephant dung rather than cow dung to produce biogas as a fuel for cooking.

How biogas can be used to mitigate the HEC and thus help conserve the elephant

As a deterrent to wild elephants: There are several methods to deter wild elephants from raiding crops. The more effective methods such as electric fences, trenches, etc are usually more expensive as well. However, fire has been used from time immemorial to deter wildlife including elephants. Even today people carry fire-torches at night in villages frequented by wild elephants. A fire line would be a very effective way of deterring wild elephants. But establishing and maintaining a fire line around a home garden or around an elephant habitat, unlike an electric fence, is difficult but not impossible. To maintain a fire line with the available technology is expensive. Usually either petroleum products or firewood is used as fuel to create the fire. Using petroleum products to create the fire is easier but very expensive, and is beyond the means of the villagers. On the other hand, using firewood to create the fire line is not only difficult, but environmentally unwise, as it would encourage further encroachment of the forest by villagers in search of firewood.

Biogas is cheap to produce and easy to set up to maintain a fire line. The raw material – the elephant dung – is freely available in the neighbourhood of the villages. It is not proposed to keep the fire line on throughout the day and night. Instead it is recommended that biogas be lit whenever the need arose, as it can be stored under pressure. A fire line around the home garden could be connected with ‘fire pillars’ which would give large flames for short periods to threaten

the elephants intent on raiding crops. The height and intensity of the flame can be controlled by anyone from a safe distance. But this needs to be tested in the field.

As a cooking fuel: From the studies carried out by the Department of Wildlife Conservation (DWC) in Sri Lanka, it appears that elephant depredations do not occur everyday. Therefore, after storing the gas required to deter elephants, the excess biogas can be used for cooking. Cooking with biogas offers many benefits in comparison to cooking with firewood. It is easy as biogas gives off a pure blue smokeless flame when it burns. This in itself would help keep the pots and pans and the kitchen free of soot. Furthermore, to create the blue flame with biogas, there is no need for sophisticated burners as in the case with LP gas. Cooking with firewood is a health hazard and causes problems in the respiratory tract and eye ailments as a result of the smoke. These characteristics of biogas give an advantage over the use of firewood as fuel for cooking, which is the major source of fuel for the majority of people living in areas frequented by elephants. Promoting people to use biogas will therefore help minimize the extraction of firewood from the forest nearby.

The DWC can also make it their policy to use biogas in park bungalows for cooking. This would set an example to the visitors and also save purchasing and transporting expensive LP gas cylinders from the city. Furthermore, visitors who fail to see wild elephants during their stay in the park may at least derive some satisfaction of having enjoyed meals cooked with biogas produced from elephant dung!

The hotels, which have invested on ecotourism in areas frequented by elephants, can also use biogas produced from elephant dung to cook food and keep food warm during the buffet meals. These meals can be sold at a higher price to the foreign tourists, if it would help conserve the elephant in Sri Lanka. Foreign tourists would willingly pay that extra if they were convinced that they are promoting conservation of elephants. The elephant dung used for this could be purchased from the local people living in nearby villages. In this way, the people who suffer constantly from elephant depredations will be able to derive extra cash from the sale of the dung. Therefore, given that the villagers can derive tangible benefits from the presence of the elephant in their neighbourhood, they would not like to see the disappearance of the elephants from their neighbourhood.

Biogas, as Lewin (1999) points out is a valuable source of energy, and so it has been used to cook food on many farms in India, Malaysia and China, and also used as fuel on a much larger scale, even in highly industrialized areas, to produce electricity (as for example in Denmark, Los Angeles and Cook County, Illinois).

As a high quality fertilizer: The residue of biogas production is a high quality fertilizer (Hansen, 2001), and it comes free. Today there is a great demand for organically grown vegetables. Crops grown using the residue will not only yield bigger harvests, they will also fetch higher prices and thus bring greater profits to the villagers. Farmers will therefore be assured of a high return for their investment.

The hotels in particular which attract the wealthy foreign tourists may purchase such organically grown vegetables at a higher price thereby wean the farmers from suing harmful chemical fertilizers which are also very expensive. The byproducts of biogas production may in some small way, help compensate the farmers for the damage caused by wild elephants to their crops.

Other uses of biogas: In addition, biogas can be used as a substitute for lighting in rural areas. Most of the houses in remote areas frequented by wild elephants have no electricity. The people use petroleum products to light their houses. Biogas can be used instead at very little or no cost. Biogas also gives a brighter light. Successful trials have been carried out to operate combustion engines using biogas. In this way, farmers can operate their water pumps or even electric generators to produce electricity. It is also possible to cultivate mushrooms from the residue. Mushroom growers are well aware of the value of horse dung as a substrate for their fungus cultures (Lewin, 1999). Wild mushrooms can be seen growing on elephant dung in the field.

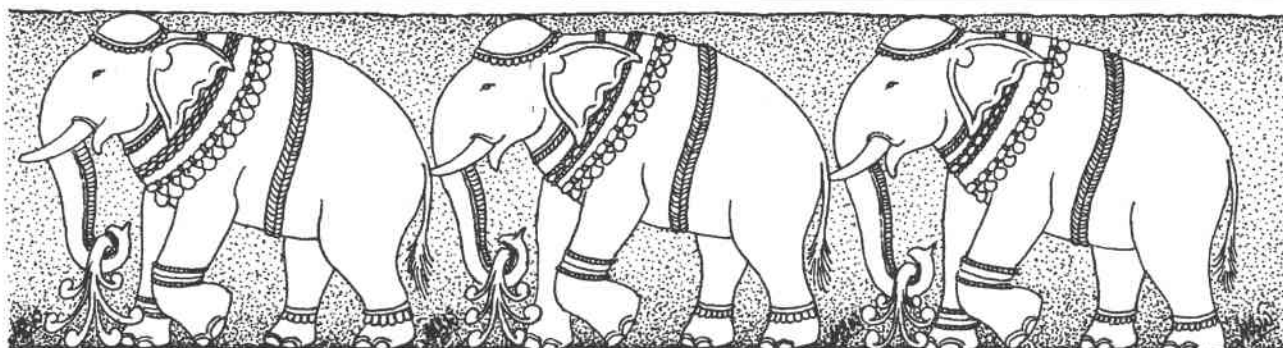
Conclusion

In Sri Lanka the major threat to the wild elephant is loss of habitat from expanding agriculture. Wild elephants are not being killed for meat, hide or ivory since less than 7% of the bulls are tuskless (Hendawitharana *et al.*, 1994). Thus ivory poaching is not a serious conservation issue in Sri Lanka. But the loss of elephants from HEC is one that seems to have replaced ivory poaching as a major cause of elephant mortality in Sri Lanka. On average 3 elephants are killed per week in Sri Lanka from the HEC. There are many reasons for such an escalation in the number of elephants killed in the wild: people who are affected by elephants, do not get any compensation for their losses, there is no economic value attached to the elephant, it has only a cultural value. No wonder elephants are killed as and when they interfere with agriculture. Unless there are proper regulations to prevent the erosion of elephant habitat, the HEC is likely to become exacerbated in the future. At the meeting convened by the IUCN/SSC Asian Elephant Specialist Group in Cambodia in 2002, a Task Force on HEC was formed. Several suggestions were made to mitigate the conflict between man and elephant. These include the provision of tangible benefits to people from elephants frequenting their areas;

compensating villagers adequately for their losses; and the adoption of a multi-pronged approach to deal with HEC. The use of biogas from elephant dung may relieve the pressure on HEC by meeting some of the recommendations of the Task Force. Villagers can obtain tangible benefits from the elephant that is now considered a serious pest. It can become an economic asset instead, if the use of biogas is promoted in villages. Biogas may also compensate in a small way, the losses incurred by villagers from elephants. Fire lines established using biogas would also curb encroachment into forests by people in search of firewood. Thus biogas from elephant dung can play an important role in mitigating the human-elephant conflict. It can also make anyone think twice before shooting an animal that is simply not a pest but an asset as well.

References

- Amarakone, S.P. (1981) Some alternative substrates for biogas production. A paper presented at the Training Course on biogas technology and biofertilizer production, held at the Bangladesh Agriculture University.
- Amarathunge, M. (1980) integrated biogas systems. *Reg. J. Energy Heat Mass Transfer* 2: 45-49
- Eltringham, S.K. (1994) Can wildlife pay its way? *Oryx* 28: 163-168
- Garg, H.P. (1980) Designing a suitable biogas plant for India. *Appropriate Technology* 7: 29-31
- Hedavitharana, W., Dissanayake, S., de Silva, M. & Santiapillai, C. (1994) The Survey of Elephants in Sri Lanka. *Gajah* 12: 1-30
- Hansen, R.W. (2003) Methane generation from livestock wastes (from the Internet)
- Karyawasam, D., Dissanayake, S.R.B. & Santiapillai, C. (2002) The status of Asian elephant (*Elephas maximus*) in Sri Lanka. Country Report. A paper presented at the IUCN/SSC Asian Elephant Specialist Group Meeting, Phnom Penh, Cambodia 27-30 May.
- Lewin, R.A. (1999) *Merde: Excursions into Scientific, Cultural and Socio-Historical Coprology*. Aurum Press, London



Elephants in stone (Hoysala period, c.1260 A. D) by Manjula Wijesundara

Lactating elephant feeds a day-old orphaned calf

R.C. Rajapakse and Samantha Mendis

In the early morning of 14 October 2002, a day-old female elephant calf was brought to the Elephant Orphanage at Pinnawala, Sri Lanka by the officers of the Department of Wildlife Conservation. The Director of the National Zoological Gardens named the calf Tikiri (Sinhala for 'little one'). As the baby was very thirsty on arrival, it was given normal saline and 4% Dextrose to drink. At 0630 h, the calf was examined by the veterinary staff and found to be alert, active and highly excited. On examination, a wounded and oedematous umbilicus, bruises over the vulva area and on the lower lip, as well as minor injuries all over the body were observed. All wounds were found to be infected and were cleaned and dressed with surgical spirit and povidone iodine solution. Moreover, negasunt powder mixed with margosa oil was applied to the vagina in order to prevent maggot infestation. To control bacterial infection, intra muscular injections of Strepto-penicillin forte (Penicillin+Streptomycin combination) were administered for five consecutive days. It was decided that Lactogen Formula II milk powder with a dilution of 3 scoops per 200 ml of boiled water was to be given to the calf at every one and half hour interval. Tikiri gulped her first meal in a couple of seconds via a rubber feeding tube as she was extremely hungry, but her second meal given by the same method was rejected. Therefore an infusion wire was fixed to the bottle that allowed the calf to suckle the free end of the tube and it proved successful. Greater efforts were required to administer further meals to the calf. She was reluctant to feed even though the method of presentation was changed, and preferred normal saline to milk. The following morning, the calf was observed to pass watery stools but remained alert and had a good appetite. The body temperature had increased to 98°F and rehydration fluid (known locally as Jeevani) was fed with milk. Diarrhoea was not observed again that day with the calf retaining a normal appetite. On the third day, yellowish watery stools were noticed, therefore 1/3 of a 3-care bolus (Halquinol bolus) was administered orally 3 times a day for 5 days.

Due to Tikiri's intense loneliness, it was decided that a tame female elephant called Noni should be brought in to care for the calf. Noni is a very gentle female known to look after calves very well. She welcomed Tikiri warmly with gentle caressing with her trunk. The calf was pleased with her new 'mama' and was soon comfortable enough to suckle Noni's dry breast. This behaviour encouraged us to introduce a lactating female to the calf. Thus Komali was selected given her great maternal instincts and the fact that she is known to

allow other calves at the Elephant Orphanage to suckle from her. Komali has a history of nursing and adopting her grandson when her daughter refused to feed her infant calf. Even though she was a good mother, there was a risk of introduction since Tikiri was a stranger. Finally Komali was introduced to Tikiri, with all the precautions to remove the calf as quickly as possible should an emergency arise. Fortunately, this attempt proved very successful and Komali began to nurse the hungry orphan.

Komali was kept in the shed with Tikiri starting from day four, while her grandson Migara was sent out with the herd. Two and one-half year old Migara was being bottle-fed in order to meet his nutritional requirements. In addition to Komali's milk, Tikiri was fed with Lactogen Formula II, ten scoops of it in 500 ml of boiled water at two-hour intervals. The calf was more active, alert and developed a good appetite and passed solid faeces. Komali cared for Tikiri as if she was her own calf, but Migara's cries in the field would alarm her, causing her to try and escape, and in the process push Tikiri out of the way. For this reason, it was necessary to keep Migara quiet and so every attempt was made to feed him on time. Due to the risk of Tikiri getting hit by Komali, extreme vigilance was exercised while supervising the pair, whenever Migara was away in the field. Komali adopted Tikiri in this way during the first two weeks, which are the most critical period of life as far as hand-reared elephant calves are concerned.

Feeding orphaned calves in the early stages their lives is the most challenging task for managers of elephants in captivity. The calves can very easily suffer from diarrhoea once they are introduced to powdered milk, even when it is half-cream. Sometimes the diarrhoea may be due to bacterial, protozoal or fungal infections. Stressful conditions such as separation from the mother, the herd or the habitat, or even transport, starvation and dehydration can lead to diarrhoea. There can also be nutritional factors such as lactose intolerance or simple indigestion due to the high fat content of the artificial feed causing diarrhoea. The condition is exacerbated should the calf fails to get cholestrum from its mother within the first five days following birth.

Introducing a nursing cow elephant to care for orphaned calves turned out to be the best solution given the circumstances. Such a management treatment reduces the stress suffered by the rescued calf, and provides an opportunity for it to receive the best milk and care from the foster mother, who knows what to do better than even the best mahout assigned to its care. Nevertheless, the constant attention and vigilance of the mahout is essential, given that the lactating cow is not the real mother of the calf.

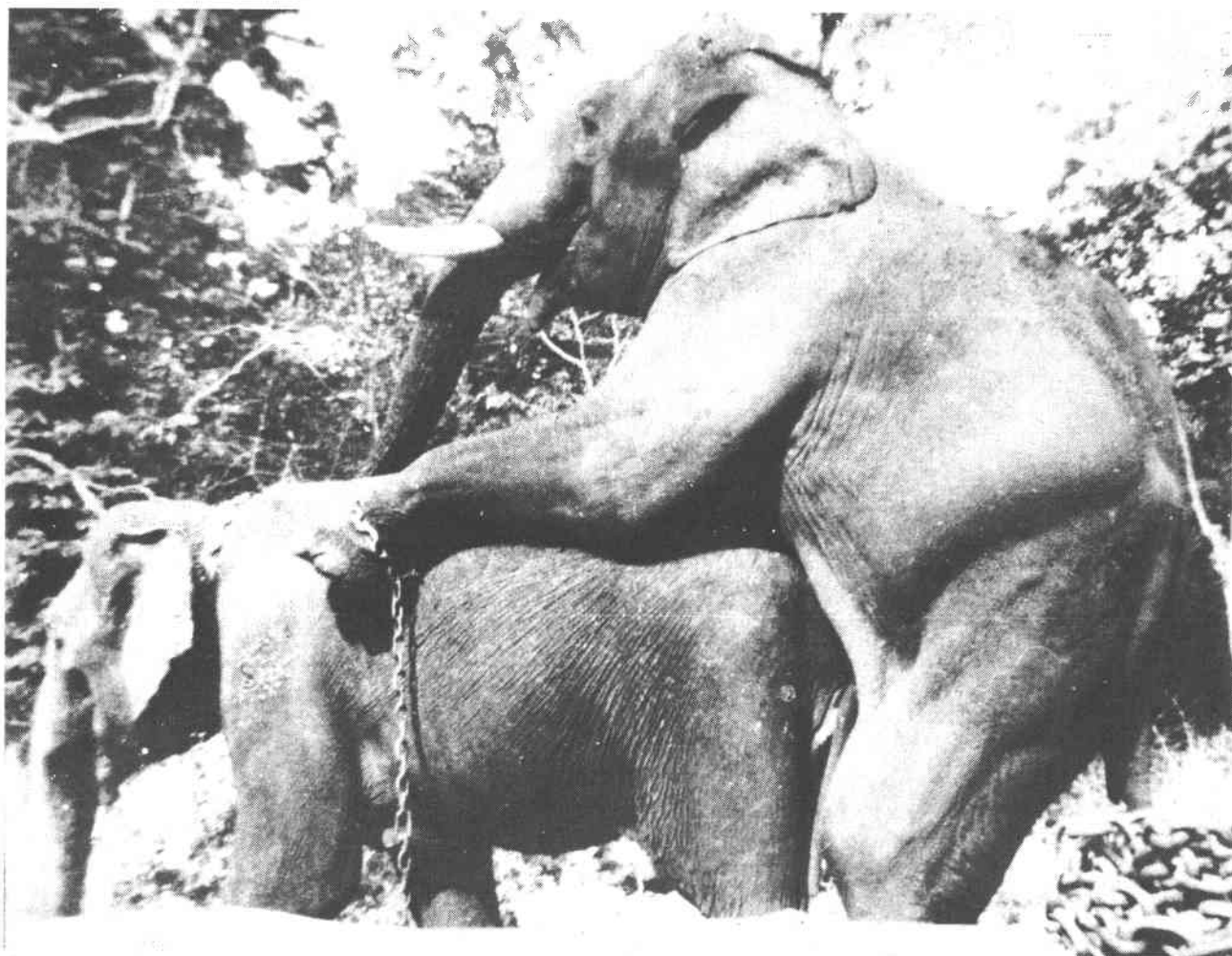
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Tikiri was given powdered milk, according to the following schedule:

age in days	milk powder	boiled water	feeding interval
1-2	3 scoops	200 ml	1.5 h
3-5	10 scoops	500 ml	2.0 h
5-10	15 scoops	1000 ml	2.0 h
10-30	20 scoops	2000 ml	2.0 h
31-60	30 scoops	3000 ml	2.0 h
61-90	40 scoops	4000 ml	2.0 h
90+	400 g	5000 ml	5 meals/day

After 3 months, the calf would learn to eat soft grass.



Elephants mating in captivity in Sri Lanka

An overview of the methods for enumeration of wild elephants in India

S.S. Bist

Introduction

Information on elephant range and numbers is important for the effective conservation and management of elephants in the wild. Despite their large size, counting elephants is not often task. Nevertheless, reliable estimates of elephant numbers, both within protected areas and outside, are necessary to determine whether elephants are increasing, decreasing or remaining stable in an area. In many parts of India, where competition for land is severe between man and elephant, it is important to know how large a protected area ought to be in order to support a viable population of elephants. Furthermore, many management objectives cannot be achieved in the absence of reliable information on elephant range and numbers. The following methods are presently being used for enumeration of elephants in India: (1) Total Direct Count (Northern, North-Eastern and Eastern India), (2) Line Transect with Direct Count (Southern India), (3) Line Transect with Dung Count (Southern India), (4) Block Sample-Direct Count (Southern India) and (5) Waterhole Count (Orissa and Southern India).

Total Direct Count

This method is popular with the forest officers because of its simplicity, but not liked by the scientists as it is not amenable to statistical analysis. It involves two essential steps: (a) searching and counting all the elephants in a given area, and (b) eliminating double counts through suitable precautions and scrutiny of data. Total Direct Count is usually carried out during the dry season when elephants are easy to locate around the limited water sources. In some Protected Areas, grasses are burnt during winter, which increases the visibility, and thus provides an opportunity for enumeration of wild elephants. Such total counts can provide information on the structure and composition of the population (e.g. sex classes, age classes, the number of tuskers and *maknas* or tuskless bulls). The information is usually collected in the following format: Adults (>7'), Subadults (5-7'), Juveniles (4-5'), and Calves (d'4'). Adult and subadult elephants are further classified as tuskers, *maknas*, females and unsexed.

Assam (2002)

Direct counting of wild elephants in Assam was carried out by engaging enumeration parties who traversed the forests either on foot or on domesticated elephants (called *Kunkis*). The

method relies on the experience of the forest staff and mahouts in (a) tracking and locating elephants, and (b) identifying and distinguishing individual elephants and family units from one another. During the enumeration in 2002, total elephant habitat in the State was divided into six zones which were further divided into several 'Counting Blocks' as per feasibility of the terrain, forest type, elephant density, etc. Maps were prepared for all the blocks showing details of important landmarks, boundary, vegetation etc. One counting block was assigned to one enumeration party. The enumeration was done over a period of 7 days (11-17 March in two zones, 15-21 March in one zone and 17-23 March in three zones). Advantage of the dry period was taken for enumeration as the elephants were concentrated around limited water sources and so were easy to locate.

The initial six days were used for positioning of enumeration parties and *kunkis*, preliminary reconnaissance of elephants and their signs and finalization of tracking route. Actual census was done on the last day by traversing from the opposite direction to the regular movement of the herd.

Assam (1997)

During the 1997 census in Assam, elephant habitats were divided into three strata viz., high, medium and low, depending on the density of elephant populations as a pre-census exercise. Enumeration parties covered the high and the medium density areas on *kunkis* and the low density areas on foot on a single day (9 April 1997). An attempt was made to treat the Total Count statistically. Immediately after the enumeration, 10% stratified sampling of the counting blocks was done and counting was repeated in the sample blocks on 10 April 1997. Two sets of counting data (obtained on 9 & 10 April) for the sample blocks were compared to determine the Standard Error, which was then applied to the Total Count to determine the confidence interval.

Western Assam (1979, 1980 & 1981)

The method counting elephants in the Western Assam (1979-1981) adopted by Mr. Deb Roy was inspired by the technique of *Mela Shikar*, the traditional method of capturing elephants in the north-east. *Mela Shikar* is practiced by *phandis* (professional noosers) who chase family groups of elephants on *kunkis*. These *phandis*, over a period of time, develop great expertise in tracking wild elephants and identifying family groups. During the third census (May-June 1981), Mr. Deb Roy deployed two parties — each comprising a *kunki*, a *phandi*, an enumerator and an elephant attendant. The *phandi* was to guide the party and its movement, identify the herds and count the numbers, identify the sex and categorize the animals into different age groups and dictate to the

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enumerator the details of individuals selected for identification of the herd. He was also responsible for locating fresh elephant trails along his path, follow such trails, and approach silently and finally locate the herds. Each party was to move in a general east or west-bound direction in a zigzag fashion, covering much of the area, so that no herds were left out during the exercise. The parties traversed 30-40 km every day, made night halts in the field and covered the entire census area in about 30 days. Mr. Deb Roy recommended that each herd should be given a name, but it is doubtful whether it was actually done.

North Bank of Brahmaputra (1982)

In November 1982, enumeration of elephants was carried out in the eastern part of the north bank of Brahmaputra along the lines of the tracking method suggested by Mr. Deb Roy. This was followed by a sample count on 27 December 1982 under the supervision of Mr. A.H. Choudhury. The entire census area was divided into 6 blocks (strata) on a map, which were then subdivided into 131 compartments of suitable size so that each one could possibly be covered by one enumeration party on an elephant. By using the Random Number Table, 13 compartments representing about 10% of the total census area were chosen from different blocks for sample counting. The sample compartments were then located on the ground and their boundaries demarcated. Attempts were made to cover the whole area of the compartments on 27 December following different trails of elephants. The data was statistically analyzed to calculate standard error of mean population, estimate of coefficient of variation of the total population and finally the confidence interval of the total population. Lahiri-Choudhury (1991) used the stratified ratio method of estimation to re-calculate the estimate of total population of elephants in each stratum separately and also in all the strata together.

Meghalaya (2002)

The six districts having elephant populations were divided into 38 counting zones. The exercise was carried out in two phases. Phase-I involved preparatory work and preliminary surveys. Phase-II involved training of enumeration parties, setting up watchtowers and hides at vantagepoints and actual enumeration. Counting in each zone was carried out from 22 to 31 March 2002. The data collected by the enumeration parties were scrutinized and errors were eliminated.

Northern West Bengal (2000)

The enumeration of elephants in North Bengal, done in March-April 2000 under the supervision of Mr. S.S.Bist, entailed separate counting of unattached bulls and family groups.

Registration of unattached bulls

Counting of unattached bulls was done by the field staff by registering them as to whether they were sighted within the forest or encountered outside the forest during crop raiding. Registration was done by means of a checklist which contained

such important features as tusks, shape of the back, tail, build, height etc. The forest staff filled the checklists either on the basis of their own observations or collected the relevant information from the villagers or the tea garden officials who had seen the elephant in question. Double counting of elephants was eliminated by comparing checklists of elephants from the neighbouring areas and examining other circumstantial evidence such as time and place of sighting, previous history etc. Screening of the checklists was done at the beat-level, range-level, division-level and the sector-level.

Tracking of family groups

Family groups were counted by tracking them inside forests. Special tracking parties on *kunkis* were deployed for counting elephant herds. Each tracking party had 2-6 *kunkis* at its disposal, more *kunkis* being pressed into service where vegetation was dense or chances of encountering wild elephants were good. It was found that tracking parties having two or more *kunkis* could track family groups, observe all the members of a family group and record details about the height and sex of the individual members more conveniently than a party with a single *kunki*. In fact, when one enumerator filled up the checklist of the matriarch or other typical elephants, the other recorded the height and sex of the individual members and yet another could look for the 'hidden' elephants. The enumerators could exchange notes and together collect all the requisite information. The movement of the tracking parties was so regulated that each sector was covered twice during the census period by one or two tracking parties. The tracking parties left for forests before dawn and attempted to encounter the family groups when the elephants were resting. Each party carried a portable wireless set and any information received by the local forest staff and villagers regarding wild elephants was promptly conveyed to them. 'On foot' parties were engaged for covering hilly regions, which could not be traversed on elephant back. It was felt that these arrangements were sufficient to guard against any under-counting of elephants. Over-counting of family groups was eliminated by comparing one or more of the following features: (a) description of one or more of the target animals (i.e., matriarch or other adult cows having any peculiar features) of the group recorded through checklists. (b) size of the group. (c) number of tusked in the group and their description through checklists. (d) number of cows in the group. (e) number of juveniles and calves in the group, and (f) time and place of sighting. The exercise for detecting double counting was done by the tracking parties themselves and then verified by the supervising officers at different levels. Registration of unattached bulls and pre-census monitoring of family groups was carried out from 24 March to 7 April 2000. Actual tracking and enumeration of family groups was conducted from 0600 to 1300 hrs each day from 8-22 April 2000 with a day off for rest of the departmental elephants.

Northern West Bengal (1986, 1989 & 1992)

In northern West Bengal, total counting of elephants was done in 1986, 1989 and 1992 using the 'Rolling Count' method in which the entire census area was divided into zones and census

was done in one zone at a time moving from east to west. Suitable arrangements were made for monitoring the elephant movement across the adjoining zones to avoid double counting. As soon as enumeration was completed in a zone, some of the resources (e.g. trained elephants, compasses, etc.) were moved over to the next zone.

Orissa (2002)

In the Simlipal Tiger Reserve in Orissa, enumeration of elephants is usually carried out during the monsoon. This is based on a study that has demonstrated that with the least input of time and effort, the success rate in elephant sighting is the highest during August-September. However, during the year 2002, enumeration was done all over the State from 5-7 May. The actual enumeration was preceded by a survey to find out the beats: where elephants are either regularly seen, or elephants were seen during the last one month, or where elephants are known to visit during certain months. All such beats were selected as 'Elephant Census Units'. Each unit was assigned to an enumeration party comprising a Forest Guard and two labourers. During the three days of census, the area of a unit was searched thoroughly. Some observers were also put on watch towers set up close to waterholes and pools along the streams. Analysis of data involved the elimination of overlap in elephant sightings in a particular unit during the same day or different days, and between adjacent units.

Uttaranchal (2002)

Counting was done in May 2002 before the rains when the elephants were easy to locate around the limited water sources. The elephant habitat was divided into 'Counting Units' and each unit assigned to one enumeration party. Usually a unit coincides with an administrative beat. Three copies of the map of each unit were prepared on a suitable scale for marking the location of elephants. The enumeration parties traversed the counting units on the appointed day from dawn to dusk and counted all the elephants seen. The counting was repeated second and third time after an interval of 7 days. Simple average of the three counts was calculated to get the 'Total Count'.

Uttar Pradesh (1991 & 1992)

In 1991 and 1992, in the month of May, total count of elephants was repeated three times after intervals of 3-5 days. The data for each year was subjected to statistical analysis to determine its significance (by chi-square test) and to calculate 95% confidence limits for the mean population of males, females, calves and unattached bulls as well as total mean population of elephants.

Sampling

Sampling methods have been tried in India usually when some scientific institute is involved in the enumeration of elephants. Sampling methods may involve direct sighting of elephants in which case information about the estimated range of population as well as composition in terms of age-classes and

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sex can be obtained. Sampling methods based on indirect evidence may not give information other than elephant density and population range.

Sampling with Direct Count

Karnataka (2002) & Tamil Nadu (2002)

In Karnataka and Tamil Nadu sample counting was done using the Block Count method (7 & 8 May 2002) and the Waterhole Count method (8 May 2002) under the guidance of the Asian Elephant Research and Conservation Centre (AsERCC). The Block Count was carried out primarily for estimating elephant densities while the Waterhole Count was meant for ascertaining population structure. However, in the final analysis, the data from both methods were pooled together to obtain sex-ratios with larger sample size.

Block Count

Elephants were counted from sample blocks selected uniformly across the entire division. A compartment map of the division was obtained and approximately 30% of the beats demarcated on the map were randomly chosen and designated as census blocks. The sample blocks were systematically surveyed by a team of 2-3 people and all elephant sightings were recorded in the prescribed data sheet. In addition, where possible, the age and sex of all the animals seen were recorded. The mean density and range (confidence intervals) of elephant numbers was calculated statistically for each division.

Waterhole Count

Approximately 30% of perennial waterholes within each division were observed between 0800-1800 hrs by a team located on a watch tower or hide. During this period, all elephants visiting the waterhole were aged and sexed. Elephants were classified into four major age classes based on shoulder heights, viz. calf (< 1 year), juvenile (> 1-5 years), sub-adults (> 5-15 years) and adults (> 15 years). Animals were sexed based on presence or absence of tusks in the case of adults, subadults and juveniles. Care was taken to differentiate *Maknas* (tuskless bulls) from females using body characteristics and shape of genitalia. From this data, sex ratio of adult elephants in each division was computed.

Line Transect Direct Count

In Kerala, enumeration was done in all the blocks by Line Transect- Direct Count method on 9 May 2002 under the supervision of the Kerala Forest Research Institute (KFRI). In each block, a transect of about 2 km long was laid by marking trees with paint or coloured biodegradable ribbons. These transects were covered on foot and the sighting distance (r) and the sighting angle (θ) to the geometric centre of the herds were recorded. Ocular estimate of the sighting distance was made. The sighting angle (θ) was measured with the compass. The density estimates were obtained by using the program DISTANCE 4.0. A 5% truncation of the largest distance values was adopted to improve the precision of the

density estimates. The density estimates were developed after adjusting for cluster size bias. The cluster size estimation was by regressing distance function $g(x)$ on the logarithm of cluster size. As reported by the KFRI, the estimates of elephant density found by this method were not reliable in most of the regions because of the high coefficients of variation, which was due to the low number of sightings.

Sampling with Indirect Count

Line Transect-Dung Count (Tamil Nadu & Karnataka, 2002)

In all divisions, line transects were laid in the same blocks as were the case in the 'Block Count' method. In each sample block, a transect of 2 km length was laid across altitudinal gradients and perambulated once on 9 May 2002 to enumerate dung piles. On sighting dung piles from the transect, information such as, perpendicular distance of the dung pile, its status, etc. were recorded. Elephant density was obtained using the program GAJAH (Ver.1.0) by incorporating the dung perpendicular distances, total transect lengths, defecation rate and dung decay rate. A defecation rate of 16.33 calculated by Watve (1992) and a decay rate of 0.0097 calculated by Varman *et al.*, (1995) were used in the analysis. In Karnataka, densities estimated through dung count were substantially different from those obtained from block counts for some divisions when data was analyzed using dung piles recorded up to 10m or 15m (perpendicular distance) from the transect line and excluding outliers. In divisions with very few or no elephants, dung count method yielded much higher estimates of elephant numbers. These differences could be due to sampling errors coupled with the inexperience of the field staff. Therefore, the Dung Count exercise in Karnataka was treated only as an experience for the field staff. However, in Tamil Nadu, only marginal differences across the densities of elephants estimated using these two methods was observed in some prominent Protected Areas which confirmed the reliability of the results. In addition, confidence interval in the Dung Count method was found to be smaller (1059) than the Block Count method (1320).

Line Transect-Dung Count (Kerala, 2002)

Enumeration of elephants by Dung Count method was done in Kerala on 8 May 2003 under the guidance of the KFRI. 2 km long transects were laid in all the blocks. The density of dung belonging to fresh and old stages was estimated by

measuring perpendicular distances to dung piles from the transect. The dung density for each vegetation type was estimated from the transect using the program DISTANCE 4.0. The dung density was converted to elephant density by the method described by Barnes & Jensen (1987). The decay rates of 0.0187 and 0.0192 were used for moist deciduous forests and dry deciduous forests respectively whereas for the other forest types, the decay rate of 0.0146 calculated by Sale *et al.* (1990) was used. The defecation rate of 16.63 calculated by Watve (1992) was used in the computations. A 5% truncation of the largest distance values was adopted to improve the precision of the density estimates. The KFRI has reported the density estimates of elephants to be quite reliable because of the low coefficient of variation of the estimates. However, this has given a very high population growth rate for Kerala as compared to the neighbouring populations in Karnataka and Kerala. The census results are being reviewed.

References

- Barnes, R.F.W. & Jensen, K.L. (1987) How to count elephants in forests. *Technical Bulletin No. 1, African Elephant and Rhino Specialist Group*.
- Lahiri-Choudhury, D.K. (1991) *Direct count of elephants in north-east India. In Censusing Elephants in Forests: Proceedings of an International Workshop. Southern India.* (eds. U. Ramakrishnan., J.A. Santosh & R. Sukumar). pp. 33-45
- Sale, J.B., Johnsingh, A.J.T. & Dawson, S. (1990) Preliminary trials with an indirect method of estimating Asian elephant numbers. Report presented to the IUCN/SC Asian Elephant Specialist Group.
- Varman, K.S., Ramakrishnan, U. & Sukumar, R. (1995) Direct and indirect methods of counting elephants: a comparison of results from Mudumalai Sanctuary. In *A Week with Elephants: Proceedings of the International Seminar on the Conservation of Asian Elephant* (ed. J.C. Daniel & H.S. Datye). pp. 331-339. Oxford University Press, Bombay.
- Watve, M.G. (1992) *Ecology of host-parasite interactions in a wild mammalian host community in Mudumalai, southern India.* Unpublished Ph.D thesis, Indian Institute of Science, Bangalore.

"The croaking of the frogs does not hinder the elephant as he drinks"

Ahmadou Kourouma in *"Waiting for the wild beasts to vote"* Cote d'Ivoire

Aristotle's Notices on the Elephant

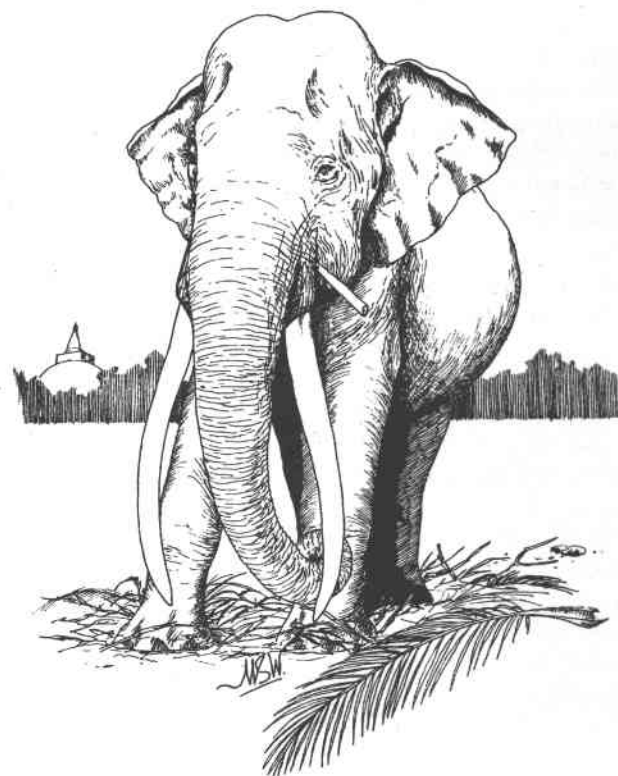
Merlin Peris

Few of those who know of Aristotle's reputation as a philosopher would be aware of his extensive researches in the field of biology. In fact it was his scientific approach to natural phenomena that influenced his study of all other subjects, including metaphysics, ethics, and literature in which his analytical approach is no less manifest. What would be most interesting to readers of *Gajah* in this context would of course be his observations on elephants, in which also is evident a scientific approach to their study the like of which nothing has been known till recent times.

Asia is reputed to have tamed and trained elephants – if we go by the evidence of the Indus Valley civilization – from as far back at 1500 B.C. at least. They have since then been captured, singly by trap and pit, or in numbers by *kraal* and other devices and employed for labour, ceremonial, war, and indeed even execution. Yet of the very few works that have been handed down to us in India and Sri Lanka on elephant lore – and these are also of more recent antiquity – hardly any devotes itself to a biological or zoological study of the animal that can be deemed scientific.

Notable among these writings are the Indian *Gaja Sastra*, and in Sinhala, the *Gajayoga Satakaya*, *Hasti Lakshana Vidyava*, the *Gajatu Lakshanaya*, the *Maha Gaja Lakshana Sangarahava*, and the Medieval *Atunge Lakshana*, all of which either concern themselves with a classification of the breeds and castes among elephants by arbitrary interpretation of physical appearance, prognostications based on crass superstition⁽¹⁾, and (which is perhaps the least ridiculous) an attempt to lay down the physical, psychological and behavioural features of the first ten years, and thereafter, of ten-year periods (*dasa*) of the animal's life. To this hocus-pocus must be added the pretence of such elephantology to a knowledge of the nerve-centres (*nila*) of the animal – the truth of which, as far as I am aware, remains unverified – by the pricking or pressing of which it is believed the animal could be manipulated to do the bidding of the mahout like a robot, but which, to my thinking, may be no more than conditioned reflexes⁽²⁾.

In contrast to the superstitions and fantasies that fill these works and are of no credit to civilizations that have developed in close association with elephants for centuries, come the observations of Aristotle, hailing from a land to which



(Tusker by Manjula Wijesundara)

elephants were exotic, making his study of them in a far greater antiquity than the authors of those aforementioned oriental treatises, and having at best a few specimens, themselves removed from their natural habitats, to work upon. Nor, it must be remembered, were elephants the only – or even the chief concern of the philosopher's study, as will be seen.

Aristotle was born in the small city of Stageira in the Chersonnese in 384 B.C. and acquired his interest in biology from his father, Nicomachus, who was personal physician to Amyntas, king of Macedon. In 357 B.C. he joined Plato's

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Academy in Athens, studying, researching and lecturing for 20 years. When Plato died, he left Athens and spent some years in Asia Minor and the island of Lesbos, then was invited by King Philip of Macedon to Pella (343 B.C.) to be tutor to his young son, Alexander. The advance Aristotle made in his biological studies, especially of marine life, belongs to these years in Asia Minor—but as it now seems, also of his studies of other animals as well, including elephants, even if it raises the question of how he came by them before the campaigns of Alexander.

With the campaigns of Alexander, however, his acquaintance with elephants must have increased considerably, as of other exotic animals as well of which he wrote. For though he did not accompany the conqueror, Alexander took along with him scientists and scholars of all sorts and is said to have instructed hunters, fowlers and the like of his rapidly expanding empire to report to Aristotle anything they encountered that was of zoological curiosity. There is also mention of a handsome grant of 800 talents that he made to the philosopher to pursue his researches.

By this time Aristotle was back at Athens, where he established his own school in the Lyceum. Alexander died in 323 B.C., Aristotle the year after, having left Athens following a wave of anti-Macedonian feeling, which was bound to have caught up with him due to his close association with Macedonia and Alexander. It was in the Battle of Hydaspes against Porus, king of the Pauravas, that Alexander faced a formidable array of elephants. But there can be no doubt that war-elephants were also present in the Indian contingents of the Persian army at the Battle of Gaugamela (329 B.C.) and others. We know that the Greek, Ctesias of Cnidus, who was at the Battle of Cunaxa in 401 B.C., at which the rebellion of Cyrus was crushed, had even then seen elephants deployed in battle, so that there is no reason to think that Greeks were not familiar with elephants before Alexander's invasion of India.

But, as mentioned earlier on, the question is how Aristotle himself had acquaintance with elephants before Hydaspes to be able to come up with all his information on them in his writings, which really belonged to the middle period of his scholarship – the years in Asia between his studies under Plato and Alexander's campaigns in the East. For, even if he may have expanded his knowledge of elephants in these later years, the information that comes to us in his biological works already show, not only a considerable familiarity with these animals through association and observation, but an anatomical knowledge that could only have been possible by clinical examination involving dissection.

Aristotle's notices on elephants, their zoology and anatomy, do not come down to us in a single treatise or even a single continuous account anywhere in his writings. Instead, they are sporadic references in the midst of his discussions of all manner of other creatures, big and small.

In the collected works of the philosopher there are four separate treatises on biology, viz:

Historia Animalium
De Partibus Animalium
De Motu et de Incessu

De Generatione Animalium

History of Animals
Parts of Animals
The Motion and Gait
of Animals
The Generation of
Animals⁽³⁾

Taken together these form the bulkiest group in the collection of Aristotle's writings. Altogether he describes in them five hundred species of animals; of these he himself had dissected specimens of fifty. The topics he discusses there are (a) the classification by genera and species (b) the distinction of the meanings of the term "parts" i.e. as materials, like flesh, bone, sinews, skin etc., or according to function, like heart, liver, head, hand, etc. (c) differences in physiology, psychology, character and habits, and (d) the question of the appropriate method to be pursued in natural science.

How different all this is from the oriental works which I have mentioned – even when they belong to a considerably late age, is best left without comment. But before I get on to Aristotle's observations on the elephant, and more particularly its trunk, which is the focus of this note, I need to draw attention to his constant use of a type of causation in nature different from the mechanical in the inorganic sphere. This is the teleological cause (Gk: *telos* = an end) or final cause (Lat. *finis* = an end) which implies that Nature has an intention for everything. This kind of causation visualized by Aristotle has been criticized, and if it is as a substitute for observation, the criticism is justified. It would be like positing that the purpose of the hand is to play the violin, says Benjamin Farrington⁽⁴⁾. Besides, every natural organ develops a variety of functions which seem to be the result of the existence of the organ than its cause.

Yet Aristotle was wise enough to realize that theories must yield to observation, and credit given to theories only to the extent that they are confirmed by facts. This is the manner and temper of this great collection of biological works which resulted in the classification of living things, a *scala naturae* not superseded till the time of Linnaeus and which drew from Darwin that oft-quoted remark, "Linnaeus and Cuvier have been my gods; but they were only children compared to old Aristotle".

Aristotle's most extensive information on the elephant has to do with its trunk, for it seems to have intrigued him as much as it did (and does) most scientists and writers. It is for this reason also that I will dwell on it in some greater detail, giving also the references to the several notices for the benefit of those who desire them. Not that Aristotle did not have surprisingly good observations on several other anatomical and behavioural features of the animal.

For instance, he observes that the elephant has four teeth on either side, present at birth itself, with which it grinds its food like so much barley-meal; that besides these it has two "great teeth" – the tusks, though he may have been misled by the specimens he had into thinking that in the male these curved upwards, and in the female in the opposite direction. Again Aristotle speaks of the scantiness of the elephant's

hair, its thick skin, the relative smallness of its tongue, the two mammae of the female as located under the axillae of the front legs and also being quite out of keeping with the size of its frame; of the intestines being “so constructed that the animal appears to have four stomachs”; of the remarkable absence of a gall-bladder, though it has a liver; of the penis of the male as (like the tongue) being disproportionately small; the invisibility of the testicles, concealed as they are inside the body in the vicinity of the kidneys; of the semen as not hardening so much when dry as to become (as Ctesias had stated) like amber.

Regarding the manner of sexual intercourse too Aristotle knew far better than the absurd notions prevalent even today and in lands that bred elephants as well – though it is the male who might seem to be squatting (and on the haunches of his rear legs, with forelegs on the female’s back) than the female herself, usually a much smaller animal, who receives him, standing on all fours⁽⁵⁾. With regard to the life of the elephant, Aristotle observes that the age at which a female becomes sexually receptive is between ten and fifteen years, and of the male as being potent when five or six – and again, that both are fitted for breeding by twenty. He is nearly correct about the period of gestation, which he opines is about 22 months – elsewhere, 3 years, observing philosophically “for it is not easy for large masses to arrive at perfection in a small time”. But he did know of opinions which put it at 2 ½ and 3 years, accounting for the discrepancy as “due to the fact that there are never human eye-witnesses to the intercourse between the sexes”, for “elephants copulate in lonely places, and especially by river-sides in their usual haunts”. “The female”, he says, “settles down on its rear to cast its young, and obviously suffers greatly in the process. The young one, immediately after birth, sucks the mother, not with its trunk but with its mouth; it can walk about and see distinctly the moment it is born”.

As to the elephant’s age, Aristotle says, “Man lives longer than any animal of which we have credible experience except the elephant.”⁽⁶⁾ But he will not commit himself to a definite period, being content to give the opinions of others as 200, 120 and some even 300, perhaps because, as with the period of gestation, one was usually not aware, or had not kept a record of its age at the time of capture or birth. On the other hand, it must be our own misunderstanding of Greek measures (*medimni, mareis, cotylae*) which is responsible for the confusion regarding the elephant’s intake of food and liquid, which Aristotle was definitely in a position to have observed and assessed. He is aware that elephants do not sleep standing, as some used to say, but bent its legs and settled down – only, that in consequence of its weight it cannot bend its legs on both sides simultaneously but falls into a recumbent position on one side or the other and in this position goes to sleep. He also knew of their being easily tamed and of their use by Indians for war, and the manner in which they were captured by employing tame ones.

And now to the trunk itself. Of it Aristotle says, “In no animal is this part (the organ of smell) so peculiar as in the elephant, where it grows to an extraordinary size and strength” (*Part. ii.16:658b30*), and again, “The nose of the

elephant is long and strong, and the animal uses it as a hand” (*Hist.ii.1:479b23*).

Thus Aristotle observes the fact that the trunk is an elongated nose, and at the same time, by appreciating “the causes operative in living nature and how they relate to each other,” sees the phenomenon as related to the inadequacy of the forefeet to serve as hands. “In the polydactylous quadrupeds, the forefeet are intended not merely to support the weight of the body, but to serve as hands” (*Part. ii.16:658b30 f.*). “In elephants, however, though they must be reckoned polydactylous, as their foot has neither cloven nor solid hoof, the forefeet, owing to the great size and weight of the body, are reduced to the condition of mere supports; and indeed their slow motion and unfitness for bending, makes them useless for any other purpose” (*Part. ii.16:658b30 f.*). Consequently the elephant’s toes are undivided and only slightly articulated, negating their use as effective hands. And this disadvantage it is that the trunk makes good, though it retains at the same time its own specific function as a breathing organ.

“The elephant uses its nose as a hand, this being the instrument with which it conveys food, fluid and solid alike, to its mouth. With it too it tears up trees, coiling it around their stems. In fact it applies it generally to the purposes of a hand (*Part ii. 16: 658b30 f.*). Elsewhere he says: “The nose of the elephant is long and strong, and the animal uses it like a hand; for by means of this organ it draws objects towards it, and takes hold of them, and introduces its food into its mouth, whether liquid or dry food, and it is the only living creature that does so (*Hist. Ii.1:492b17 f.*). Afterwards he writes: “It has a nose such in properties and such in size as to allow its using the same as a hand. For it eats and drinks by lifting up its food with the aid of this organ into its mouth, and with the same organ it lifts up articles to the driver on its back; with this organ it can pluck up trees by the roots, and when walking through the water it spouts the water up by means of it; and this organ is capable of being crooked or coiled at the tip but not of flexing like a joint, for it is composed of gristle” (*Hist. ii.1:497b23*).

Besides its extreme pliancy, Aristotle is aware that the trunk is boneless, for he says that, had it been hard and incapable of bending, it could not have been a proboscis; “for its very length would have prevented the animal from supplying itself food, being as great an impediment as the horns of certain oxen that are said to be obliged to walk backwards while they are grazing” (*Part. ii.16:658b30 f.*).

As is well known among elephantologists, George Cuvier and his colleagues had estimated that an elephant’s trunk was made up of as much as 40,000 muscles – while others found the effort of counting absolutely futile. These muscles themselves are constituted of units, or muscle fascicles, which, if so counted, would exceed 150,000, or near four times Cuvier’s estimate! Notwithstanding the pliancy of the trunk, the fully developed tusks of an adult elephant could prove somewhat the kind of impediment Aristotle visualized had the trunk been rigid – as is evident in an African elephant of the stature of the famous Ahmed of Kenya⁽⁷⁾. What is

however more surprising is Aristotle's failure to take into consideration the absence of much neck in the elephant (perhaps due to having to carry the tusks) and again the height it had attained. For even without differentiated toes and pliant forefeet, the animal could have fed without a proboscis like the rhinoceros and hippopotamus, if it had shorter legs and a longer head and neck to help it to reach the ground. On the other hand, granting the height, an elongation of the neck, as with giraffe, camel and other long-necked animal was a possibility. (It is interesting that *Moeritherium*, the oldest ancestor of the Proboscideans, was a short, pig-like creature which was able to scrape the vegetation off the floors of marshes directly with its lower jaw). Nor must it be thought that the trunk merely off-set a feeding problem caused by the height developed by the elephant in its evolution, for now it was able to feed, like the long-necked, not only upon pasture and underbrush but reach up to the fodder provided by the branches of trees above it.

The elephant, says Aristotle, has the double character, both of a land animal and one that lives in swamps, and besides this, that it got its food from the water (*Part. ii.16:658b30*). "Seeing that it got its food from water⁽⁸⁾, yet must necessarily breathe, in as much as it is a land animal and has blood: seeing also that its excessive weight prevents it from passing rapidly from water to land, as some sanguineous viviparia that breathe can do, it becomes necessary that it shall be suited alike for life in the water and for life on dry land. Just then as divers are sometimes provided with instruments for respiration, through which they can draw air from above the water, and thus may remain for a long time under the sea⁽⁹⁾, so also elephants have been furnished with their lengthened nose; and wherever they have to traverse the water, they lift its tip up above the surface and breathes through it. For the elephant's proboscis, as already said, is a nose."⁽¹⁰⁾ (*Part ii.16:658b30 f.*). And soon afterwards, he adds, "The nostril, then, is given to the elephant for respiration, as to every other animal that has a lung, and is lengthened out and endowed with its power of coiling because the animal has to remain for considerable periods of time in the water, and is unable to pass thence to dry ground with any rapidity." (*Part.ii.16:659b30 f.*).

The mistaken notion that elephants (surely in their wild state in the lands that bred them) got their food from) the water (however true it may have been of the *Moeritherium* and its close successors in evolution) must have been held by Aristotle from hearsay, not having seen them in their life before captivity. It is true, as he says, that the elephant is often found by the banks of rivers but he is not a river animal; it is also true that he can make his way through water, but he is wrong when he says it can do so only as long as the tip of his trunk can be above the surface (for he blows with his trunk and breathes through it), if by this he implies that elephants habitually submerge themselves for long period of time in their quest for food like the hippopotamus or in crossing water. This mistaken notion that the trunk by nature (not by accident) was meant to serve as a kind of snorkel and that the elephant can only remain beneath the water in depths which allowed the tip of its trunk to be raised above the surface, have both arisen from Aristotle's mistaken notion

that "the animal is a poor swimmer owing to the heavy weight of his body" (*Hist. ix.46:630b25*).

The truth is quite the contrary, and with it discredits his notion that the trunk was designed by nature for this purpose as well. For the elephant, with his pneumatized bones, is an excellent swimmer and does not hesitate to enter water well out of its depth. Various people have reported elephants swimming across rivers, lakes, oceans and to and from the islands of Kenya, among the Andaman islands, off the coast of Sri Lanka, and captive elephants off the coast of South Carolina, U.S.A – single elephants, mothers and calves, and groups (as many as 79 individuals in one report)⁽¹¹⁾. An elephant can swim six hours at a time without touching the bottom, travelling as much as 30 miles at a stretch and swimming as fast as 1.3 miles an hour, while it seems swimming came instinctively to calves.

There was no necessity for them to traverse underwater, holding the trunk up like a snorkel, as Aristotle imagined, though they might do so over brief distances in depths permitting this, as Emerson Tennant⁽¹²⁾ noted; otherwise they would lie down partially or totally immersed in water, holding their trunks up sideways for breathing. I cannot understand what the difficulty elephants had of passing rapidly from water to land, which Aristotle mentions, which also called for the use of the trunk as a breathing apparatus – for, as said, unlike the hippopotamus, it does not graze in water – and would not be capable of doing both at the same time, grazing and breathing. Or is he meaning the ability to coil the trunk?

Equally accidental must be the elephant's use of the trunk as a weapon. Aristotle writes "Excessive bulk, such as has been given in still greater measure to elephants, is sufficient in itself to protect the animal from being destroyed by others" (*Part. iii.2:663a5*). Elsewhere he says "Elephants fight fiercely with one another and stab one another with their tusks" (*Hist. ix.1:610a15*). But at the same time he sees one of the several uses of the trunk to be as a weapon "as does also the sting, when placed in connection with the tongue, as in some insects, answer more than one end" (*Part. ii. 661a25*, also *Part. ii.17:661a26*).

Included in the versatility of this organ of the elephant Aristotle notes its use in the animal's vocalizations. Writes he, "The elephant makes a vocal sound of a wind-like sort by the mouth alone, unaided by the trunk, just like the sound of a man panting or sighing; but if it employs the trunk as well, the sound produced is like that of a hoarse trumpet" (*Hist. iv.9: 536b22*).

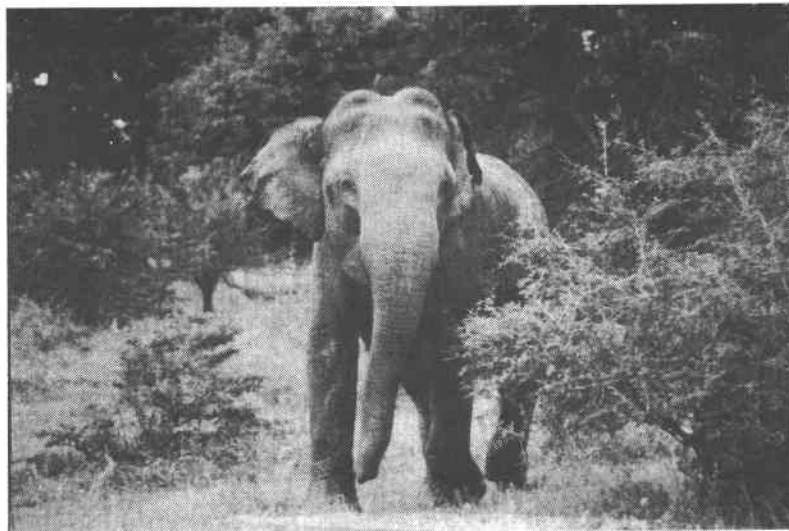
"Elephants have a large and varied repertoire of vocal behaviour, ranging from their well-known trumpets to the infrasonic calls which are too low in pitch for humans to normally hear", write Katherine B. Payne and William R. Langbauer Jr.⁽¹³⁾ but they can no more than presume that all these originate in the larynx. Others think the frightening sounds involve the trunk as well – that it is used by means of muscular movements to produce screams, squeals and

trumpetings, especially when the animal is infuriated, excited or making certain calls.

The elephant Aristotle has been dealing with in these studies is without doubt the Asian (*Elephas maximus*) trained and handled by Indian mahouts, which Pyrrhus, the king of Epirus afterwards led against Rome in 279 B.C., not the African forest elephant (*Loxodonta africana cyclotis*) which Hannibal was to lead against Rome nearly sixty years later. It is clear from a passage in the *De Caelo* (ii.14:298a) that he was aware of the existence of two species, but found no reason to differentiate them when making his observations, since he seems to have taken these to be true of both. It is doubtful whether he had himself seen an African, though there is little doubt he would have learnt, from those who had, the significant physical differences of that species from the Indian, which he seems to have known so well, indeed even dissected in his researches.

Notes

1. Peris, M. (1998) Abusing the Elephant: Pseudo-specification and Prognostication in Ancient Elephant Lore. *Gajah*, 20: 51-59.
2. Peris, M. (1992) Nila in Elephants. Physical Fact or Human Input. *Loris*, 9:199-203.
3. See the Loeb Class. Libr. Edition by A.L. Peck. With Peck's demise the work (vol. III, bks 7-10 of the *Hist. An.*) was completed in 1984 by Prof. D.M. Balme, under whom the author of this brief article was privileged to work for his Ph.D. – though by no means on elephants!
4. Farrington, B. (1965) *Aristotle: Founder of Scientific Philosophy*. London. p.48
5. "The female squats down and settles with her legs and the male mounts and covers her" (*Hist.* v.2:540a20).
6. The Indian *Gaja Sastra* gives the elephant 120 years (12 dasa of 10 years each). The life of the animal is nearer the three score and ten of man, dying through inability to digest its food when the last set of teeth in the molar succession that is a distinctive feature of elephants undergoes wear.
7. His tusks were about 3 metres in length, and the pair weighed about 300 pounds. A fibre-glass replica of the animal is mounted outside the National Museum in Nairobi.
8. William Ogle (*De Partibus Animalium* ed. J.A. Smith & W.D. Ross, Oxford (1911) n. *ad loc.*) writes "The elephant is much given to bathing; but Aristotle appears to have entertained an exaggerated idea of its aquatic habits, and to have misinterpreted its reasons for betaking itself to the water, imagining that it went there not merely to slake its thirst or for the luxury of a cool bath, but because it depended, of course in its wild state, on water-plants for its sustenance".
9. "From this curious passage", writes Ogle (n. *ad loc.*) "it would appear that the ancients were already acquainted with some form of diving apparatus corresponding to the submarine helmet and tubes in use at the present time".
10. From the Greek *pro:* in front, and *boskein:* to feed. Jeheskel Shoshani's translation "before the mouth" (*Elephants: Majestic Creatures of the Wild*. R.D. Press, NSW. Australia (1992). p. 74) is not quite right.
11. L. Calor & Maria Polombo in *Elephants: Majestic Creatures of the Wild*. p. 60.
12. *Ceylon* II. London (1860) p. 310 "In crossing deep rivers, although his rotundity and buoyancy enable him to swim with less immersion than other quadrupeds, he generally prefers to sink till no part of his huge body is visible except the tip of his trunk, through which he breathes, moving beneath the surface, and only now and then raising his head to look that he is keeping the proper direction". In the accompanying footnote 3 Tennant adds, "A tame elephant, when taken by his keeper to be bathed, and to have his skin washed and rubbed, lies down as his side, pressing his head to the bottom under water, with only the tip of his trunk protruded, to breathe".
13. *Elephants: Majestic Creatures of the Wild*. p. 120.



V. Krishnamurthy (1929-2002)

With the death of Dr V. Krishnamurthy on 9 December 2002, India lost one of its most prominent and experienced elephant veterinarians. His death at the age of 73, leaves a deep void in the Asian Elephant Specialist Group (AsESG) where his lively nature, sense of humour, boundless energy and a rich stream of ideas never failed to influence the people around him. He was arguably the most famous of all elephant veterinarians in India, and among the most influential. Those who came to know him referred to him affectionately as "Doc".

I have vivid recollections of my first meeting with Doc in 1987 at the Theppakadu Elephant Camp in the Mudumalai Wildlife Sanctuary (Tamil Nadu, India). By then Doc was already a legend, having worked for over three decades as a forest veterinary officer looking after the health and welfare of the elephants in Tamil Nadu. What struck me most was his humility despite his fame. He had a strong aversion for any form of outward show. I was fascinated by the ease with which he worked among elephants and his cautious but confident approach in dealing with bulls in musth. I had a foretaste then of what has remained with me as an abiding memory of Doc: his immense vitality, charm and boundless energy. To work with him was indeed a privilege. I have been extremely fortunate in my friends; among them, one of the most important and influential was Doc.

Doc started his long career in 1952, following his graduation from the Madras Veterinary College, when he joined the Madras Animal Husbandry Service as Veterinary Assistant Surgeon. He retired as Joint Director of Animal Husbandry in 1987. At his first post as a Veterinary Assistant Surgeon at Kambam, a small town in Tamil Nadu close to the Kerala border, Doc had ample opportunities to perform postmortems on the numerous elephants killed by poachers for ivory in the nearby Periyar Wildlife Sanctuary. He built his career on his own merits and strengths and was richly rewarded by the recognition he received both within India and abroad. But he never craved for power or glory despite his remarkable expertise and international standing. During his long stint as the Forest Veterinary Officer, Doc treated over 300 elephants and delivered more than 70 calves. The Elephant Camp at Theppakadu was particularly successful at breeding elephants in captivity during his time. Between 1950 and 1983 about 74 calves were born to 37 captive female elephants in Tamil Nadu. Such recruitment was possible given that elephants were maintained by the Forest Department in groups and let out to feed at night inside the reserves where the estrous females could be mated by wild bulls. In this way, wild genes were introduced into the captive population.

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After his retirement, Doc worked as Project Officer in the Bombay Natural History Society's Elephant Research Project from 1988 to 1991, and subsequently at the Salim Ali Centre for Ornithology and Natural History, at Coimbatore until 1993. He was involved with the study of elephants in captivity with the scientists from the Smithsonian Institution – a very productive time for him in working with some of the best in the west. His collaboration with (Betts) Rasmussen (from the Department of Biochemistry and Molecular Biology at Oregon Health and Science University, USA) and Heidi Riddle (of the Riddle's Elephant and Wildlife Sanctuary, Arkansas, USA) led to the discovery of the use of mood-altering secretions by excited bull elephants to smooth out social interactions. Their findings, which were published in the prestigious scientific journal *Nature*, London (415:975-976, 2002) may help formulate a deterrence programme against crop-raiding wild elephants, most of which are male and are often in musth. Doc held a position in the Asian Elephant Research and Conservation Centre in Bangalore where he spent his twilight years, during which he wrote several chapters for a manual on the care and management of elephants in captivity. Unfortunately, like the two greatest teachers in the European tradition, Socrates and Jesus, Doc never wrote a book. Nevertheless, he influenced many.

Doc was a man endowed with great enthusiasm and blessed with an inquiring mind. By chance, he moved away from treating pussy cats, poodles and ponies to caring for pachyderms, which he loved so much. Working with elephants demands patience and Doc had ample measure of it and the right temperament as well. He shared his knowledge willingly with anyone who worked with him. Doc possessed the virtues of a true Tamilian: cheerfulness and good humour. To us Tamils, cheerfulness costs nothing while humour is a gift. Doc was also very fond of Indian classical music, and enjoyed the spectacle of the Indian classical dance or Bharata Natyam. He was among the most courteous and considerate of men; he evoked great admiration, affection and loyalty in friends and colleagues. Doc was the most ebullient, experienced, energetic and endearing personality in the AsESG. He was also one of the "founding fathers" of the AsESG and his presence always had a sobering effect on the conduct of some of the more contentious and cantankerous members of the Group during meetings, symposia and conferences. There is always a sense of drama and theatre about the AsESG meetings where personalities clashed and egos crashed, but Doc never failed to defuse the tension through his ready sense of humour, which earned him many an admirer even among those who disagreed with him.

But success and respect were no match against the wiles of some scurrilous animal rights activists who pilloried Doc rather unfairly in the press over the famous Moorthy Elephant case in Mudumalai. Doc was very hurt and badly shaken at the perfidy of these animal lovers, who usually exploit the emotions of the public to attract international funding for their dubious projects by playing on people's sensitivity against cruelty to animals. Like dentists, they too thrive in decay. But in the end, Doc was greatly elated when Prof. Raman Sukumar, the Chairman of the AsESG came to his defence, and the

Tamil Nadu Forest Department stood by him, while Sally Walker provided wide coverage in **ZOOS' PRINT** on his behalf. That year, Doc was awarded the Venu Menon Animal Welfare Award by the then President of India!

Doc came to Indonesia to help manage the elephants in captivity at the Elephant Training Centre at the Way Kambas National Park in Sumatra. It was here that I was able to spend more time with him as I was based in Sumatra at that time. He made a number of recommendations for improving the management of captive elephants and introduced much gentler methods of training elephants than those adopted by mahouts brought from Thailand. He never liked the use of hooks by mahouts. He recommended that the mahouts should gradually be weaned from the practice of using hooks and learn to control their charges with sticks only. He introduced the provision of a balanced diet to the elephants in captivity, but being a strict vegetarian found it almost impossible to get a balanced diet for himself from the Indonesian kitchen. So he began to cook for himself and in the process converted a few die-hard carnivores to adopt a strict vegetarian diet, by making

his curries spicy and hot. One or two Indonesian mahouts got stoned on his curries.

Doc is one of those rare human beings who really have to be experienced to be appreciated fully. He was, above all, a wonderful human being, who asked for nothing but gave everything he had. He had a reputation for generosity. Anyone who admired something of his, was quite likely to be given it. This was how I acquired a copy of G.P. Sanderson's "*Thirteen Years Among the Wild Beasts of India*"! He was a deeply religious man who put his beliefs into practice in all what he did. He was loved and held in deep affection by all. He will be sadly missed by those who had the good fortune to have known him. But his work will endure. He has bequeathed to us warm memories of a man modest to a fault, a man of the highest personal integrity, and one whose friendship brightened our lives. He was the most unselfish of men I ever met. He had that rare gift for communicating with anyone his unbounded enthusiasm and he bestowed innumerable kindnesses even on strangers. He is survived by his wife Saraswathi and four daughters and a son.



Dr. Krishnamurthy in the field (photo: courtesy Prof. Raman Sukumar)

John F. Eisenberg (1935-2003)

With the death on 6 July 2003 of Dr John F. Eisenberg, the scientific world lost a great mammalogist and wildlife biologist, but those of us who knew him personally and have had the privilege of working with him in the field, are deprived of a remarkable human being who bestowed innumerable kindnesses on students, friends and colleagues. John died at his home in Bellingham, Washington State. His untimely death at the age of 68 leaves a gap that would be difficult to fill. In his passing, we have lost one of the intellectual giants who contributed so brilliantly to the advancement of mammalogy. He was a remarkable man and mentor.

John Frederick Eisenberg was born in Everett, Wash. but his family traces its origins from Germany. Having graduated from Washington State University he then went on to read for his Master's and PhD degrees in Zoology at the University of Berkeley, California. In 1965 he moved to Washington D.C where he was an assistant director for Animal Programs at the Smithsonian Institution's National Zoological Park, and an Adjunct Professor of Zoology at the University of Maryland. He left Washington to teach at the University of Florida, where he held the title of Eminent Scholar and was the Katherine Ordway Professor of Ecosystem Conservation for nearly 20 years. He retired in 2000 and moved back to Washington State. Prior to 1982 Dr. Eisenberg was the recipient of the 1981 C. Hart Merriam Award – the highest honour bestowed by the American Society of Mammalogists. In addition, he received the Archie F. Carr Medal in recognition of his outstanding contributions to the knowledge and understanding of man's natural heritage. Dr. Eisenberg was also a fellow of the Animal Behavior Society and the New York Zoological Society.

Despite the distinctions he achieved in several different spheres, John remained a very modest man. As well as being a renowned researcher, he was also a prolific writer. A measure of John's contributions can be seen in the vast number of scientific publications he produced, including **"The Mammalian Radiations: An Analysis of Trends in Evolution, Adaptation, and Behavior"** published in 1981 by The University of Chicago Press. The three volumes on **Mammals of the Neotropics** (two of which were co-authored with Kent. H. Redford) represent major contributions to our understanding of the mammalian fauna of the region. Neotropics refers to the geographic region of subtropical Mexico, Central America, the Caribbean Islands, and the continent of South America. John began his fieldwork in the tropics of the western hemisphere in June 1960 when he and his brother Thomas crossed the Tropic of Cancer to trap small mammals in Mexico. He made several visits to the region to study the mammalian fauna. Of the 449 species of mammals known from the northern neotropics, John had first hand experience with 116 species.

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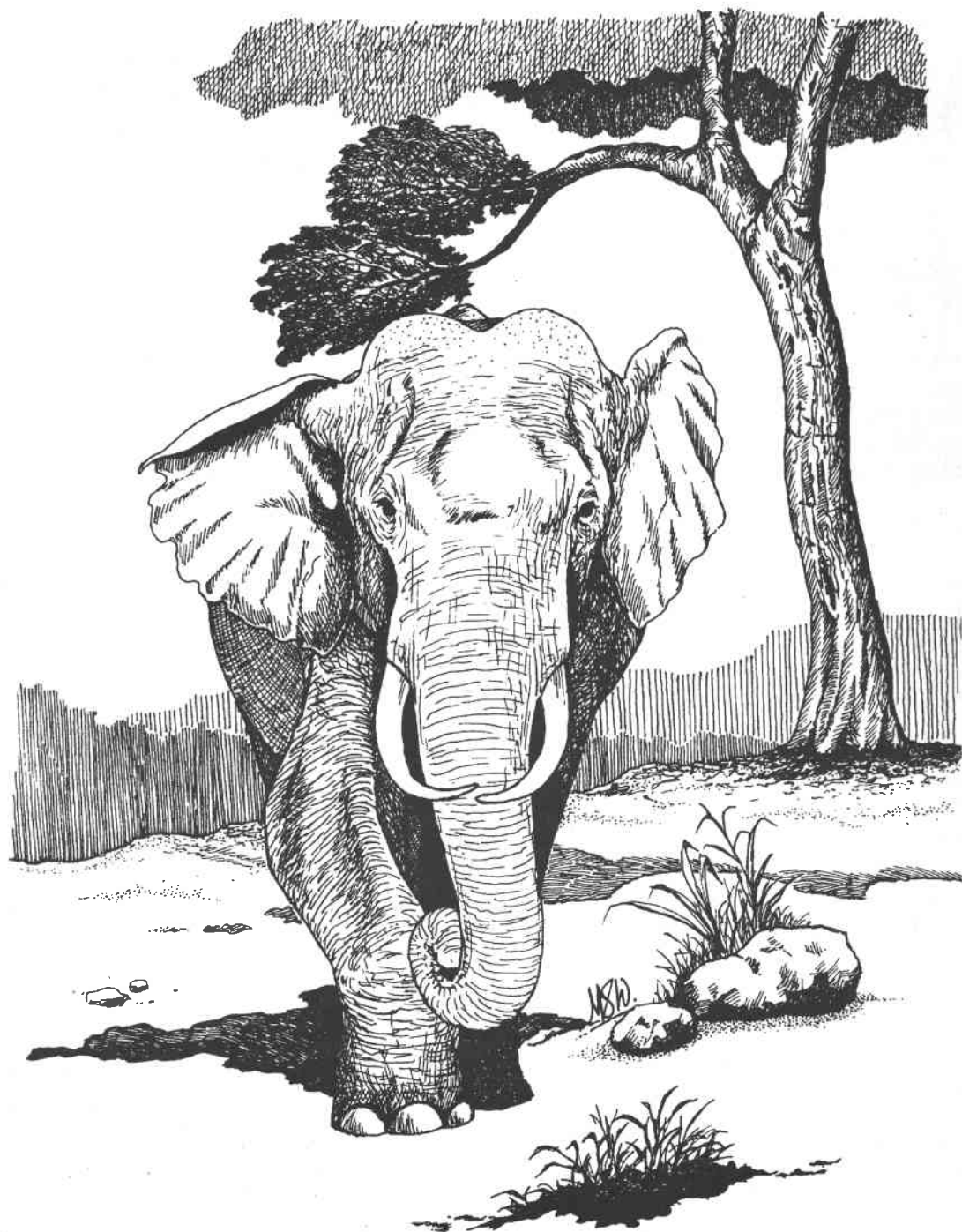
In 1966-69, his research efforts were diverted to Madagascar and Sri Lanka. The Smithsonian Institution, chartered for the "increase and diffusion of knowledge among men", has traditionally been deeply involved in the study of mammals. When a request was made jointly by The Wild Life Protection Society of Ceylon and the Department of Wildlife in 1966 to initiate a detailed study of the elephant in the island, the Smithsonian Institution sent Dr. Eisenberg as the Team Leader. The study that lasted from 1967 to 1969, concentrated on three dry zone national parks: Wilpattu, Gal Oya and Ruhuna. John, with the able assistance of Melvyn Lockhart, began an ecological study of the elephant and other large mammals in Wilpattu National Park. It was the late Professor Hilary Cruz who gave me the opportunity to work with Dr. Eisenberg in Wilpattu. I have very vivid recollections of my first meeting with John at a makeshift camp by the side of the Moderagam aru (river) in the northwestern corner of the park, and I had a foretaste then of what has remained with me as an abiding memory of John – his warm friendship, rambunctious personality, cheerfulness and his passionate hatred of hypocrisy and pretension.

Ecological research then was basic but tremendously exciting. I found working with John and Melvyn in Wilpattu a wonderfully rewarding experience. Using only a pair of binoculars and a notebook, Eisenberg and Lockhart carried out a detailed study of the large mammals in Wilpattu, with particular reference to the elephant, which was subsequently published by the Smithsonian Institution Press in 1972 entitled, **"An Ecological Reconnaissance of Wilpattu National Park, Ceylon"**. It was a remarkable contribution to the understanding of the ecology of Wilpattu's large mammals, for until then wildlife management was merely an art of the possible. Their study led to the acceptance of the need for systematic research as a basis for improved management of wildlife in Sri Lanka. Eisenberg and Lockhart's survey of Wilpattu National Park provides ecological and behavioural data on over a dozen mammal species, and it underlines the fact that large mammals not only merit protection for their own sake, but their presence may be necessary for the proper functioning of the ecosystem, and for the survival of at least some of its plant components.

John Eisenberg influenced all who worked with him because he combined the strengths of a brilliant field biologist with those of a meticulous teacher. It was he who in 1968 introduced the study of mammalian biology and wildlife ecology at the Department of Zoology, University of Peradeniya. We would remain spellbound when he delivered his lectures, for he knew the art of oral scientific presentation. He introduced us to the works of George Schaller, Raymond Dasmann, Paul Leyhausen, Paul Errington, Frank Pitelka and J.B. Calhoun. He was a delightful and inspiring teacher, and we are in his debt as a wise and witty exponent of mammalian ecology. John had the gift of being able to paint the broader picture of mammalian evolution and radiation. His conscientiousness and meticulous attention to detail contributed in no small measure to his incredible achievement in the field of mammalogy.

Man passes but deeds endure: John Eisenberg will be sadly missed but his work will endure. What John gave us perhaps were the most valuable gifts anyone can offer his fellow human beings: his time and inspiration. To the future generations,

John has left his scientific legacy, but to those of my generation who knew him and interacted with him, he has bequeathed a pleasant memory of a man whose friendship brightened our lives.



Tusker by Manjula Wijesundara

Raman Sukumar – Winner of the Whitley Gold Award 2003 and the Friends Award (March 14, 2003)

The endangered Asian elephant took a step near survival on the night of 14 March 2003, when ecologist Prof. Raman Sukumar from the Centre for Ecological Sciences of the Indian Institute of Science, Bangalore (India) was awarded 50,000 pounds sterling at the annual Whitley Awards ceremony held at the Royal Geographic Society, in London.

Presenting Prof. Sukumar with both the Whitley Gold Award and the Whitley Laing Foundation's Friends Award, HRH The Princess Royal – patron of the Whitley Laing Foundation – said the most important challenge facing conservationists was the need to strike a balance between the world's wild and human populations. Princess Anne said, "We share this planet, and we need to share the environment we live in. This is not a single issue, it's a co-operative issue between different species. We need to understand what enables each of us to survive, within that context."

Prof. Sukumar from Southern India has dedicated much of his life to saving the Asian elephant. His award will help provide support to local farmers to mitigate the impacts of elephants on their lands as well as supporting his field research team who act as a "watchdog" – identifying threats such as poaching for ivory and monitoring the health of the elephant population.

"Each year the judges face really tough decisions as all of the Finalists are of extremely high calibre and completely committed to the conservation work they are undertaking" said Edward Whitley, founder of the Whitley Awards. "Raman Sukumar is a truly exceptional person – who most probably knows more about elephants than anyone else in the world and has devoted his professional life to their survival. We are honoured to be able to support his work by presenting him with the Whitley Gold Award."

The Nilgiri landscape covers some 14,000 km² in Southern India. This vast area, varied in climate and vegetation, is rich in biodiversity and has the largest single population of the endangered Asian elephant anywhere in the world. The Asian elephant is an integral part of the continent's natural environment as well as the culture of her people. First tamed over 4,000 years ago, it has played a pivotal role in the political, economic, social and religious life of Asian people.

Prof. Raman Sukumar is the Director of the Asian Elephant Research and Conservation Centre (AsERCC) and Chairman of the IUCN/SSC Asian Elephant Specialist Group

(AsESG). The AsERCC – an independent organization – works closely with the Indian Government's Project Elephant, providing technical support and advice to the government on elephant conservation matters. Sukumar's work provided the first comprehensive overview of the interaction between a large mammal and humans. He is now concentrating on the conservation of Asian elephants in the Nilgiri region, working at all levels – from complex science to trying to find simple and practical ways to ease the at times troublesome relationship between elephants and villagers.

There are currently three major threats to the integrity of the Nilgiri landscape, the elephant population, and the interests of the local people. Destruction of habitat and as a result fragmentation of remaining areas is rife: development projects such as hydroelectric dams and railway projects combine with growing agricultural pressure. Conflict between elephants and humans is widespread. Elephants raid crops and have been known to kill humans in the process – and farmers reciprocate. Thirdly, widespread poaching occurs. The vast majority of male elephants in this area are tusked and therefore valuable targets. The killing of mainly male animals is rapidly changing the sex ratio of wild herds. Sukumar's work seeks to save the varied habitats and wildlife of Nilgiri by using the Asian elephant as "the ultimate flagship species". He combines scientific research firmly rooted in good theory with pragmatic conservation solutions involving local communities, and is determined to succeed. If we can protect elephants in heavily human dominated landscapes, surely humans can save smaller creatures in less crowded habitats.



The Whitley Foundation

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U.S. - Asian Elephant Conservation Act Summary Report Available

The Asian Elephant Conservation Act of 1997 (AsECA) was enacted to "Assist in the conservation of Asian elephants by supporting and providing financial resources for the conservation programs of nations within the range of Asian elephants..." Originally authorized for 5 years between 1997-2002; the AsECA has been re-authorized for an additional five years beginning in 2003. The Congress of the United States appropriated \$1,944,500 to the Asian Elephant Conservation Fund (through which the Act is implemented) during the first three years of activity (1999-2001). A 40-page summary report describing progress in implementing the Act during this period through support to 44 projects in 12 Asian elephant range states may be requested from the U.S. Fish and Wildlife Service.

Information on submitting proposals to the Asian Elephant Conservation Fund may also be requested as proposals are accepted year-round.

Please address your requests to:

Chief

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Asian Elephant Conservation Fund,
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Asian Elephant Conservation Fund Fact Sheet Update

1) During the four-year period ending in 2002, the U.S. Fish and Wildlife Service received 160 proposals and awarded 65 grants totaling \$ 3,027,050. This effort leveraged close to a 1:1 match of in-kind support and additional funds contributed by project executants and other partners.

The following paragraphs summarize significant challenges to Asian elephant conservation and provide examples of contributions made by the Fund to address these threats.

Habitat loss: This is the single greatest threat to the survival of substantial numbers of wild Asian elephants in the long term. A recent report suggests that overall, the geographic

range of the Asian elephant has declined by some 70% since the 1960's. In Sumatra, Indonesia (thought to be home to some 3,000 Asian elephants) and the State of Assam, India (thought to be home to some 5,000 Asian elephants), unsustainable logging, an expanding agricultural frontier, recession, civil unrest, and (human) immigration have worked together to fuel rampant habitat loss. Symptoms of this habitat loss are greater elephant-human conflict, characterized by increased elephant deaths by poisoning, shooting, and electrocution, and (in Sumatra) capture and domestication of problem elephants.

To combat habitat loss and maintain viable elephant populations in the wild, the Fund has supported habitat protection and habitat management work in 10 Asian elephant range states. In Assam, the fund has supported the construction of anti-poaching camps in wildlife sanctuaries and reserve forests to halt illegal encroachment while in Sumatra, Sabah (Malaysia) and in southwestern Cambodia, the Fund has supported the development and implementation of land use planning programs to develop core protected areas surrounded by elephant friendly buffer zones. In addition, the Fund has supported the establishment of elephant corridors at key sites in Thailand, India, and Nepal.

Human-elephant conflict (HEC) over crops is often held as the chief proximate cause of human-induced elephant deaths. For example, in Assam (in North-eastern India), 31 elephants were recently poisoned to death within a 70-day period as retribution for crop raiding. In Sri Lanka, a country with some 3,000 elephants, some 110 -120 elephants are killed each year, most of them while raiding crops. The Fund is supporting 14 projects (of which 3 are in Sri Lanka) that directly address HEC. The first project seeks to fence villagers and their crops in and fence the greater (elephant range) out. Under this model, circular solar-powered fences of 8-10 kilometers in length are built around village cropfields, but only after agreements have been reached with local communities to insure routine maintenance. In a companion project, a group of engineers are working to apply their technical skills towards the development of new techniques to detect elephant movements towards cropfields and then to deter elephants away prior to crop damage. Yet a third strategy aimed at enhancing human tolerance for elephants is being undertaken outside of Sri Lanka's Ruhuna (=Yala) National Park. Given that up to 70% of Sri Lanka's 3,000 Asian elephants live outside parks, it was reasoned that the development of ecotourism opportunities based on elephant viewing in Yala's buffer zone might provide an alternate source of income for farmers and thus help compensate them for crop losses.

Poaching - the destruction of Asian elephant populations by unregulated hunting - continues to be a major threat and is the primary cause for the decline of the species in some

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Gajah 22: (July 2003)

parts of its range. Cambodia, for example, has plentiful elephant range of at least 8000 square miles -however, after some 30 years of warfare and civil unrest, only some 300 elephants remain in habitat that is likely to support an order of magnitude more. In some parts of southern India, centuries of ivory poaching, which targets male elephants exclusively, has produced a skewed sex ratio of some 50 adult female elephants to every adult male. In response to such threats, the Fund has supported on-the-ground antipoaching work in 6 Asian elephant range states, including the development and implementation of a protection and monitoring program in 3 key elephant ranges in Cambodia. In Cambodia's Cardamom Mountains, 45 full time rangers and 75 part-time community-based wildlife monitors and guides were trained to protect wildlife populations and counter illegal activities. On their very first joint patrol, these rangers broke up a band of hardened elephant and tiger poachers. In southern India the fund has supported anti-poaching training, the equipping of ranger staff, the construction of anti-poaching camps, and the provision of legal assistance to increase prison sentences for elephant poachers.

In addition to working with partners to address threats the Fund has contributed to the assessment of elephant

population size, and to applied research into the distribution, seasonal movements, and habitat use patterns of elephant populations at some 11 sites in South and Southeast Asia. For example such projects in Cambodia supported national surveys of all elephant ranges and set the stage for on-going protection and park-establishment projects. In a similar vein, applied research to improve elephant population survey techniques and to examine aspects of Asian elephant conservation genetics have helped to provide information needed by managers to prioritize on the ground conservation actions in Malaysia and Indonesia.

Almost all projects supported by the Fund have training components and many also have conservation education/outreach components. For example, a training project for the forest field staff of elephant reserves in Tamil Nadu (India), enhanced the applied technical skills of some 100 state forest rangers and Asian elephant conservation education outreach materials developed with Fund support were used as pedagogic aids by over 1600 teachers in India. In addition, the Fund has supported the World Conservation Union's development of a range-wide Asian Elephant Conservation Action Plan, as well as National Action Plans for Bangladesh and Cambodia.



Surveying elephants in Cambodia

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Instructions for Contributors

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Kahl, M.P. & Armstrong, B.D. (2000) Visual displays of wild African elephants during musth. *Mammalia*, **66**: 159-171

Hanks, J. (1981) Characterization of population condition. In *Dynamics of Large Mammal Populations* (eds. C.W.Fowler & T.D.Smith), pp. 47-73. John Wiley & Sons, New York.

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