GAJAH

Number 20

January 2001

ISSN : 1391 - 1996

JOURNAL OF THE ASIAN ELEPHANT SPECIALIST GROUP

IUCN
The World Conservation Union

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Urinary, temporal gland, and breath odors from Asian elephants of Mudumalai National Park

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ABSTRACT *Chemical investigations, based on previously substantiated behavioral interactions, have identified specific compounds or combinations of compounds in emissions from captive Asian elephants,* Elephas maximus, *that are biologically active, eliciting either previously observed behaviors or new reactions. In addition, these emissions vary with the age, sex and hormonal state of a particular elephant; conversely responses by elephants vary according to their physiological status, gender and experience. Such chemical signals aid in the functioning of elephant society. This study is an initial effort to determine the chemical similarities/dissimilarities between temporal gland, breath and urinary emissions of Asian elephants living in their native Asia and conspecifics dwelling in the northern western hemisphere. This investigation reflects cooperative efforts between mahouts, the staff of Mudumalai Wildlife Sanctuary, veterinarians, and research scientists; its goal is information that ultimately will be useful in the management of Asian elephants in their native environment.*

Keywords: Asian elephants, *Elephas maximus*, chemical signals, breath, urine, temporal gland secretions, India.

Introduction

Previous studies have demonstrated a spectrum of characteristic volatile compounds in the exhaled air and in the airspace (headspace) above various elephant excretions and secretions, including urine and temporal gland secretions (Rasmussen *et al.*, 1997a, b; Rasmussen, 1998) Especially interesting are compounds that degas from the apparently dry orifice of male Asian elephants *(Elephas maximus)* just prior to overt musth (Rasmussen & Perrin, 1999). Since all these investigations were based on samples from captive populations in the northern western hemisphere, this study represents the first analyses of elephant-released volatiles from Asian elephants dwelling in their native land. Because of the inherent honesty that chemical signals represent, we are interested in the similarities/dissimilarities of the volatile compounds between nine samples (four urine, three breath, and two temporal gland) obtained from elephants at the Mudumalai Wildlife Sanctuary in south India (~12° north latitude) and samples from captive elephants in the northern western hemisphere (latitudes 29-48°) experiencing similar physiological states.

Materials and methods.

Sample Collection

Under the direction of Dr Krishnamurthy and the auspices of the Forestry Division of Mudumalai Wildlife Sanctuary, we were able to obtain volatiles directly from the orifice of the temporal gland and from the exhaled air, and indirectly by the collection of urine and subsequent headspace procedures.

For the collection of the TGS volatiles, a specially contoured open-bottom, stainless-steel, funnel-like device with a diameter of 7cm was gently placed directly on the cheek of the two male elephants so that the temporal gland orifice was centered within this primary collection device. The device was connected via ultraclean Nupro SS-4H4 bellow-stem valves to a 0.8-L internally summa-polished, stainless-steel receiving bottle evacuated to - 30 in Hg vacuum. After several seconds, the valve of the receiving bottle was opened, and volatiles emanating from the orifice were drawn into the evacuated receiving bottle from the primary collection device. The first bull sampled, Subramanian, a 47-year-old tusker, was in a premusth state. The samples were obtained on October 31, 1998; he came into musth on November 15, 1998. While Drs Krishnamurthy and Rasmussen took the sample, the mahout, Bomman, controlled Subramanian with the assistance of Forester Babu and the watcher, Sivakumar. The second male, Anna, 38-year-old tusker, had been in musth 4 months previously; therefore he was in very late postmusth or nonmusth condition. His mahout, Kalan, controlled him while the guard, Halan, and Dr Krishnamurthy took the sample.

From these two males, Subramanian and Anna, concurrent samples of exhalant breath were obtained by Dr Krishnamurthy and the guard, Halan. To obtain the breath samples, the narrow ($1cm^2$) orifice of the valve of the evacuated receiving bottle was placed in the end of the trunk. When moist, warm exhalant air was felt, the valve was opened and closed almost immediately to prevent the inclusion of inhaled air. Between 3 and 10 breaths were required to fill the canister. Subsequent analyses for CO_2 percentage content confirmed the breaths were exhalant.

In addition to the two adult males, on November 1, 1998, Drs Krishnamuruthy and Rasmussen obtained an exhalant breath sample from a 42-year-old, very-near-term pregnant female elephant, Kamatchi, who delivered her fifth calf, a male, on November 24, 1998. The mahout restraining Kamatchi was Bomman. In addition, during the evening, the mahouts had kindly collected in a glass jar 500-mL of fresh urine from Kamatchi. This sample was subdivided into two aliquots for subsequent collection of headspace volatiles. Each aliquot was placed in a 500-ml glass sample collection apparatus with a special lid equipped with a swaglock fitting. Under field conditions, we were unable to purge the system with zero air in order to reduce the concentration of background compounds to insignificant levels; however, in practice we have found that our modified system yields almost identical results provided that the surrounding air is relatively clean. We attached an evacuated bottle to the fitting on the jar top; the system was allowed to equilibrate for 30 min. Then the glass jar containing the urine aliquot was heated to 38^0 C while the receiving canister was attached at the lid region. The jar was maintained at this constant temperature for the duration of the headspace collection. After 30 min at 38°C headspace volatiles were drawn into the stainless-steel, evacuated receiving bottle when the valve of this bottle was opened. Because the system was deliberately not sealed, surrounding air slowly replenished the air supply in the jar. Again, a 30-min interval was observed before the next headspace sample was taken. For the first aliquot, the sample was maintained at 38^0C for 3h, and six headspace collections were added to the receiving canister. For the second aliquot, the sample was maintained at 38°C for 6h, and headspace collections were added to the receiving canister starting at 2 h, for a total of eight collections.

A 35-40-year-old, recently captured (4 months previously) makhna bull elephant was intermittently dribbling urine, and we were interested in comparing his urinary volatiles with those of musth bulls that were also urine dribbling. We obtained a 500-ml sample and subdivided it into two 250-ml samples; headspace collections were conduced similar to those described above for the female sample. For the first aliquot, during a 4-h period, we collected four headspace samples into one receiving canister; for the second

aliquot, during the second half of an 8-h period, we collected three headspace samples into one receiving canister.

After transport of these now-ambient-pressure receiving bottles, the samples were pressurized with helium to 30 psig at the laboratory in Oregon to ensure long-term storage and to facilitate subsequent chromatographic analysis.

Gas Chromatography-Mass Spectrometry Analyses

All samples were analyzed for total non-methane hydrocarbons prior to analysis by gas chromatography-mass spectrometry (GC-MS), thus allowing optimal concentrations of each sample to be analyzed on the GC-MS. In addition, breath samples were analyzed for total CO_2 content to assess their validity as exhalant air samples. The sample introduction system involved loading measured mg amounts of the sample onto a tenax trap followed by desorption at temperatures reaching 50°C. Subsequently, the volatiles were cyro-trapped on a U-tube cryogenic trap (0.125 in. ODx9in.) containing 60/80 mesh glass beads. A Carle six-port valve was employed in line to achieve these maneuvers. GC-MS analysis was conducted using a Hewlett-Packhard 5890A GC and a Hewlett-Packard 5970B MS. The GC used a DB-1, 0.25 mm ID x 60 m x 1.0 µmfilm thickness, polymethyl silicone-coated capillary column (J&W Scientific, Inc.) The GC oven was temperature programmed from -60°C to 200°C at 4°C/min, with a 5-min initial hold at -60°C (Perrin et al., 1996). The mass spectrometer was programmed for a mass scan of 33-300, which allowed for identification of compounds from C3 through C14. The conditions allowed quantitation as low as 0.10 ppbv. Compounds were identified using an NBS 75 K Hewlett-Packard MS Chem Station library search and were manually rechecked with NIST/EPA/NIH Mass Spectral Data base Version 4.01.

Results

Temporal Gland Volatiles

Premusth

A striking characteristic of the volatiles of this sample taken above the dry orifice area of the temporal gland of a bull elephant who was nearing the time of his annual musth was the presence of a high concentration of 2-butanone. The corresponding aldehyde, butanal, another ketone, acetone, and isoprene (2-methyl-1,3-butadiene) were in high concentration (Table1)

Table 1 Volatiles in temporal gland emissions

Compound	*RT-min*	*PostM-TG-I*	*PreM-TG-I*	*PreM-TG-C*	*Skin-C*
acetaldehyde	18.10		x	x	
ethanol	26.20	x	x	x	x
acetone	26.75	x	x	x	x
propanal	27.60		X	X	
acetic acid	28.00	x			x
furan	29.20	x			x
isoprene	29.80		X	X	
2-methyl 2-propanal	31.20		x	x	
carbon disulfide	31.37	x			x
butanal	35.40			X	
2-butanone	35.70		X	X	
2-butanol	36.70		x	x	
tetrahydrofuran	38.10			x	
acetic acid	40.90	x	x	x	x
pentanal	41.58	x			x
hexanal	48.20	x	x	x	x
decenal	53.80	x			x
cyclohexanone	54.20				
2-butoxyethanol	54.30	x			
benzaldehyde	56.90	x	x	x	x
octanal	54.00	x			x
4-methyl phenol	63.00		x	x	
nonanal	64.10	x	x	x	x
2-nonanone	64.50				
azulene	68.70	x			

x,present; X,present in high concentration; PostM-TG-I, temporal gland emissions from male Asian elephant four months after musth at Mudumalai Wildlife Snctuary; PreM-TG-I, temporal gland emissions from male Asian elephant premusth at Mudumulai Wildlife Sanctuary; PreM-TG-C, temporal gland emissions from male Asian elephant premusth in captivity in the U.S.A.: Skin-C, temporal gland emissions from the skin of male Asian elephant.

Postmusth

In contrast, the volatiles of the dry orifice area of the 4-month postmusth bull closely resembled skin volatiles. This sample contained acetone, acetic acid and a number of aldehydes, including pentanal, hexanal, decenal, octanal, and nonanal (Table 1).

Breath Volatiles

The volatile compounds emanating from the breath of the two bulls were very similar to compounds from the breath of captive Asian male elephants in the U.S.A. who were in similar premusth and postmusth states. Aldehydes, furans and certain hydrocarbons and ketones predominated. These two samples were distinctly different from the breath of captive musth bulls. In particular, a high concentration of C-3 to C-9 ketones, which characteristically dominates musth breath, was not observed.

Premusth

The sample of premusth breath was characterized by a high 2-butanone concentration. Such high 2-butanone concentrations have been observed in numerous male Asian elephants in the U.S.A. (Rasmussen & Perrin, 1999) (Table 2)

Postmusth

Postmusth breath had a similar qualitative pattern and similar concentration ranges of hydrocarbons and aldehydes demonstrated in breath samples analyzed from Asian male elephants in nonmusth in the U.S.A. However, one unusual compound, 4-hexen-1-ol, was noted (Table 2).

Pregnant female

The breath of the pregnant female contained many hydrocarbons, aldehydes and furans. The most distinguishing components were relatively high concentrations of isoprene and 1,3 butanediol, and octylthioglycolate, a previously undetected compound (Table 2)

Table 2 Dominant volatiles in breath of Asian elephant during several physiological states

Compound	RT-min	PerM-I	PreM-C	PostM-I	PostM-C	Preg-I	Preg-C
carbonyl sulfide	9.70			x			
acetone	26.75	x	x	x	x	x	x
fural	29.20			x	x		
pentane	29.35	x	x			x	x
isoprene	29.80	X	X			X	X
1,2-pentadiene	30.88	x	x	x	x		
butanal	35.40	X	X				
2-butanone	35.70	X	X			x	x
2-butanol	36.70	x	x				
3-methyl-furan	37.10					x	x
3-buten-2-ol	37.30	X				x	
3-methyl butanal	39.40					x	
formic acid	39.40					x	
acetic acid	40.90	x	x	x	x		
pentanal	41.58			x	x		
2-ethyl furan	42.60					x	
hexanal	48.20			x	x		
2,3-butanediol						x	X
2,5-dihydrofuran	49.12			x	x	x	
benzaldehyde	56.90			x	x		X
a-pinene	56.95	x				x	
camphene	58.00	x				x	
ß-pinene	59.23					x	
octanal	59.09					x	x
3-ethylphenol	59.20						X
4-hexan-1-ol	59.20			x			
limonene	61.49					x	
nonanal	64.10				x	x	x
decanal	68.60				x	x	x
octylrhioglycolate	72.00					x	
tritetracontane	73.10						x

PreM-1, breath from male Asian elephant during premusth at Mudumalai Wildlife Sancuary; PreM-C, breath from male Asian elephant during premusth in captive facility in the U.S.A.; PostM-I, breath from male Asian elephant four months after musth at Mudumalai Wildlife Sanctuary; PostM-C, breath from male Asian elephant four months after musth in captive facility in the U.S.A.; Preg-I, breath from pregnant female Asian elephant at Mudumalai Wildlife Sanctuary; Preg-C, breath from pregnant female Asian elephant in captive facility in the U.S.A.

Urine Volatiles

Pregnant female

The urine headspace sample from the pregnant female was very distinctive. In the first aliquot, there was a strikingly high concentration of 4-heptanone. In addition, many C5 and C6 ketonic compounds, such as 1-penten-3-one, 3-penten-2-one, 2-pentanone, 3-pentanone, 2 methyl 2 cyclopenten-1-one and E-3 methyl 2-pentanone, were evident (Table 1). Ketones clearly were the dominant chemical species (whereas aldehydes dominate in follicular urine).

The sulfer compounds 3-methyl thiophene, DMDS, isothiocyanate, and 2 phenols, 3-ethylphenol and 2-ethyl 4,5 dimethylphenol were detected, but no (Z) - 7-dodecenly acetate, the estrous pheromone, was resolved. The second aliquot demonstrated a similar signal profile; the major difference was a higher percentage of acetones among the total volatiles (Table 3). Interestingly, both urine samples contained 4-hexan-1-ol, a compound that was also detected in the breath of the postmusth male elephant.

Recently captured makhna

The makhna male was recently captured from the wild and intermittently dribbled urine. The urinary headspace volatiles did not contain volatiles charateristic of musth urine. Trimethylamine, 2-nonanone, most of the spectrum of ketones, frontalin (1,5 dimethyl 6,8 dioxbicylo [3.2.1] octane) and cyclohexanone were lacking. Dimethly disulfide was in striklingly high concentration (Table 3).

Table 3 Volatiles in urine headspace

Compound	*RT-min*	*Preg-I*	*Preg-C*	*Makhna-I*
carbonyl sulfide	9.70			x
ethanol26.50				
acetone26.85	X	x	X	
carbon diulfide	31,37			X
2-butanone	34.90		x	x
3-methyl butanal	39.40	x		
formic acid	39.42	x		
acetic acid	40.90	x		
1-penten-3-one	40.87	x		
2-pentanone	41.03	x	x	
pentanal	41.58	x	x	
3-pentanone	41.69	x		
2-ethyl furan	42.60	x		
2,5-dimethyl furan	42.98	x		
2-methyl 2-cyclopenten-1-one	43.45	x		
E-3-methyl 2-pentanone	44.09	x	x	
2-methyl 1-penten-3-yne	44.40	x		
methyl isobutyl ketone	44.54	x		
dimethyl disulfide	45.00	x		X
3-methyl 2-pentanone	45.40	x		
3-hexanone	47.23	x		
3-methyl thiophene	47.40	x		
hexanal	48.20		x	
2,5- dihydro furan	49.12	x		
isopropyl isothiocyanate	49.75	x		
4-methyl 3-hexanone	50.70	x		
E-2-hexenal	50.89	X		
4-heptanone	51.70	x	x	
6-methyl 3, 5-heptadien-2-one	52.00	x		
allyl isothiocyanate	52.24			X
2,5-dihydrofuran	53.90	x		
heptanal	54.70		x	
an acetate	57.89	x		
3-octanone	58.20	x		
2-pentylfuran	59.01	x		
octanal	59.09	x	x	
4-hexen-1-o1	59.20	x		
B-pinene	59.23	X		
6-methyl bicyclopetan-2-one	59.90	x		
acetophenone	62.10	x		
nonanal	64.10	x	x	
2-ethyl 4,5-dimethyl phenol	64.90	x		
5-methyl hexanal	66.60	x		
decanal	68.60		x	

Preg U-I, volatile compounds in urine of near-term pregnant female Asian elephant at Mudumalai Wildlife Sanctuary; Preg U-C, volatile compounds in urine of near-term pregnant female Asian elephant in captive facility in the U.S.A.; MakU-I, urine from Makhna male elephant captured several months before at Mudumalai Wildlif Sanctuary.

Discussion

Chemical signals are known to be important in the lifestyle of the Asian elephant (Rasmussen, 1998). Such signals are relatively honest, being hard to disugise and often emitted involuntarily. We are especially interested in the variations of chemical signals between sexes and among elephants of differing physiological states and living in different locales and habitats, perhaps eating considerably different foods.

A striking characteristic of the volatiles of the sample taken above the dry orifice area of the temporal gland of a bull elephant who was nearing the time of his annual musth was the presence of a high concentration of the ketone, 2-butanone. Odoriferous 2-butanone is usually present among many other ketones in male TGS during musth, but during premusth has been demonstrated in a number of captive Asian male elephants to be the dominant component degasing from the apparently dry temporal orifice (Rasmussen & Perrin, 1999). In contrast, the volatiles from the postmusth temporal gland sample only contained compounds characteristic of skin volatiles. Such chemical information detected and quantified by GC-MS is presumably also readily detectable by conspecifics. In captivity in the U.S.A., we have seen females touch the apparently dry orifice of male elephants. In addition, 2-butanone is a low-molecular-weight, readily volatile, reasonably stable compound that has been demonstrated in other mammals to be readily detected by olfaction at low concentrations (Cometto-Muniz & Cain, 1995).

The sample of premusth breath was also characterized by a high 2-butanone concentration. Such high 2-butanone concentrations have been observed in numerous male Asian elephants in the U.S.A. (Rasmuseen, 1997b). Our current investigations are aimed at determining if this ketone is a functional chemosignal as a single or as part of a ketonic blend. In contrast, postmusth breath had normal ranges of hydrocarbons and aldehydes similar to numerous breath samples of nonmusth Asian male elephants previously analyzed. However, the alcohol 4-hexen-1-ol has not yet been previously identified in elephant emissions.

The predominance of aldehydes in the breath of the pregnant female was within the normal range for female elephants; such high aldehyde concentrations are especially evident during the follicular stage of the estrous cycle but may occur during the luteal phase (Rasmussen *et al.*, 1997b). The concentrations of furans were somewhat unusual. The relatively high concentration of isoprene is interesting in view of increases in isoprene levels in the blood during early musth and its release in high concentration in temporal gland secretions prior to musth (Rasmuseen & Perrin, 1999). The high concentration of isoprene was also observed in the breath of a captive female Asian elephant during her seventh month of pregnancy (Rasmuseen, unpublished). Isoprene is known to accumulate in fatty tissue (Dahl *et al*, 1987).

The most striking observation in both aliquots of the urine headspace of the pregnant female was the predominance (except for the omni-present acetone) of 4-heptanone. The synthetic and metabolic history of 4-heptanone is interesting. A considerable amount of information has been obtained from human studies: 4-heptanone is syntheized from ß-oxocarboxylic acid or from 2-ethyl-3-oxohexanoic acid via decarboxylation (Liebich, 1983). During diabetes mellitus the urinary excretion of 4-heptanone is often elevated fiv-fold (from 200-2500 micrograms/24 h to 1000 microgrms/24h) (Liebich, 1986). Especially interesting was the spectrum of C5 and C6 ketones in the urine of the pregnant female. These ketones were distinctive from the ketones characteristic of musth urine, 2-heptanone, cyclohexanone, 2-nonanone. Our limited knowledge of the metabolism of the Asian elephant makes further interpretation difficult. This suggests that further research on these aspects would be of value.

The lack of ketones in the volatiles of the urine from the recently captured adult male was surprising, considering his condition and age. With presumed changes in diet and certainly the stress of capture, metabolic perturbation would not have been unexpected. However, the extremely high dimethyl disulfide in the urine of this makhna could be metabolic or bacterial in origin.

These initial studies clearly demonstrate that we are just beginning to decipher the chemistry of elephant emissions and that we have barely begun to decipher their meanings to the elephants.

Acknowledgements

We thank the Forestry Department of the State of Tamilnadu, especially forester Babu, watcher Suvakumar, mahout Kalan, guard Halan, and mahout Bomman for their help. Without the encouragement of Dr. Raman Sukumar, this study would not have been possible. We acknowledge the support of the Oregon Zoo for their partial support for travel to India and Biospherics Research Corporation for their additional support.

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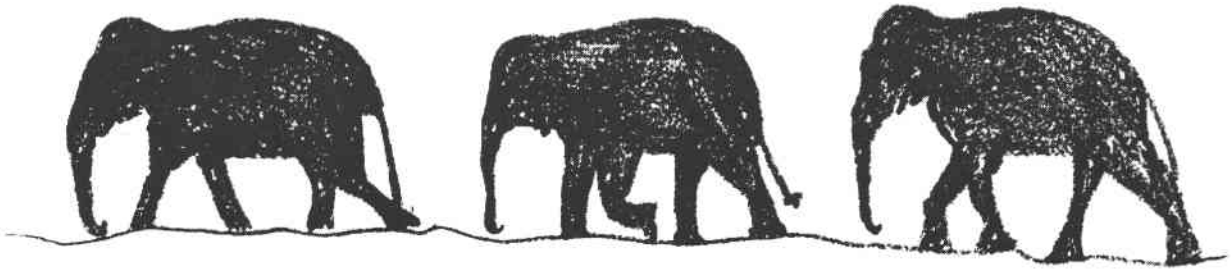

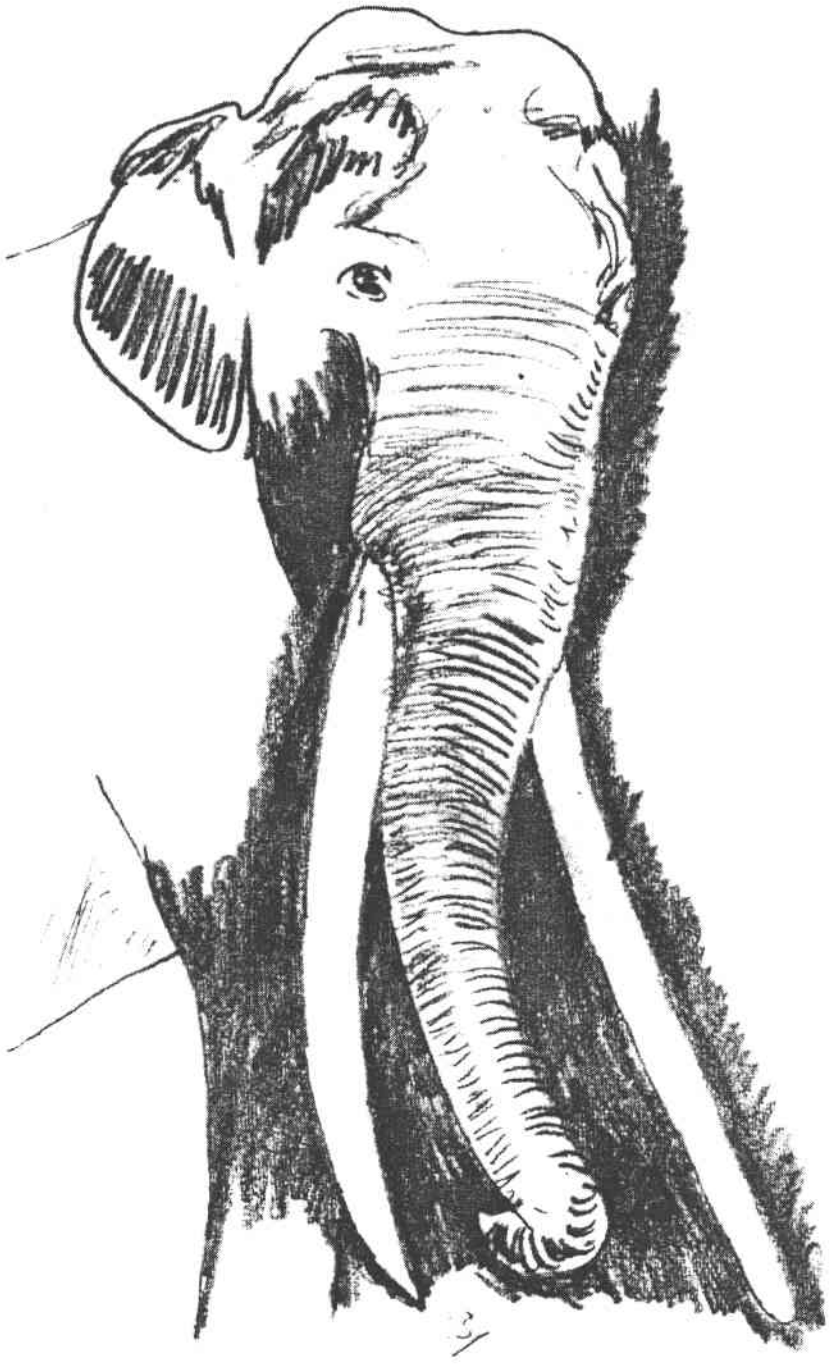

Observations on Elephants in the Maduru Oya National Park, Sri Lanka (Mammalia, Elephantidae)

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ABSTRACT *Maduru Oya National Park (58,850 ha) was established as a new conservation area in the Accelerated Mahaweli Development Programme, mainly to accommodate some of the estimated 800 elephants that were displaced by the development activities. Prior to the development, the area was inhabited by elephants belonging to the subspecies* Elephas maximus vilaliya *referred to as the Marsh elephant. A preliminary study was carried out to determine the status of the elephants in the park from June to December 1989 in which a total of 1,162 animals were recorded in 87 observations. The population was characterized by female - biased sex ratios and adult-dominated age structures. The overall average adult male:female ratio was 1:2.4, but among the herds and bond groups it was 1:6. Tuskers were few and represented just 0.5% of the total population but made up 3.2% of the adult males. The population was characterized by both large group sizes and herd sizes. The largest group size observed was 65, while the largest herd observed had 52 animals. Stressful conditions brought about by the presence of human settlements and the reduction of habitat may have led to the formation of such large groupings. Both bulls and groups showed the highest activity during the late evenings. The population appears to be breeding well. Although calves were seen regularly during the study period, yet the calving intensity was not constant. More calves were observed in the wet season than during the dry season. The limited data points to an average calving interval of 5.6 years. The poor quality of food resources available to the elephants within the park could be one of the reasons for the movement of elephants into cultivated areas which offer more energy rich food. Given this situation, containing elephants within the boundaries of the park is difficult. Although the population is not yet adversely affected by poaching (given the inherently low numbers of tuskers in the area), the mitigation of human-elephant conflict remains the key to the long-term survival of the elephants in the park.*

Introduction

The Government of Sri Lanka embarked on an ambitious hydro-electric scheme in 1970 to harness the resources of the island's longest river, the Mahaweli Ganga to provide irrigation to boost agriculture and human settlement. The scheme known as the Accelerated Mahaweli Development Programme, called for the development of some 360,000 ha of land (of which 260,000 ha represented forests that had been cleared for agriculture) and the construction of a number of storage reservoirs. The Mahaweli basin was the home of a population of the so called Marsh elephant *(Elephas maximus vilaliya)* estimated at that time to number about 800 animals (Anon, 1981; Jansen, 1986), and the planned development activities in the area were considered to pose a direct threat to these and other wildlife in the area. Therefore, in order to safeguard their long-term survival, a system of protected areas totalling some 218,000 ha was designed in and around the project sites (Fig.1). This network of protected areas included some reserves that were already in existence, and some new ones especially created to accommodate the elephants displaced from

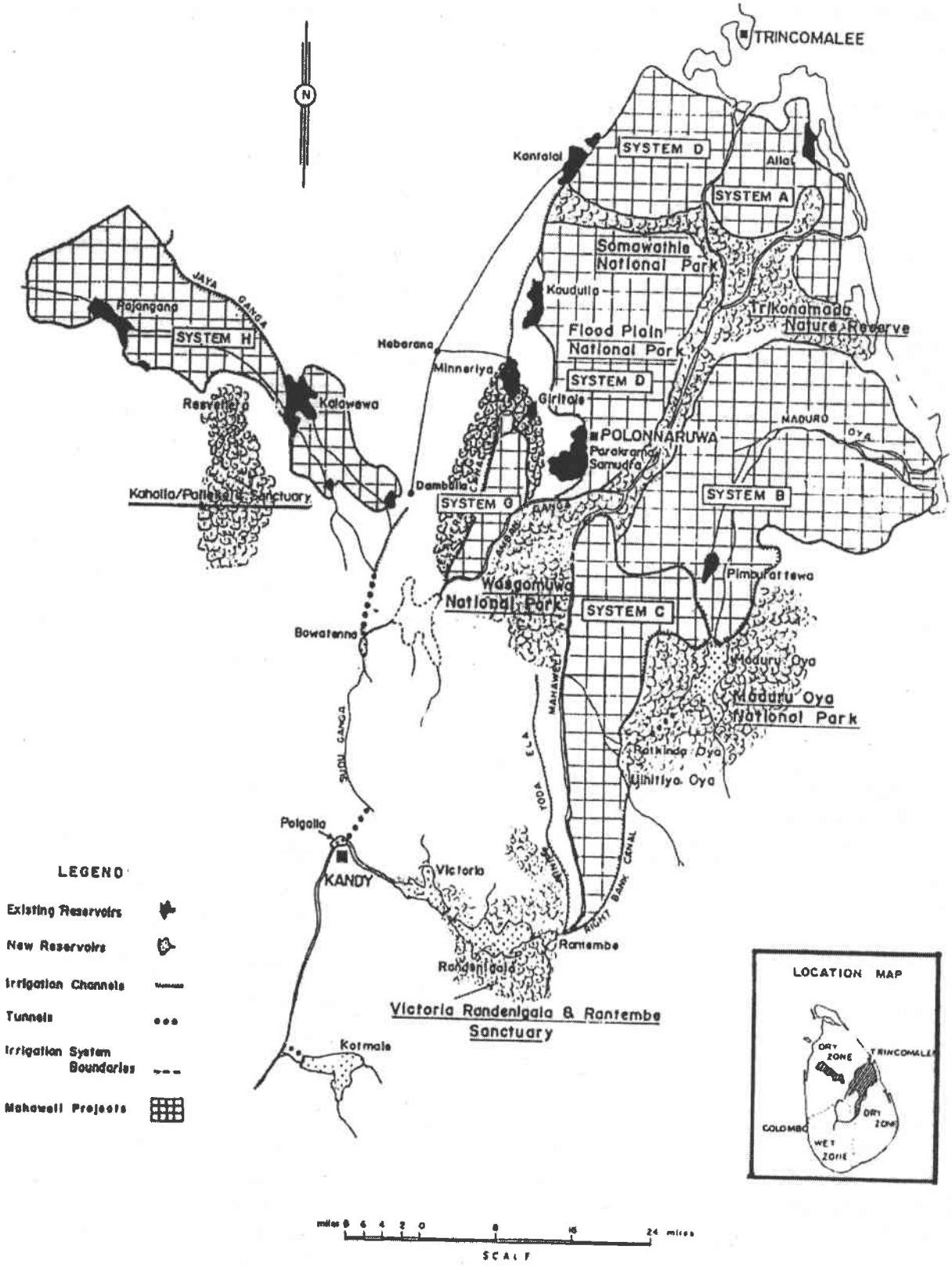

Fig. 1 Map of the Accelerated Mahaweli Development Programme Area, Sri Lanka

their original habitat. Maduru Oya National Park represents one of the new conservation areas added to the system of protected areas in Sri Lanka as a result of the Accelerated Mahaweli Development Programme. The original plan called for the linkage of Maduru Oya National Park with the Gal Oya National Park to the south through a forest corridor (Anon, 1981). By 1995, the Mahaweli Development Programme had settled a total of 20,653 families (or about 117,446 people) in System C, which adjoins the Maduru Oya National Park. This paper deals with a short study that was carried out in order to assess the status of the elephants in the Maduru Oya National Park, in the light of the changes in the demography of the area.

Study Area

Maduru Oya National Park (Fig. 2) with an area of 58,850 ha lies east of System C in the Dry Zone between the Polonnaruwa-Batticoloa road and Mahiyangana-Padiyatalawa road in the districts of Ampara, Badulla and Polonnaruwaa, spanning the border between Eastern and Uva provinces ((IUCN, 1990). It was established in 1983 under the Fauna and Flora Protection Ordinance. The most conspicuous topographic feature is the 8 km-long range of rocky mountains in the south-west of the park. Wetlands constitute about 15% of the park and they include the Maduru Oya (6,100 ha), Ulhitiya (2,300ha), Ratkinda (1,000 ha), NDK (800ha), Henanegala (700 ha) reservoirs and tributaries of the Mahaweli and Maduru Oya river systems (MEP/DWLC, 1985;1987). The vegetation is tropical dry mixed evergreen forest characterized by tree species such as *Drypetes sepiaria* (weera), *Chloroxylon sweitenia* (satin), *Manilkara hexandra* (palu), *Limonia acidissima* (wood apple), *Pterospermum canescens* (velang), and *Cassia fistula* (ehela). Much of the park is dominated by grasses suh as *Imperata cylindrica* (illuk), *Panicum maximum* (guinea grass), and *Pennisetum sp*. A rare and endemic tree *Vatica obscura*, the only species of the Dipterocarpaceae to occur in the Dry Zone, is found in some areas along the banks of the Maduru Oya and Gallodai Aru (IUCN, 1990). In addition to the population of elephants *(Elephas maximus)*, the park also supports a number of threatened or endangered species of mammals such as leopard *(Panthera pardus)*, sloth bear *(Ursus ursinus)*, and water buffalo *(Bubalus bubalis)*. Endemic species include the Ceylon jungle fowl *(Gallus lafayetti)*, Broad-billed roller *(Eurystomus orientalis)* and the Toque macaque *(Macaca sinica)*. The park's wetlands support a rich avifauna. In the past, some parts of the park were inhabited by veddhas - aboriginal people- who were traditionally hunters and gatherers. According to Uragoda (1969) the veddha families living at Dambana have retained a traditional lifestyle to some extent.

Methods

The study was undertaken as a part of the faunal survey of Maduru Oya National Park, undér the Mahaweli Environment Project. One of the basic objectives was to obtain information on the status and ecology of the elephants in the area. Elephants were observed in Maduru Oya National Park for a total of 45 days from June to December 1989, between noon and 1900 hrs. Most of the observations were made in the north-western part of the park, where elephant activity was high. Special attention was paid to the north and north-western parts of the park, since areas adjoining them were already being developed. For the purpose of classification, the following categories based on Eisenberg & Lockhart (1972) were adopted: adult male, adult female, subadult, juvenile and calf. In addition, all the tuskers encountered, were identified. Whenever possible, every time elephants were encountered; their number, composition, location, time and activity were recorded. When such classification was not possible, a total count of the number seen was recorded under the category of "unclassified". All observations were made on foot and from a Jeep using a pair of 8x40 binoculars. In this study, a group refers to three or more animals of any age or sex moving together in a coordinated manner. Therefore, it excludes solitary and paired animals. A family unit or herd consists of a matriarch (oldest female) and her offspring excluding adult males. (Adult males could

however join such herds from time to time for the purpose of breeding but they are not an integral part of them). A bond group refers to an aggregation of two or more (usually related) family units. Most of the park lies between 30 and 150 m altitude. The park receives 1,650 mm of rain annually, during the north-east monsoon which lasts from October to January. Mean annual temperature is about 27^0 C.

Results and Discussion

Population structure

A total of 1,162 elephants were recorded in 87 observations (Table1). On average, 25.8 animals were seen per day (range: 15.0-37.9). Of the 434 animals that were classified, 240 (55.3%) were adults (males and females), 84 subadults (19.4%), 80 juveniles (18.4%) and 30 calves (6.9%) (Table 2). Such adult-dominated structure is characteristic of many elephant populations in Sri Lanka (Eisenberg & Lockhart; Ishwaran, 1981; McKay, 1973; Nettasinghe, 1973; Santiapillai *et al.,* 1984), including those in the Mahaweli region (Hendavitharana *et al.,* 1994). Such an age-ratio is not unusual in a species characterized by long life - span, gestation period and calving intervals. Of the total number of groups sighted, 25 (28.7%) were of family unit or herds and 35 (40.2%) were either lone males or male groups. Males were found singly (29% of the

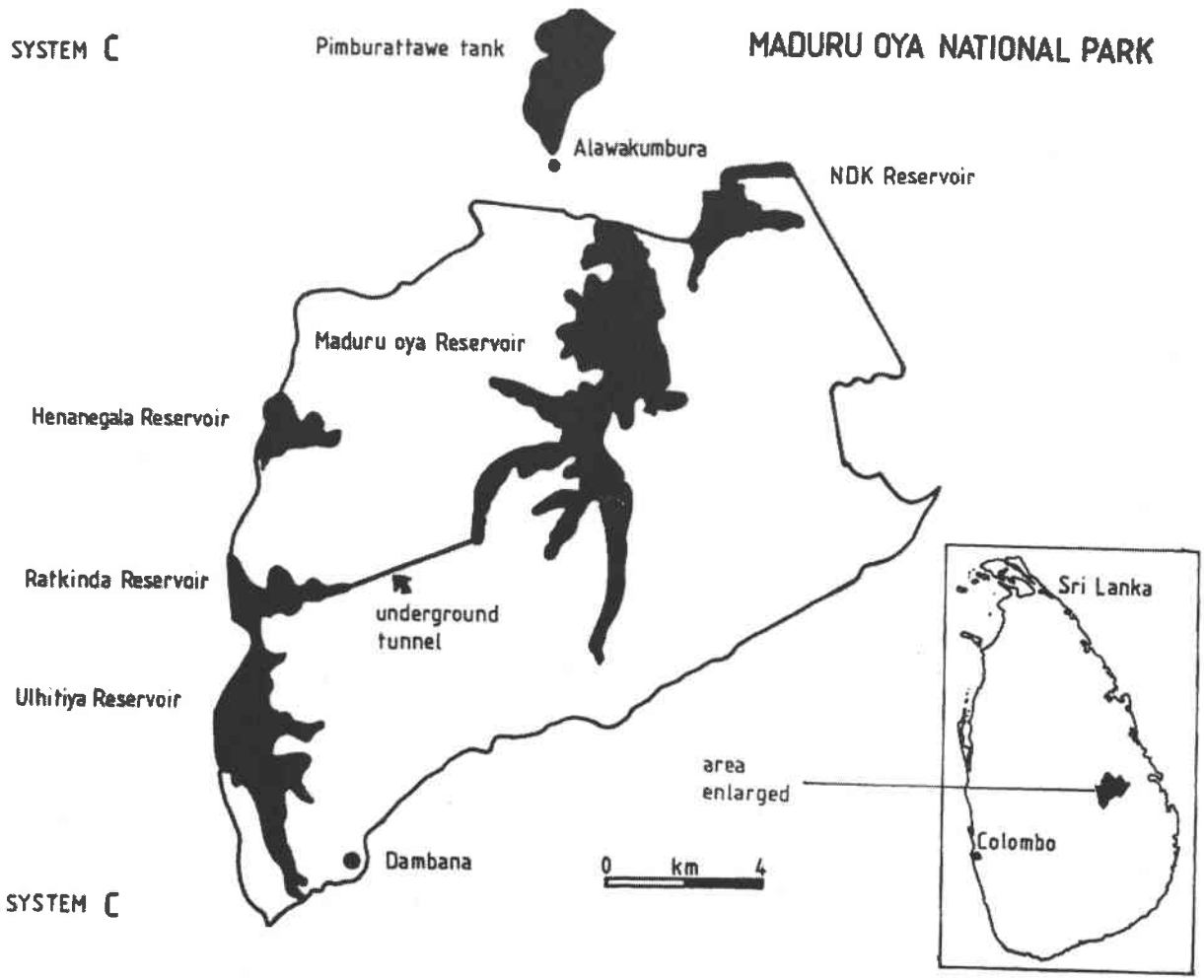

Fig. 2 Map of Maduru Oya National Park

sightings), in temporary all-male groups (range 2-3), or in association with females. There were only 6 tuskers, and they comprised just 0.55 % of the total population and 3.2% of the total number of bulls (n = about 190, obtained from 71 classified bulls and 119 estimated from the unclassified animals). By 1993, the proportion of tuskers among the bulls had declined to 2.8% in the Mahaweli area (Hendaavitharana *et al.*, 1994).

Sex-ratio

Elephant being a polygynous mammal, the 'natural' adult sex ratio is unlikely to be parity. However, there is evidence that the sex ratio in elephants does not vary from the expected ratio of 1:1 up to the subadult stage (Sukumar, 1989). In Sri Lanka, where most of the male elephants are makhnas (tuskles bulls), the ratio of male to female elephants is about 1:3 (McKay, 1973; Kurt, 1974). In Maduru Oya National Park, the observed average adult male:female ratio was 1:2.4 (Table 2), less skewed than the national average. In a subsequent survey carried out in June 1993 too, the average adult sex-ratio was found to be similar (Hendavitharana *et al.*, 1994). This may indicate a low level of poaching in the area. According to Deraniyagala (1955) the lower Mahaweli River basin is the home of the subspecies, *Elephas maximus vilaliya* or the Marsh elephant, characterized by the lack of tusks among the bulls. The observed tusker:makhna (tuskless bull) ratio was 1:30. Although this may explain the low level of poaching on the few tuskers in and around Maduru Oya National Park, even tuskless elephants (makhnas) are killed when they come into conflict with farmers. Intense poaching on elephants can distort their age structure considerably and thereby have a major impact upon elephant population dynamics (Barnes & Kapela, 1991). But poaching in Sri Lanka is nowhere as serious as in some parts of South India. Indiscriminate poaching of the tuskers in the Periyar Tiger Reserve in South India has led to a bizarre sex-ratio of 1:101 in favour of the females (Ramakrishna *et al.* 1998)

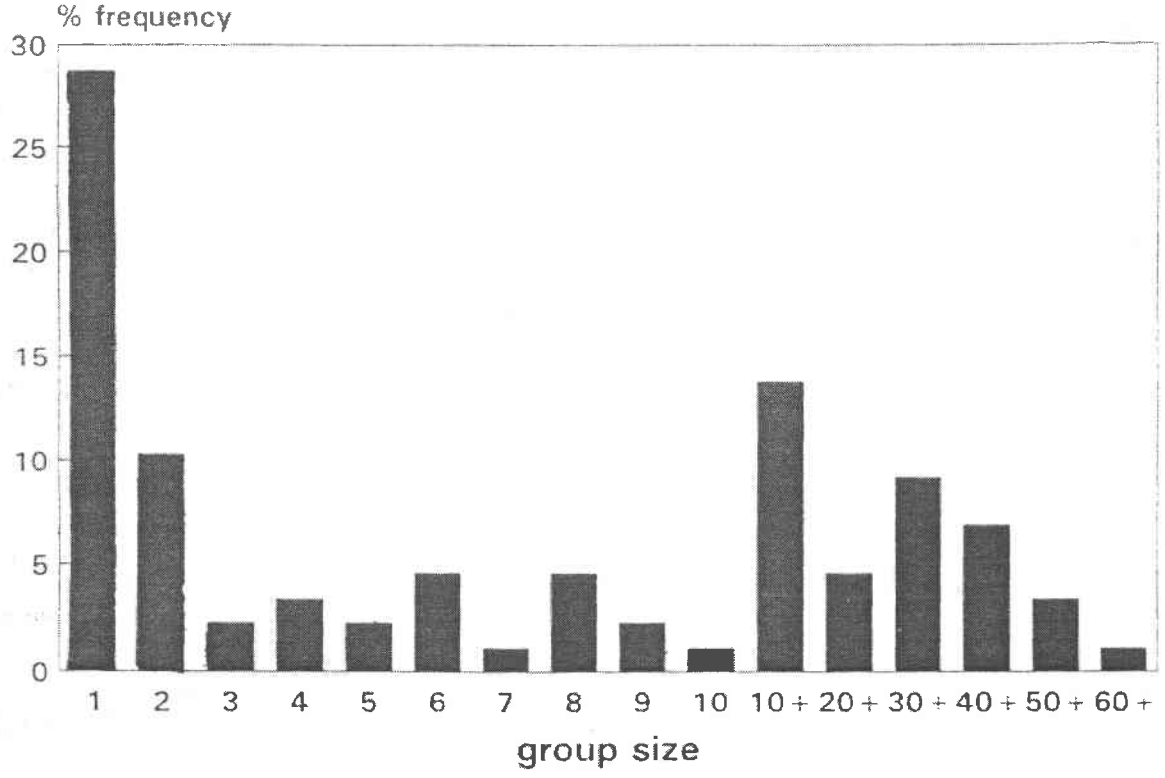

Fig. 3 Frequency of sightings for elephant groupings of various sizes

Table 1 Number and group sizes of the elephants seen in Maduru Oya National Park

time	# of days	# of sightings	# of tuskers	largest group	total	# of animals observed/day
June	5	9	3	46	95	19
July	17	44	1	65	644	37.9
August	9	12	0	44	152	16.9
September	6	10	2	38	90	15
October	6	7	0	50	116	19.3
November	1	4	0	31	31	31
December	1	4	0	12	34	34
Total (av.)	45	87	6	(409)	1162	(25.8)

Table 2 Monthly changes in the composition of elephants

	Adult male	tusker	adult female	subadult	juvenile	calf	total	not classified
June	6	3	59	9	15	3	95	
July	35	1	58	41	33	9	177	(467)
August	10	0	17	5	15	4	51	(101)
September	3	2	13	4	8	3	33	(57)
October		0	16	19	6	7	56	(60)
November	0	0	0	0	0	0	0	(31)
December	3	0	6	6	3	4	22	(12)
Total	65	6	169	84	80	30	434	(728)

	adult	subadult	juvenile	calf
	240	84	80	30
%	55.3	19.4	18.4	6.9

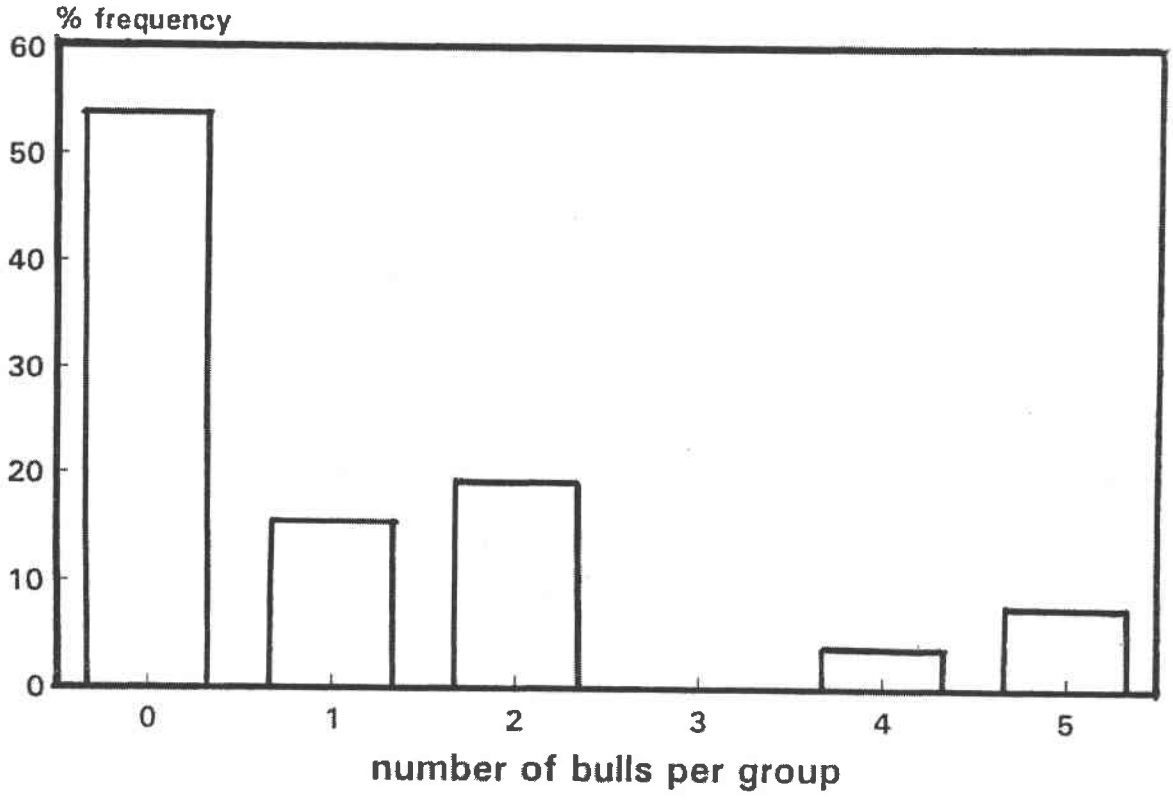

Fig. 4 The proportion of adult bulls seen in elephant groupings

Group size

Of the 87 observations made on elephants, 25 (28.7%) were of solitary animals, all of them being bulls (Fig.3). Paired animals composed of bulls, made up 10.3% of the observations. Besides the solitaries and pairs, group sizes of 11-20 animals were the most frequently observed. The largest group size observed was 65 (Table 1). It is interesting to note that of the 53 observations of elephant groupings (excluding solitaries and pairs), 34 (64.2%) were of large size having more than 10 animals, while only 19 observations (35.8%) were characterised by small size of between 3-10 animals. Thus elephants frequent Maduru Oya National Park in large groups of about 40 animals (Table 1). Furthermore, the larger groups were seen mostly during the dry season (between June and October). In general, animals living on open ground are found in large groups than those living in forests (Dasman & Taber, 1956; Peek *et al.*, 1974: Franklin *et. al.*, 1975). There could be several reasons for the formation of large groups in Maduru Oya National Park.

Table 3 Monthly changes in the proportion of calves per 100 females

	% males	100 females	% subadults	% juveniles	% calves
June	10.2	100	15.3	25.4	5.1
July	62.1	100	70.7	56.9	15.5
August	58.8	100	29.4	88.2	23.5
September	38.5	100	30.8	61.5	23.1
October	50.0	100	118.8	37.5	43.8
November	-	-	-	-	-
December	50.0	100	100.0	50.0	66.7
Total N	71	69	84	80	30
/100 cows	42.9	100	49.7	47.3	17.8

Much of the forest has been already degraded and vast areas of grasslands dominate the landscape. Such habitat topography can promote the formation of large groups. Large group size may give more protection from disturbance in open areas (Jarman, 1974). On the other hand, the large groupings seen in Maduru Oya National Park may reflect stressful conditions brought about by the human settlements in the vicinity

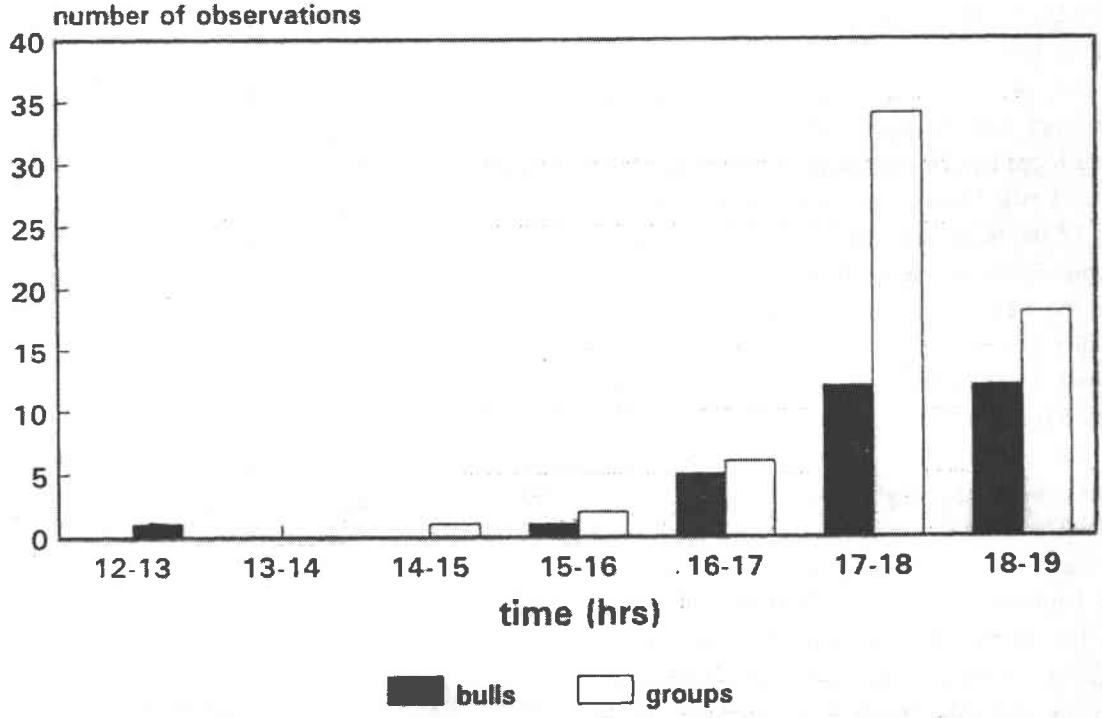

Fig. 5 Diurnal activity patterns of the elephant bulls and groups

of the park. Laws (1974) has postulated that group size is a measure of the ecological health of an elephant population since aggregation of family units and bull groups is the result of stressful conditions. It is likely that social factors in the area are responsible for the increase in group size. The stress may arise from the reduction of the habitat available to elephants as a result of conversion of forests in the area and the establishment of human settlements and agriculture. As Ishwaran (1998) points out, frequent random aggregations among elephants in Sri Lanka could be directly related to losses in their home range as a result of human encroachment. Moss (1988) has suggested that there are social and reproductive benefits to be gained from formation of large aggregations in the case of African elephant (*Loxodonta africana).* About 53.8% of the groups had no adult males, while 15.4% had only one male, and 19.2% had 2 males (Fig.4). The largest number of males seen in any group was 5.

Herd size

During the study 26 separate herds (including some bond groups) were identified (Table 4). The herds represent fairly stable associations of elephants characterized always by the presence of at least one matriarch (the oldest female), and a number of adult females (allomothers), and young. Adult bulls are not an integral part of the herd, but they are known to associate from time to time with the herds for the purpose of breeding. This is indicated by the observed average adult male:female sex-ratio of 1:6 biased largely in favour of the females (Table 4). Adult males represented only 7.2% of the total. Of the 26 herds recorded in the area, 14 (53.8%) were without any adult males, while 4 herds (15.4%) had only a single male. The highest number of adult males seen with the herds was 5 (Fig. 4). It is interesting to note that the herd size ranged from 3 to 52, and the average herd size of 15 is one of the highest recorded anywhere in Sri Lanka. The average herd size recorded in Ruhuna National Park, was 5.9 (Santiapillai *et al.*, 1984). All the large herds in Maduru Oya National Park were observed late in the evening, after 1700 hrs, and so could represent bond groups. Small related herds are known to join with other herds in the evenings, while feeding on grasslands or drinking from river or water holes. The large herd size may reflect stressful conditions in the area as a result of the human settlements. On the other hand, the large herd sizes observed may refer to the bond groups which are formed by the aggregations of a number of usually related family units. Calves represent 7.7%, which translates into a inter-caving interval of 5.6 years.

Table 4 Herd composition of elephants in Maduru Oya National Park

herds	adult males	adult females	subadults	juveniles	calves	total
1.	1	4	3	-	-	8
2.	-	34	-	9	3	46
3.	1	21	6	6	+	34*
4.	-	24	12	15	1	52
5.	-	5	3	3	-	11
6.	-	4	6	1	1	12
7.	-	1	1	3	1	6
8.	-	1	4	-	-	5
9.	-	2	4	-	-	6
10.	-	4	2	1	1	8
11.	2	3	-	-	1	6
12.	2	3	-	-	1	6
13.	2	6	6	10	3	25
14.	4	5	2	-	-	11
15.	5	5	2	4	-	16
16.	2	4	1	5	2	14
17.	-	2	-	1	-	12
18.	-	6	2	5	2	15
19.	1	7	3	1	-	12
20.	-	2	1	-	2	8
21.	-	4	1	3	1	9
22.	2	1	-	2	-	5
23.	5	15	19	4	7	50
24.	1	2	2	2	-	7
25.	-	1	2	-	1	4
26.	2	3	2	1	3	11
Total	28	169	83	80	30+	390
%	7.2	43.3	21.2	20.5	7.7	100

**It is likely that calves present in this herd were missed during the observation.*

Feeding activity

Fig. 5 summarises the diurnal feeding activity patterns of the bulls and groups. It is interesting to note that the mixed groups of elephants show a pronounced peak in activity about 1700 hrs, followed by a decline in activity at 1800 hrs, and the bulls continue their activities at the same level from 1700 to 1900 hrs. This is related to the feeding behaviour of the elephants in areas close to human settlements and agriculture. Most of the solitary elephants were observed crossing into the adjoining settlements to the west in System C, which is heavily populated. The fact is that mixed groups of elephants made up of matriarchs, allomothers and young ones, do not take great risks in moving into cultivated areas. They raid crops during the nights and move back into the safety of the forest. By contrast, the males appear to take more risks into moving out of their natal area into cultivated land for raiding crops which have a high nutritive content. Relatively more adult and sub adult males were seen moving into cultivated areas in the late evenings. As Sukumar & Gadgil (1988) argue, this high level of crop raiding by male elephants is a consequence of the "high-risk, high-gain" strategy to enhance their reproductive success. The cultivated crops provide more crude protein than do the wild plants. Bull elephants not only raid more frequently they also consume more per capita compared to members of the family units.

Recruitment of young

The population of elephants seems to be breeding well. The proportion of calves per 100 females showed a steady increase from a low of 5.1 in the dry season month of June to a high of 66.7 in the peak rainy month of December, but the overall population of calves per 100 females was about 17.8 (Tables 3 & 4). This gives an average calving interval of 5.6 years. This slightly extended calving interval points to poor habitat quality within the park. Much of the area has been invaded by *Imperata cylindrica* and *Panicum maximum*, which are eaten by elephants only during their early stages of regeneration following burning (Ishwaran, 1993). Although many previous research workers have concluded that there was no seasonal pattern of breeding among elephants in Sri Lanka, the limited observations made in Maduru Oya National Park appear to indicate that although breeding may go on throughout the year, the calving intensity could vary according to season. In Maduru Oya National Park, it appears that slightly more calves were produced during the wet season than in the dry season. The average number of calves per 100 females during dry season was 12.9 compared to 50.0 in the wet season. The production of most of the young during the optimal time for their survival to coincide with the onset of the rains will ensure the availability of high quality food rich in protein but low in fibre (Barnes, 1983). The key to the reproductive success of the elephants in Maduru Oya National Park, despite the poor habitat quality may be associated with the structure and composition of the family units. 87% of the herds classified had more than one adult female. Calf survival is affected by many factors, including the age of the mother, size of the family, number of allomothers, sex of the calf and environmental conditions (Moss, 1988)

Conclusions

Although a system of protected areas was established in the Accelerated Mahaweli Development Area in order to accommodate the elephants displaced from their original habitat, yet in practice containment of these elephants within the confines of the protected areas has proved almost impossible. The reason is two-fold: on the one hand, much of the habitat within the protected areas, such as Maduru Oya National Park is of poor quality, and on the other, the cultivations around these protected areas offer well irrigated, nutritionally richer food resources for the elephants almost year round. These two factors have resulted in the movement of elephants into cultivated areas, and increased incidents of crop depredation by the elephants. The original Master Plan recommended the establishment of forest corridors linking the Maduru Oya with the Wasgomuwa National Park to the north and the Gal Oya National Park to the south - east.

However, these recommendations were rejected as they were not economically feasible (TAMS, 1980) In the absence of such safeguards, elephants from Maduru Oya often utilize the fallow lands as grazing grounds during the dry season. Although mean group size of elephants usually decrease in poorer habitats (Leuthold, 1976), the observed large group sizes in the Maduru Oya National Park point to the presence of stresful conditions following range contraction. The Department of Wildlife Conservation has stationed two teams to drive the marauding elephants away from the development areas, but these units are ineffective as they are poorly equipped to deal with the problem. They have not even been provided with thunder flashes to drive the elephants away (Jayawardene, 1989). At the time of the study, the elephant population in Maduru Oya was not seriously affected by poaching, given the low number of tuskers in the area. But today even tuskless elephants (makhnas) are being killed in defence of crops by irate farmers. The human-elephant conflict has become a serious conservation problem that needs to be resolved or mitigated if elephants are to survive in the area. The reality is that nowhere in Sri Lanka can the entire home range of an elephant population be insulated from the disturbances by man. Containing elephants within small reserves that are surrounded by densely populated human settlements and perennial agriculture is becoming increasingly difficult in Sri Lanka and it calls for not only changes in the land use pattern and the establishment of a buffer zone outside the reserves but also for improved management of the grazing grounds within the reserves.

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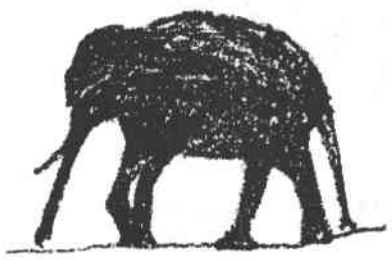
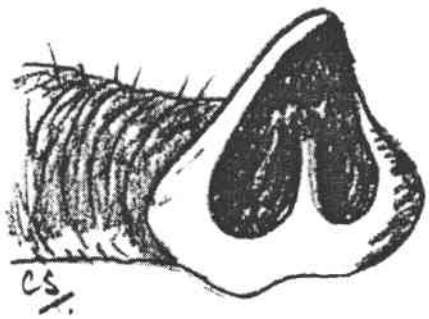
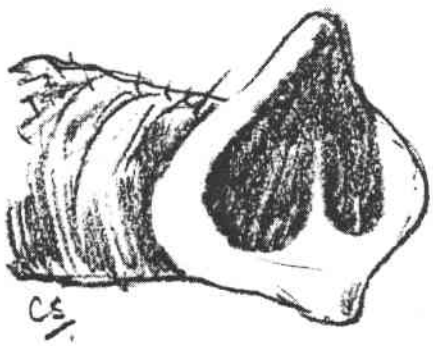
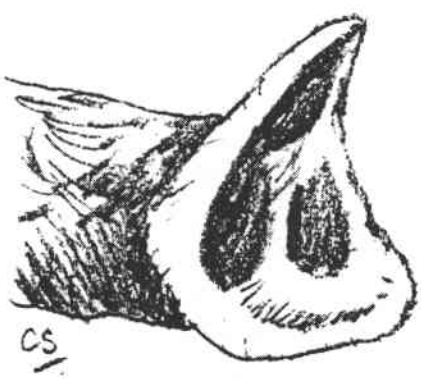




Asian elephant
one finger - like process



African elephant
two finger - like processes



Woolly mammoth
one finger - like process

The Elephant Orphanage (Pinnawela): a proposal for development

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ABSTRACT *The Elephant Orphanage at Pinnawela is a unique resource in Sri Lanka. A herd of about sixty elephants is maintained by mahouts in a setting suitable for observation. However, the potential of this collection is far from realised. There is no permanent information available to visitors concerning elephant biology, ecology, conservation, breeding and training, nor are there any facilities to encourage further studies on these animals. This paper presents outline proposals for developing the centre to portray all aspects of the relationship between elephants and humans with emphasis on captive breeding of the earth's largest terrestrial mammal. The elephant orphans have the potential to form a major focus in Asia for the education of the Sri Lankan public and international visitors. Provision for holding meetings, library, museum, and laboratory facilities and modest accommodation could transform the centre into a major attraction for national and foreign tourists, naturalists, photographers, artists, scientists, government officials, and those responsible for elephant conservation in Sri Lanka and elsewhere. The centre should provide a museum display of artefacts relating to elephant capture and training. A registration and training scheme for elephants and mahouts would improve the care and maintenance of domesticated animals. Library and laboratory facilities would allow a repository of library, archival, photographic and artefactual material attractive to international scholars and researchers world-wide. Of central importance is the development of the Elephant Orphanage as a breeding centre for animals within and outside the orphanage which could enhance the experience of undergraduate and postgraduate veterinary surgeons in all aspects of breeding behaviour, conception, artificl insemination, pregnancy, birth, and postnatal development. Permanent display of educational, library and archival material would make the centre more valuable to scientists and other visitors, especially Sri Lankan children, who need to be better informed about a significant aspect of their rich heritage. Additionally, if international funding were obtained to develop the area, the Elephant Orphanage could be converted into a significant source of income for Sri Lanka.*

Introduction

In biological time, the elephants, like the dinosaurs, are probably destined for extinction. Today the greatest threat to the survival of *Elephas maximus* is loss of habitat. The elephant is part of our rich heritage, and through recognition of the service which has been obtained by domestication of the largest land mammal, we have a responsibility to maintain this species for as long as possible. This means compromising the conflicts which arise where humans and elephants interact ecologically.

There are two aspects, which distinguish the policy for elephants from that for any other species, to action plans for the management and conservation of elephants. The two aspects relate to the maintenance of wild stocks and supplying the need for domesticated animals. Apart from the possibility of interaction through breeding, the two groups are essentially distinct and require different management schemes. Yet, the two populations are not totally unconnected; limited breeding success with domesticated stock means that numbers can only be sustained through the import of wild animals. This import can be a consequence of a controlled capture programme, or the adoption of wild animals orphaned by poaching or natural disasters.

There are only a few elephant orphanages in the world, of which the one at Pinnawela is the first of its kind and also the largest. The elephant orphanage (EO) at Pinnawela currently maintains about 60 elephants of both sexes and all age classes. The herd is managed by a small group of mahouts and other staff. Visitors to the EO can see the animals bathing in the river and being fed. Occasionally, the younger animals may be touched, but contact is mainly for the purpose of obtaining souvenir photographs of the visit. Mahouts will answer questions although language differences make communication difficult. Sadly, there is no permanent information available about elephant biology, ecology, history and conservation, or the training of mahouts and elephants and the use of elephants.

The Potential

The EO is probably a resource which is unique to South -East Asia with unrealised potential to:

- educate Sri Lankans and foreign visitors about all aspects of elephants

- provide registration and training for elephants and mahouts

- provide a library and information service for lay people, naturalists, conservationists, government officials and scientists,

- make available meeting and basic laboratory facilities for *bona fide* researchers

- develop an archival collection of literature, photographs, and artefacts illustrating the history of the relationship between humans and elephants, and the methods used in the past to capture and domesticate wild stock

- to serve as a breeding centre to ensure genetic diversity of existing stock, to facilitate breeding within and outside the EO, and for the education of veterinarians in all aspects of breeding and breeding behavior.

The EO has the potential to take the lead in forming an association of those concerned about elephants, produce a newsletter, provide an integrated forum for scientists, conservationists, and those whose lives are interwoven with those of elephants, to provide basic facilities for holding meetings and accommodation, and to generate funds. A well organised centre would also enhance tourism.

Possible developments

An Education Centre

Elephant Conservation will not be effective unless there is widespread public awareness of the problems and their solutions. The emphasis of the EO needs to be on education, not entertainment. Visitors to the EO should be able to obtain education and information about all aspects of elephants. This should include the biology, ecology, numbers of wild and domesticated elephants, causes of human/elephant conflicts, elephant and mahout training methods, and current research activities. The education centre should contain material in Sinhala, Tamil and English, on permanent display, and leaflets, books and booklets at affordable prices, directed at a range of readership. Mahouts or others fluent in more than one national language, should be able to answer visitors' questions about their work and the animals in their charge. Suitable volunteers, who might be drawn from teachers, especially biology teachers, or those staying for longer periods at the EO for cultural or scientific purposes, could be trained as guides.

Learning Resource Centre

There is a need for more advanced literature, on elephants, which can be consulted by writers and researchers from a range of backgrounds. A library with books, journals, bibliographies and literature searching facilities and a photocopier should be established. Such a library should contain only reference material.

A meeting room would give the opportunity for lectures to the public, school parties and tourists, and provide a forum for naturalists, scientists and others

concerned with the dissemination and sharing of knowledge about elephants. The meeting room should be fitted with audio-visual facilities for multimedia presentations. Frequent video presentations could be interspersed with live lecture demonstrations. A backup generator would ensure continuity presentations during electricity failure.

Laboratory and Research Facilities

Elephant management and conservation must be based on scientific research and principles. The EO can offer a minimal service for research in the first instance with little more than the basic requirements: benches, stools, water and electricity supply. Researchers could bring their own equipment as required (e.g. microscope, collecting tubes etc). This would facilitate the collection of body fluids, parasites or post mortem materials needing examination. The research centre could develop projects relevant to the biology, genetics, pathology, breeding, conservation, and migration of elephants Facilities may be extended in a later phase to include full veterinary pathology, hospital and therapy services.

There is a need for more work at the ecological level, of course. More synecology needs to be studied. For example, buffaloes are commonly seen with, or close to, elephants in the wild. Paradoxically they seem to fill similar ecological niches and share similar food. If so, how can such competitors survive together?

Much research needs to be done on and beneath the elephant's skin, especially in relation to working elephants. What blood and gut parasites do they have? What happens to the cardiorespiratory system under working conditions. and how are serum concentrations of nutrients affected by such conditions? How efficient is energy or water balance? How do elephants regulate their temperature? Can parallels be drawn with the working buffalo? Such information is needed to provide a rational basis for the working conditions and length of work time appropriate for domesticated stock.

Perhaps the time is right to make an appeal. The days of 'one-man' research have almost ended. Now, grant awarding authorities expect to see applications from multi-disciplinary teams; even multi-national co-ordination. If descriptive and experimental research is to progress at the speed necessary to ensure elephant conservation, then we must stop being selfish about our own corner of research and prepare to work in a collaborative manner. There is a certain satisfaction, and a success rate, that comes from working as a team member, which cannot be matched by working alone.

Museum

There is unlikely to be another keddah in Sri Lanka but the trapping and training of elephants from the wild stock has been an important part of the history of Sri Lanka and other Asian countries until recent times. Artefacts still exist pertaining to this and the knowledge about the capture and training of elephants is still just first hand. It needs to be put on record in a consolidated manner. This can be achieved by collecting photographs, records, recordings of those with experience, artefacts, and skeletal material relevant to the use of elephants in the service of man. The display can include the role of elephants in forestry, agriculture, and religion. The museum display can also be extended to include current research findings.

Training and registration

Methods of training elephants and mahouts have become traditionally established. However, there is value in formalising training programmes and sharing experiences gained in other Asian countries. Maintaining a register of all domesticated elephants and their mahouts or handlers could provide a source of information about elephant breeding and genetics. Additionally, handlers should have education and training in elephant well-being and illnesses. Mahout and elephant training aspects would have to be dealt with by outside mahouts as those handing elephants at Pinnawela deal with elephants on a herd basis and not as individual animals.

The Department of Wildlife Conservation is legally required to have a register of domesticated elephants; however, the records of these animals are incomplete. If the spirit of the laws relating to cruelty to animals and the care of those in captivity is to be maintained, there should also be a register of experienced (qualified?) mahouts and owners. (In many countries of the world the drivers of vehicles as well as the vehicles are tested). Perhaps all domesticated elephants should have a mandatory veterinary examination annually, and all mahouts should also be examined for their suitability to train, maintain and manage the health of the animals in their care. More knowledge about the changes in the physiology of an animal under working conditions could lead to legislation about its working conditions and duration of work. This would lead to improvements in the health of working elephants and a limitation of the extent to which they may be worked by commercial pressures.

Domestic facilities

There are needs of two kinds;

- a shop supplying snacks, meals and souvenirs (pictures, post cards, carvings etc)

- simple residential accommodation for naturalists scientists photographers, artists and others wishing to spend longer periods at the EO for their studies.

Both of these should be profit making facilities.

Elephant breeding

A central focus of activities of the EO should be its development as a breeding centre. Selected males could serve as a stud source for outside domesticated breeding females. Registration and regulation would ensure the maintenance of appropriate genetic diversity. A breeding centre would provide education for undergraduate and postgraduate veterinary surgeons in all aspects of breeding behaviour, conception, pregnancy, birth, weaning, and postnatal development. Registered breeding, as with cattle, could lead to improvements in genetic diversity and stock selection.

Friends of the Elephant Orphanage

Many zoological gardens have associated groups of "Friends" who may engage in a range of activities which include publishing newsletters, raising public awareness of the work of the zoos, and funds. A similar organization "Friends of the Elephant Orphanage", would be of grate benefit to the Elephant Orphanage.

Other facilities

Sri Lanka has other relevant resources and personnel which could be networked to the EO. These include:

- working elephants that can be seen at another nearby centre. Some museum material is poorly displayed here, but elephant rides are available

- the IUCN Asian Elephant Specialist Group

- NARESA and the National Museum in Colombo

- the Dehiwala Zoological collection where Asian and African elephants can be seen

- the Natural History and Wildlife Society

- the Department of Wildlife Conservation

- the Veterinary Faculty at the University of Peradeniya

- the Zoology Departments at Peradeniya and Colombo Universities.

- special personnel: These include Professor V. Kuruvita (Dean, Faculty of Veterinary Science, University of Peradeniya), and Professor Charles Santiapillai (of the Department of Zoology, Faculty of Science, University of Peradeniya, and Editor of ***Gajah***, Journal of the IUCN/SSC Asian Elephant Specialist Group), as well as many others who have researched a variety of aspects of elephants and their biology.

Funding

Necessary funding for these proposals will be substantial, but the world 'climate' is currently sympathetic to animal conservation, especially the conservation of elephants. This has been enhanced by the recent discovery of 300 carcases of African elephants killed by poachers using machine guns. The EO has the potential to become self funding but 'pump priming' will be necessary. Funding can be raised internationally by the sale of entrance tickets, souvenirs, the hire of facilities and through special fund-raising events such as adopt an elephant, private donations and legacies, and the activities of the Friends of the EO. Experience has shown that many visitors to the EO are keen to donate funds *at the time of their visit.* Official receipt of international currency should be possible at that time and before enthusiasm wanes.

Funding will be needed for:-

- buildings - education centre, museum, library and meeting room, laboratory, accommodation, staff offices and quarters, and animal holding stables. These must be environmentally suitable, cost effective and hygienic.

- materials - books, journals, telephones and computers with Internet facilities to allow international contacts, keddah artefacts, photographs, educational and museum displays, collections of skeletal and other materials, laboratory facilities and basic equipment.

- staff - managers, lecturers (part time staff could be drawn from interested teachers and others), animal keepers, technicians, library and museum attendants, and security staff.

Planning

Implementation of these proposals must be preceded by mapping and planning the area for development. The costs involved mean that the development plans must be phased and carefully 'milestoned' to ensure that development is matched by availability of funds.

Discussion

There are several reasons for developing the elephant orphanage. As custodians of our environment we have a collective responsibility to care for animals displaced by human activities. Housing such animals is expensive and other national priorities may result in the required funding being inadequate. These animals must either attract or generate sufficient funding if the needs of the animals are to be met. The plight of the Asian elephant must be publicised either by attracting people to the centre or disseminating information from it. This requires an educational programme. Knowledge about elephants is essential if conservation plans are to be rationally devised. This means more research must be done and research facilities provided. Health of captive and wild elephants needs to be monitored and improved, especially in conditions of habitat destruction, food shortage and attempted poaching. Commercial interests may be jeopardised if the animals are overworked and unhealthy. Additionally, everybody should have the opportunity to experience and enjoy these magnificent animals, which from part of our heritage, in their natural habitat.

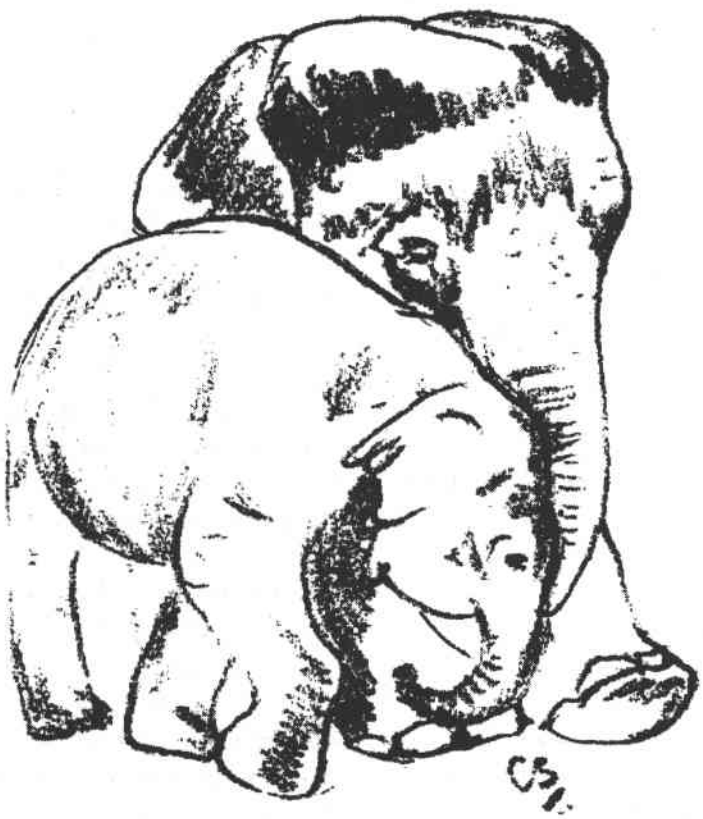
If the potential of such a centre is to be fully realised, certain key issues must be addressed. Is the project needed? Are the funds available, or can they be made available? Is there willingness on the part of the people and the Government of Sri Lanka to make the project work? Is the project sustainable? Is there a model in Sri Lanka or abroad on which the project could be based? An affirmative answer can be given to all these questions. Globally, in Asia and in Sri Lanka there is a willingness to improve the lot of both wild and domesticated animals.

However, there are those who are unsympathetic to the use of elephants for domestic work. Nevertheless, even if all additions to domesticated stock stopped now there will still be a need to care for and improve the care of the animals already domesticated, which cannot be released back into the wild. The young age of some of the elephants in the orphanage at Pinnawela shows that this need will continue for the next seventy years at least.

There is a model in Sri Lanka on which the development of the EO could be based. The Wetlands Conservation Project has been funded by the Ministry of Transport, Environment and Women's Affairs, and the Netherlands Government. This project has set up most of the kinds of facilities listed above. (Details from: Wetland Conservation Project, Central Environmental Authority, Maligawatte Secretariat, Colombo 10, Sri Lanka). These include nature trails, educational displays, an exhibition with videos on conservation, a restaurant, a shop, and a 'Friends' Association. It has published guidelines on conservation, technical reports and educational material. It is committed to institution strengthening, implementing a national programme of public awareness, and publishing a newsletter summarising the progress and achievements of the project. It is close to being cost effective. What has already been achieved for the wetlands of Sri Lanka should be repeated for Sri Lanka's Asian elephants.

Conclusions

The EO has the potential to become an international centre of renown, attracting tourists, scientists and funds, It can be an important centre in Sri Lanka providing education about the biology and ecology of elephants. Most important would be its contribution to the breeding and conservation of all elephants.



Integrating Elephant Conservation with Protected Area Management in Sri Lanka

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ABSTRACT *Gray Haynes (1991) has correctly noted that "it is no longer possible to describe the optimal or ideal preferred habitats of wild elephants, because, virtually all surviving populations inhabit special protected lands such as national parks which are restricted ecosystems". In Sri Lanka, a large part of what was once the elephant's home range in the dry and intermediate zones has been converted to agriculture. Even where the cores of their home ranges overlap with the boundaries of Sri Lanka's protected areas, elephants move outside of those boundaries and come into conflict with subsistence and plantation agriculture. Despite the limitations of national parks and equivalent reserves of Sri Lanka as elephant habitats, it is inevitable that future management of wild elephant populations would have to be planned in and around clusters of such protected areas. Management planning for* in-situ *conservation of elephant populations cannot be solely dependent on defensive, agriculture-friendly prescriptions, i.e. removal of troublesome individuals, translocation of elephant herds pocketed-in by surrounding agricultural lands to nearby protected areas, capture of elephants for protection in captive herds such as those at Pinnawela orphanage etc. (Ishwaran, 1993). It must necessarily include attempts to regularly monitor the composition and "health" of wild elephant populations, and interventions to manage habitats and land-use in and outside of protected areas so as to improve range conditions, and the elephant's access to parts of its range which were lost to agriculture and other land-uses in the past. This paper provides an overview of the ecology and population structure of the Asian elephant, and the interactions between humans and elephants in Sri Lanka. A framework for designing a pilot project, that could build on a cluster of Sri Lanka's protected areas for elaborating a management regime to improve habitat and range conditions for* in-situ *conservation of the elephant is outlined.*

Ecology and population structure of the Asian elephant in Sri Lanka-an overview

Parker & Graham, in their two-part analysis (1989a,b) of the downward trends in African elephant distribution and numbers note that: "Humans and elephants are complete competitors. Biological theory maintains that such species cannot co-exist on the same range and that increase in one will exclude the other. Measurements of human increase, elephant decline and ivory production are in keeping with this hypothesis".

Competition between humans and elephants is particularly intense in agrarian societies. In Asia, most elephant range countries have large rural populations which seek land for agriculture. Governments have sought to use the pride and the sense of security which people associate with owning a plot of arable land to launch massive river valley development projects where agricultural land is parcelled out to settlers. More often, settlers in such schemes are not necessarily indigenous to the area where the project is executed. Many of the settlers are drawn from rural, suburban and urban populations sympathetic to ruling powers and are attracted to new settlements through the offer of economic and other incentives. The preferential settlement of river valleys and similarly high-yielding habitats for crop production has been a policy that has denied the elephant its most favoured habitats. That policy has been in vogue among Asian rulers, both

native and colonial, for millennia. The following quote from Sukumar (1989) clearly illustrates the antiquity of this policy and its attendant practices. "Kautilya's *Arthasastra* (c 300BC to 300 AD), a manual of state-craft, advises that elephants were to be eliminated from river valleys under settlement but preserved in the outer hill forests"

One of the latest sagas in river valley development schemes displacing elephants from preferred parts of their home ranges occurred in Sri Lanka, under the Accelerated Mahaweli Development Programme (AMDP), which changed the water-flow of the Mahaweli River, the longest of Sri Lanka's rivers, and has perhaps already led to long-term changes in the ecology of the villus.

The Mahaweli villus, which were abundant on both sides of that river's course northeastward from Mannampitiya, were a unique grassland habitat. Prior to the late 20th century renaissance of irrigated agriculture in the dry zone of Sri Lanka, the Mahaweli river, which drains catchements and river-basins in the wet, intermediate and dry zones before draining into Indian Ocean near Trincomaee, flooded the villus at least twice a year, during the southwest as well as the northeast monsoons. The Mahaweli villus thus ensured a supply of palatable stages of grass for the elephant and other grazing herbivores throughout much of the year.

The quality and quantity of grass and grazing lands in the Mahaweli villus would have been considerably higher than that even in areas further upstream along the river, in and around what is currently the Wasgomuwa National Park, and in the flood plains of other nearby rivers such as Maduru Oya, During 1981-1982 when the implementation of AMDP was beginning to be 'accelerated', one measure of food-quality, i.e. percentage crude protein of faecal samples of elephants, was significantly higher in the villus and surrounding forests than in the Wasgomuwa National Park and habitats along the Maduru Oya (Ishwaran, 1984)

Grasslands are the preferred feeding habitat of elephants; they do however, need other habitats for movement, resting, shade, breeding and other purposes. Chena lands which have been invaded by 'illuk' *(Imperata cylindrica)* are grazed upon soon after a burn, when fresh growth of grass is abundant. Once illuk matures, particularly after it has past the flowering stage, it does not constitute a significant feed for the elephant. Where there is a range of habitats and a river flow regime which provides access to varying extents of grasslands throughout the year, browse constitutes only a small portion of the diet (Ishwaran, 1984). Most size-classes of browse are used in proportion to their availability (Ishwaran, 1984); earlier findings showing preferences for certain size classes of woody plants (Ishwaran, 1983) are inconclusive since preference indices were calculated as point-estimates, and did not include estimates of variation due to sampling biases.

Results of studies on relationships between elephant densities, and variables related to grassland structure and composition, and densities of other herbivores such as water buffalo and domestic cattle, in mixed, upland grasslands in the AMDP area (Ishwaran, 1984) have important implications for designing management policies for the elephant. In the dry season elephant densities are positively influenced by availability of tall grasses. As McKay (1973) pointed out, elephant grazing in the dry season is negatively impacted by the presence of other herbivores which graze grasses down to ground level, resulting in elephants having to "scarify" grasses with their front legs before collecting them with their trunks for injestion. In the event elephants are forced to spend increasing amounts of time in scarfying grasses before collecting and feeding upon them, there is likely to be a point where the decreasing net energy gain obtained from a mouthful of grass may force the elephant to seek out alternative diets, such as plantation crops and woody plants, even if those alternatives would not be eaten or be avoided under optimal range conditions. Elephant feeding preferences and behaviour are known to change over time to due to changes in its habitat. In the case of elephants in the Rjaji National Park of India, Vinod Rishi, as quoted in Sarka *et al.* (1995), had observed that "as far back as 1969, the changes in the eating

habits of elephants were recognised as spelling impending disaster. But this recognition went unheeded. A famous publication of 1962, ***Camera in Tigerland,*** says that elephants abhor rohini, *Mallotus philippensis* as food, and today we see that elephants in Rajaji are causing destruction by uprooting this plant..... the source of this problem (is located) in the large scale extraction of bamboo from the region in 1969"

Even during the wet season, elephant densities could be negatively correlated with densities of buffalo and livestock since heavy grazing pressure from the latter could increase patchiness in available grass cover, causing elephants to spend a decreasing amount of time in any given grassland-site. The extent to which densities of buffaloes should be controlled has been a controversial issue in the management of protected areas such as the Yala (= Ruhuna) National Park of Sri Lanka. In Yala where densities of other grazing herbivores, like spotted deer and sambur are quite high, merely reducing buffalo densities may not increase grazing opportunities for the elephant. In the 1980s when the implementation of the AMDP was beginning to gather momentum, hunting of deer, sambur, and even wild buffaloes, though illegal, was widespread and perhaps contributed to keeping the numbers of these ruminant populations under check. Furthermore the availability of tall-grass-grasslands more favorable to intensive feeding by elephants, such as those found in the Mahaweli villus, made wildlands in the AMDP area far better elephant-habitats than areas inside many of Sri Lanka's national parks. The protection afforded to all wildlife in parks and sanctuaries could set in motion ecological and demographic changes that could gradually lead to increases in grazing herbivore densities which over a period of time could negatively impact availability of grazing opportunities for the elephant.

The establishment of national parks around artificial reservoirs such as Gal Oya, Maduru Oya, Ulhitiya Oya, Uda Walawe etc., is probably one of the best options available for conserving elephants in a country like Sri Lanka, where irrigation, hydro-power and flood control benefits due to those reservoirs provide economic justification for their construction. Fluctuating water levels in such reservoirs mimic floodplains of rivers in exposing varying extent of grasslands throughout the year. However, allowing a large number of domestic livestock to graze inside parks such as the Gal Oya National Park could in the long run lead to changes in the structure and composition of grasslands along the shores of the waters of the Senanayake Samudra that could be detrimental to the use of those grasslands by elephants (McKay, 1973; Ishwaran, 1979). Furthermore, the extents of grassland that are exposed by receding waters in reservoirs located within protected areas like the Gal Oya National Park is a function of the withdrawal of water for agricultural and power generation purposes. Considerations for managing the extents of grasslands for elephants have never entered the equation that determines schedules of water withdrawals from reservoirs located inside national parks.

In the Gal Oya National Park, the northeast monsoonal rains during 1975-1976 was exceptionally heavy. Throughout 1975, due to regular rainfall conditions, elephants were observed to graze in the grasslands along the shores of the Senanayake Samudra even during the normally dry months of July and August (Iswaran, 1981). Earlier studies at the same site (McKay, 1973) had indicated that elephants left the park during the dry season, but grazed in the grasslands along the shores of the reservoir only during the rainy season. During the 1975-1976 rainy season, there was a period of about 15 days in January 1976 when the reservoir had filled to such an extent that the water level extended up to the forest border and there was hardly any grassland exposed for elephants to feed upon. Elephants were known to move outside the park during those high rainfall months when the reservoir had filled up. (Iswaran, 1979).

It is probable that the use of grasslands by elephants, in reservoir-centred national parks such as Gal Oya, apart from being determined by factors such as grassland composition, densities of water buffalo and domestic cattle etc., would also depend on other factors, *i.e.* the distance of grazing locations from the forest

border; and proximity of grazing locations to drinking sites. Grasslands in a natural floodplain, like the Mahaweli villus, provide grazing locations which are in close proximity to both forest cover and drinking sites. In an artificial reservoir like that in Gal Oya or Maduru Oya National Park, grazing locations along the shores of the reservoir could become unattractive to the elephant, particularly during the height of the dry season, when the distance between the forest border and the high-water mark increases. Human demands for water from these reservoirs are also highest during the dry season.

Considerations for managing grasslands along the reservoir to favour elephants is likely to run contrary to the requirements of human needs. In the wet season when more and more grasslands are inundated, it will be useful to release water from the reservoir in order to keep a minimum extent of grasslands "open" for grazing although the demand for water for agricultural activities is likely to be minimal. In the dry season, the situation reverses itself; more and more grasslands are opened up by water withdrawal for irrigatiobn but the grasslands which are exposed, both from a point of view of access and quality may not provide optimal grazing conditions for the elephant. The ecology of these grasslands could be further impacted if domestic cattle, sometimes brought into the park by herders from distant provinces and municipalities, and large numbers of water buffalo continue to graze these grasslands during the dry season (Ishwaran, 1979;1981)

The favourable habitat conditions for the elephant in ranges which occurred along the Mahaweli river prior to the completion of the AMDP may have also influenced the age class structure of elephant populations. In Table 1, age-class distributions with respect to infants, juveniles, sub-adults and adults for elephants using the villus and forests in Trikkonamadu, and the Wasgomuwa National Park areas during 1981-1982 are provided. Observations provided are for selected days when the total number of individuals observed was 30 or more and could therefore have comprised at least 10% of the population of elephants using the respective areas (see Ishwaran, 1993 more details).

Table 1 Age Class data for Trikkonamadu and Wasgomuwa National Park Areas based on elephants observed on separate days during the specified time periods (% estimated in parentheses)

Trikkonamadu area:

[1981 (August-November) and 1982 (April-June)]

	I	J	SA	A	Total
a.	2(6.1)	13(39.4)	10(30.3)	8(24.2)	33
b.	14(15.4)	41(45.1)	23(25.3)	13(14.3)	91
c.	3(6.7)	27(53.3)	9(20.0)	6(13.3)	45
d.	3(2.8)	21(58.3)	9(25.0)	3(8.3)	36
e.	5(8.5)	21(35.6)	20(33.9)	13(22.0)	59
f.	10(10.8)	42(45.2)	24(25.8)	17(18.3)	93
g.	4(9.5)	13(31.0)	15(35.7)	10(23.8)	42
h.	10(14.5)	22(31.9)	20(29.0)	17(24.6)	69
avg %	9.3	42.5	28.1	18.6	

Wasgomuwa area: (1981 May-November)

a.	4(10.0)	17(42.5)	11(27.5)	8(20.0)	40
b.	4(12.5)	16(50.0)	6(18.6)	6(18.8)	32
c.	3(7.3)	21(51.2)	15(36.6)	2(4.9)	41
d.	7(14.2)	19(38.8)	17(34.7)	6(12.3)	49
e.	7(10.0)	26(37.1)	23(32.9)	14(20.0)	70
f.	7(8.0)	30(34.1)	33(37.5)	18(20.5)	88
g.	8(9.2)	28(32.2)	31(35.6)	20(23.0)	87
h.	3(8.8)	14(41.2)	12(35.3)	5(14.7)	34
i.	2(4.8)	21(50.0)	13(30.9)	6(14.3)	42
Avg %	9.4	41.9	32.2	16.5	

I- Infants; J-Juveniles; SA-Sub Adults; and A-Adult as per McKay (1973). Parts of these data published in Ishwaran (1984) and (1993)

In Table 2, age-class distributions are provided for elephant populations that were observed in a number of protected areas of Sri Lanka during the 1960s and the 1970s as reported in McKay (1973) and Kurt (1974). Unpublished data from my own studies in Gal Oya National Park and Ampara Sanctuary during 1975-1977 have also been included. These age-class distributions have been derived from (a) the total number of animals observed during a month (McKay, 1973),

(b) the total number of individually identifiable animals (Kurt, 1974), and (c) the minimum total number of recognisable individuals for months when the largest number of observations were made (Ishwaran, unpublished). Despite these differences in the methods used for the estimation of age-class distributions which make direct comparisons between the different sets of data impossible, they may have value as background information for designing future research studies.

Both Wasgomuwa and Trikkonamadu populations (Table 1), at the time of observations in the early 1980s, had less restricted home ranges than the other populations in the protected areas indicated in Table 2. Hence, the fact that the two populations described in Table 1 had relatively higher percentages of juveniles and lower percentages of adults compared to those populations described in Table 2 provides room for speculations that may lead to the postulation of hypotheses that could be tested by future research.

Table 2 Age class data for other elephant populations of Sri Lanka from published and unpublished data of various authors from 1967-1976.

I	J	SA	A	Total
Yala National Park				
7(8.0)	26(29.9)	23(26.4)	31(35.6)	87[ai]
13(14.6)	21(23.6)	19(23.9)	36(40.5)	89[b]
Gal Oya National Park (Hatpatha area)				
8(12.0)	7(11.1)	26(41.3)	22(34.9)	63[a2]
5(12.2)	7(17.1)	11(26.8)	18(43.8)	41[a3]
9(15.0)	14(23.3)	21(35.0)	16(26.4)	60[ci]
Ampara Sanctuary				
9(14.5)	16(25.8)	15(24.2)	22(35.5)	62[a4]
7(14.5)	17(35.4)	13(27.0)	11(22.9)	48[c2]
Lahugala				
8(10.6)	23(30.7)	26(34.7)	18(24.0)	75[a5]
21(16.9)	29(23.4)	41(33.1)	33(26.7)	124[a6]

I - Infants; J-Juveniles: SA- Sub Adults and A-Adults as per McKay (1973). McKay (1973) reporting observations made in August 1967 [a1], June 68[a2], January 69[a3] December 68[a4], November 67[a5] and November 68[ab]; Kurt (1974) reporting observations during 1968-69[bi] and Ishwaran's (unpublished) observations made in September 1975[cl] and May 1976[c2]

[See text of the paper for differencees in the methods used by the different authors in the estimation of number of individuals (percentages in parentheses) per size clas category].

Sukumar (1989) provides a discussion on scenarios that could arise from different kinds of relationships between age distribution and population growth rates. As he has pointed out, populations could grow due to an increase in fertility, decline in mortality or a combination of the two. Given the long life spans of elephants a population could still be growing even when the percentage of calves in a population is falling. While, it would be impossible to make any statements as to whether or not any of the populations referred to in Tables 1 and 2 are growing, declining or stable, the following conjenctures may be used to derive hypotheses that could be tested in the future:

as elephant range and habitats change from an "open-ended" situation as in Trikkonamadu and Wasgomuwa of the early 1980s to the Parks and Sanctuaries referred to in Table 2, population structures may be becoming more dominated by adult classes; this may well be due to a combination of low mortality of adults, and increased recruitment of juveniles into sub-adult and adult classes.

despite the fact that all protected area centred populations in Table 2 have higher percentages of calve in comparison to the two populations referred to in Table 1, all of them have lower percentages of juveniles; this may be due to a lower recruitment from infant to juvenile classes that may be related to nutritional and habitat factors influencing infant mortality rates.

sex-ratios of sub-adult and adult classes are skewed in favour of females, and in all cases except in Wasgomuwa the ratios of females to males were higher among sub-adults than adults; adult and sub-adult sex ratios approaching unity may be an indicator of decreasing opportunities for sub-adult and adult males to disperse from their maternal herds and home ranges. Such opportunities may be reducing in protected areas, as surrounding lands become gradually converted to year-round agricul-

ture, and habitat fragments suitable for elephant feeding and movement outside of the protected area become less accessible to elephants.

Protected areas - management principles, priorities and practice

Principles of managing protected areas, *i.e.* national parks, strict nature reserves, wildlife sanctuaries etc., have changed, particularly since the late 1960s and the early 1970s. The concept of the "human environment" introduced during and after the Stockholm Conference in 1970 has challenged the assumption that protected areas could be managed as enclaves with minimum or no regard to the needs of people resident in the immediate vicinity of parks and equivalent reserves. The notion that conservation and development are two sides of the same coin has gained ground and peaked at the UN Conference on Environment and Development, held in Brzil in 1992. The outcome of the growing recognition of conceptual linkages between conservation and development has had both advantages and disadvantages for protected areas. It is no longer necessary to belabour the point about the indispensable role protected areas play in national economic development. But at the same time, protected areas may have lost their privilege of being isolated enclaves in rural and marginal lands catering to the aesthetic and recreational pursuits of the urban and well-to-do folks. Protected area managers are more and more complied to give due consideration to the social and economic well being of the poorer sectors of rural societies resident in the immediate vicinity of parks and reserves.

Integrated Conservation and Development Projects, or ICDPs, implemented in and around protected areas have become increasingly attractive to donor agencies because they make an explicit commitment to bringing benefits to rural poor and/or tribal and indigenous communties. Some others have, however, cautioned against the tendency in many ICDPs to de-emphasise the biodiversity protection objectives of national parks and equivalent reserves. Sanderson & Redford (1997) point out that "conservation has become use" and go on to add that the "concerns that fostered the original concept of biodiversity have been surrendered - even forgotten - in the struggle for common ground, to the detriment of science and conservation". Similarly, others have questioned whether there has been "too much emphasis on the "lose or use" argument for conserving species and on economic justifications of conservation areas" (MacKinnon, 1979). The mix of activities implemented by ICDPs sometimes tilt heavily towards "development" rather than supporting "conservation". In an ICDP being implemented with financial assistance from the Global Environment Facility (GEF) in and around the Kerinci-Seblat National Park in Sumatra, Indonesia, 40% of the development activities undertaken consisted of bridge and road construction projects; as pointed out by MacKinnon (1997) it was not clear whether those roads and bridges "will draw populations away from the park or actually open the hinterland to more developments that further threaten the park's integrity". MacKinnon (1997) also agreed with the observation made earlier by Wells & Brandon (1992) that too many ICDPs turned out to be rural development projects with no obvious linkages to conservation.

The need for linking conservation and development has been accepted by most governments and conservation groups. Yet, land and resource use activities which can co-exist with, and in the long-run benefit conservation are not always easy to identify and execute. Where rural poor are resident near protected areas there appears to be a tendency to promote crop cultivation as the optimal land use for helping people and conservation. In lands within or adjacent to protected areas, which are home ranges of elephants, raising crops, particularly those belonging to the family Garminae, such as rice and sugar cane, will most likely result in human-elephant conflicts. It is perhaps necessary to identify other income generating activities, e.g. animal husbandry, community based tourism, small scale rural and/ or artisanal industries, and construction, operation and management of service sector installations like schools, research stations and hospitals etc., whose goals and objectives are more compatible with those of management of habitats for elephants. Furthermore, the abrupt spatial transition from an elephant habitat inside a protected area to paddy and/or sugar cane lands immediately outside the protected area is not a suitable design for a landscape

architecture which aims to minimise human-elephant conflicts.

The following "idealized" categories of protected areas (IUCN, 1997) allow for a broader range of resource use areas to be juxtaposed with elephant habitats in and around protected areas of Sri Lanka, than those solely devoted crop production, either on a subsistence or industrial scale:

CATEGORY I a : Strict Nature Reserve
A protected area managed mainly for science

Definition: An area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.

CATEGORY I b: Wilderness Area
A protected area managed mainly for wilderness protection

Definition: A large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.

CATEGORY II : National Park
Protected area managed mainly for ecosystem protection and recreation

Definition : A natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

CATEGORY III : Natural Monument
A protected area managed mainly for conservation of specific natural features

Definition: An area containing one, or more, specific natural or natural/cultural features which are of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.

CATEGORY IV : Habitat/Species Management Area
A protected area managed mainly for conservation through management intervention

Definition : An area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

CATEGORY V : Protected Landscape/Seascape
A protected area managed mainly for landscape/seascape conservation and recreation

Definition: An area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

CATEGORY VI : Managed Resource Protected Area
A protected area managed mainly for the sustainable use of natural ecosystems

Definition: An area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

Of the six categories of protected areas mentioned above , only Ia and I b would contradict with interventionist management strategies. In all other cases interventions to manipulate habitats and resource use in order to favour targeted species conservation objectives could be justifiable. Zoning approaches to protected area management can also facilitate habitat

manipulations and other interventionist management regimes to favour elephants in all protected areas. In the Sri Lankan scenario, it is not difficult to foresee an elephant range to comprise one or more national parks (category II) linked to a wildlife sanctuary (category IV) with additional areas which may be forest reserves (category VI) and jungle corridors (category IV, V or VI depending on the specifics of the legislation used to protect the area).

Building a protected area centred *in-situ* conservation and management regime for elephants in Sri Lanka would require that conservationists, resource managers and planners and scientists accept the philosophy behind interventionist management regimes, i.e. that fragments of natural areas legally protected as parks and equivalent reserves require :

(i) explicit definition of their management objectives,

(ii) agreement among different land and resource use agencies regarding strategies and actions prescribed for attaining those objectives, and

(iii) effective monitoring and evaluation mechanisms for assessing the performance of the management with regard to outcome of the implementation of prescribed actions and activities.

This would apply even in cases where the management decides to "leave nature as it is"; in such cases maintaining fragments of a natural ecosystem in as "natural" a state as possible would require a series of prescriptions with regard to:

(i) an appropriate and effective legislative framework to ensure protection,

(ii) staff and other resources to regularly patrol the areas and to prevent illegal encroachments and other violations, and

(iii)education of people resident in the vicinity of the area in order to seek their compliance with protection objectives of the management.

Outline of a Protected area centred management plan for *in-situ* elephant conservation in Sri Lanka

In Sri Lanka, specific protected area clusters have been identified in the past with a view to developing tools such as management plans (see Kotagma *et. al.*, 1990). These clusters may still be valid for designing a plan for elephant conservation. However, current knowledge on elephant movement patterns outside protected areas, and the potential for maintaining the most contiguous elephant ranges must be reviewed and assessed in order to select one protected area cluster which can serve as a pilot project site to test and demonstrate the feasibility for linking protected area management and *in-situ* conservation of elephant populations. In selecting such a pilot project site, factors such as difficulties in access to parts of a cluster where security conditions may have deterioration since the early 1990s must be given due consideration.

In the early 1980s, the Wasgomuwa-Maduru Oya - Gal Oya cluster of reserves was considered to be the most important from the point of view of conservation and management of elephants in Sri Lanka (see Ishwaran & Punchi Banda, 1982). Although this cluster, together with Wasgomuwa's links to the Mahaweli floodplains, is still likely to be the home of the largest concentration of elephants in Sri Lanka, its choice as a pilot site for testing and demonstrating *in-situ* elephant conservation may have been adversely affected by the following:

deterioration of security conditions which prevent access to the more northeastern parts of the Mahaweli floodplains and eastern parts of the Gal Oya National Park

the rejection of the proposal made by the Wildlife Department for a corridor linking Wasgomuwa and Maduru Oya National Parks because the establishment of such a corridor was considered economically unjustifiable ((TAMS 1980), and

the extent to which elephants, particularly female herds, use the Nilgala corridor linking the Maduru Oya and Gal Oya National Parks.

Reasons of easy access and the ability to monitor habitat use by elephants in all parts of the protected area cluster, including areas which may be outside the boundaries of protected areas, could lead to the choice of the cluster of reserves extending westwards from Yala National Park to Uda Walawe National Park as the best option for a pilot project. Access and security conditions also play an important role in considering the following in the design and planning of the pilot project:

feasibility to propose alternative resource and land use schemes to agriculture in areas immediately juxtaposed to protected areas, e.g. animal husbandry; community based tourism development, establishment of facilities for research, education and/or health that can cater to the needs of nearby resident communities, environment-friendly rural industries, and setting up locations for captive herds of elephants, such as the orphanage in Pinnawela etc.,

habitat manipulations in selected parts of protected areas where natural habitats have already been modified, and in areas outside protected areas where elephant intrusions and crop damage are frequent enough to provide social and economic justifications for changing land use to alternatives which are less conflicting with elephants

Proposals for re-visiting the dogma that agriculture is the only land use option in areas immediately adjacent protected areas which serve as cores of elephant habitats are likely to be dismissed as utopian. But the social and economic hardships of villagers living under continuous threat from elephants to their property and crops may lead them to opt for other livelihood options which are less stressful and have a better revenue generating potential. Land distribution in most river valley development schemes of Sri Lanka are based on egalitarian principles, i.e. each settler is given the same area of land. The area of land per settler family in some of the more recent river valley development projects, such as the AMDP, was as low as 1-1.5 ha., including the area for constructing a house and establishing home gardens and cultivating paddy. The extent to which such a small area of land could provide a sustainable livelihood option and revenues for many settler families is questionable. In all river valley development schemes in Sri Lanka, cases where settlers have been known to either lease or sell their lands to other farmers or even outsiders are not difficult to come across. Hence, the feasibility of a Government Department repurchasing the land from a settler or giving the settler incentives to use it for alternative purposes other than agriculture merits serious consideration and should not be dismissed as unrealistic.

Even where agriculture is practised in lands adjacent to protected areas which are elephant home ranges, limiting cultivation to the wet season with the intention of opening fallow agricultural lands for dry season grazing by elephants must be investigated. In agricultural areas southeast of the Wasgomuwa National Park, elephants were observed feeding in fallow lands during the dry season (Ishwaran, 1993); similar observations have been reported for the African elephant too (Lewis, 1986).

Despite the fact that indisputable scientific evidence is lacking for the negative impacts which competition from water buffalo and domestic cattle may be having on elephant populations, it will be desirable to minimise grazing by domestic cattle in wildlands and keep wild water buffalo populations under check where they share grazing areas with elephants. A combination of prescribed burning and grazing techniques may also improve the value of *Imperata* and other upland, tall-grass grasslands as elephant habitats (see Ishwaran & Punchi Banda, 1982).

Interventions to construct water-holes for the elephants should be assessed with considerable caution; it would appear that the creation of water-holes or "mini-reservoirs" will be justifiable only when they are of sufficient size and are subject to a river-flow regime whose fluctuations can create adequate areas of grass-

lands along the edge of the water. Management interventions to create and improve grazing opportunities for elephants should also receive priority consideration over "habitat enrichment" programmes planting preferred browse species of the elephant. Increasing grazing opportunities is likely to provide better results in containing elephant herds and individuals within predetermined limits of their home ranges and minimising crop damage in nearby agricultural lands.

Community based tourism development options, as an alternative to agricultural crop production, in lands adjacent to elephant home ranges must be given serious consideration. This may be combined with the creation of "captive herd populations" similar to that in the Pinnawela orphanage immediately adjacent to the home ranges of wild elephants. The best option for success in captive breeding of elephants is to allow females to feed in areas frequented by wild male elephants. This technique is practised in several parks in India, Myanmar and Nepal (see Lair, 1997), where captive elephants, maintained near protected areas which provide home ranges for wild elephants, also carry visitors and tourists into the protected area, thereby minimising the need for road construction inside protected areas.

A pilot project which aims to experiment with using a protected area cluster for elephant conservation must be designed on the basis of the best available scientific date for the particular areas and elephant populations under consideration. Preliminary studies for rapid assessments of elephant movement patterns and population structure and for vegetation and land use mapping as well as socio-economic and villager attitude surveys are likely to be essential. Furthermore, management interventions that are to be tested out must be phrased as hypotheses, i.e. their predicted outcome should be stated explicitly and the time frame for monitoring and evaluating the outcome of management interventions must be defined (Peterson, 1996). The results and outcome of the pilot project must be objectively and rigorously analysed before any decision to repeat the project in other elephant ranges is entertained.

Table 3 Sex ratios (female/male) among observed numbers of sub-adult and adult elephants described in Table 1

	Sub-adult			*adult*		
	M	F	F/M	M	F	F/M
Trikkonamadu Area:						
a.	5	5	1.0	2	6	3.0
b.	4	19	4.75	5	8	1.6
c.	3	6	4.75	3	3	1.0
d.	2	7	3.5	1	2	2.0
e.	6.	14	2.33	5	8	1.6
f.	2	22	11.0	9	8	0.9
g.	5	10	2.0	2	8	4.0
h.	5	15	3.0	5	12	2.4
Avg F/M			3.7			2.1
Wasgomuwa area						
a.	4	7	1.75	1	7	7.0
b.	1	5	5.0	2	4	2.0
c.	3	12	4.0	-	2	--
d.	-	17	-	2	4	2.0
e.	8	15	1.88	5	9	1.8
f.	11	22	1.88	5	9	1.8
g.	10	21	2.1	5	15	3.0
h.	6	6	1.0	1	4	4.0
i.	4	9	2.25	2	4	2.0
Avg. F/M			2.5			3.1

Table 4 Sex ratios (female/male) among observed numbers of sub-adult and adult elephants described in table 2

	Sub-adult			*adult*		
	M	F	F/M	M	F	F/M
Yala NP						
	8	15	1.88	10	21	2.1
	6	13	2.2	7	19	2.7
Gal Oya NP						
	6	20	3.33	10	12	1.2
	5	6	1.2	11	7	0.64
	6	15	2.5	5	11	2.2
Ampara						
	6	9	1.5	11	11	1.0
	6	7	1.16	4	7	1.75
Lahugala						
	4	22	5.5	8	10	1.25
	7	34	4.9	12	21	1.75

Conclusions

Elephant conservation in Sri Lanka may be nearing a turning point where research and management may have to consider taking new directions. The future of *in-situ* elephant conservation would have to rely on clusters of protected areas and adjacent lands and their management to improve habitat conditions and expand home ranges. Land use options for villagers resident within and adjacent to elephant ranges must diversify beyond agriculture and consider animal husbandry, community based tourism development, rural and artisanal industries, and the establishment of educational and health installations. Areas adjacent to wild elephant ranges could also provide locations for managing captive elephant populations and thereby benefit island wide elephant conservation programmes and community based tourism operations. The design and implementation of a pilot project for the protected area cluster between Yala and Udawalawe National Parks, based on the best scientific information available, management interventions posed as scientific hypotheses and systematic monitoring and evaluation of results against predicted outcome, could mark a new beginning for linking *in-situ* elephant conservation and protected area management in Sri Lanka.

Acknowledgements

Ideas expressed in this paper were developed during my research career on the ecology and conservation of the Sri Lankan elephant from 1975 to 1985. Several institutions and individuals supported my work during that period and I owe my sincere gratitude to all of them. Although I cannot provide a full list here, I wish to recognise the following institutions which supported my research at various stages during the 10 year period referred to above: Department of Wildlife Conservation and Department of Zoology, University of Peradeniya (1975-1985), Smithsonion Elephant Ecology Project, Gal Oya National Park, Sri Lanka (1975-77), NARESA, Sri Lanka (1980-82), WWF/IUCN Project on the Conservation of the Asian Elephant-Planning and Management of the Wasgomuwa-Maduru Oya-Gal Oya Complex of Reserves (1980-82), USAID/ Mahaweli Development Authority studies on Environmental Impact Assessment of the AMDP (1979-1980), and Michigan State University, USA (1982-1985). Key individuals I wish to recognise here are: the late Prof. Hilary Crusz, Mr Lyn de Alwis, Prof. George A. Petrides (USA), Dr Charles Santiapillai, Dr Robert C. Olivier (U.K), Martin and Rosemary Sommer (Switzerland), Upali Ekanayake, Lalith Baranage, Tissa Alagoda, and Mr A.M. Punchi Banda and several other staff of the Department of Wildlife Conservation.

My participation in the National Elephant Symposium held at the BMICH, Sri Lanka, on 29 and 30 May 1998 was in a personal capacity. Hence the views and opinions expressed in this paper are mine and should not in anyway be interpreted as the policy of UNESCO and/or the UNESCO World Heritage Centre where I am employed.

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The elephant density of Ruhuna National Park as estimated by the dung count method, and a review of the methods used in Sri Lanka

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ABSTRACT *The density of the elephant population in Block I of Ruhuna National Park (141 km²), was estimated by indirect dung count method using data obtained from variable width transects. The dung density was found to be 527.10 (95% CL 198.54). The overall elephant density of the RNP-I was estimated to be 0.87 (Standard Error 0.12) km⁻². Although direct count methods have been used by several workers to estimate elephant population densities in Sri Lanka, indirect dung count method has been used only in one previous study. The various methods that have been used in the estimations of elephant density in Sri Lanka are discussed.*

Introduction

The Asian elephant *Elephas maximus* L. is considered a globally endangered species (IUCN, 1996). It occurs in 13 countries in Asia, including Sri Lanka, with a metapopulaiton of about 34,000 to 54,000, which is only one-tenth of that of the African elephant *Loxodonta africana* (Santiapillai & Jackson, 1990). In Sri Lanka it occurs in the Dry Zone (Fig. 1), mostly in Protected Areas.

The elephant is one of the most studied large mammals in Sri Lanka, but surprisingly authorities differ widely even in estimating the number of wild elephants in the country (McKay, 1973; Olivier, 1978; Hoffmann, 1978; Hendavitharana *et al,* 1994). There has been no rigorous scientific study to ascertain the size of the elephant population in any part of Sri Lanka, except by visual observation, the only exception being that of de Silva (1999) which estimated the elephant density in the Yala Protected Area Complex by the dung count method using fixed-width transects. Visual studies have been carried out by several workers in various areas, particularly in the Block I of the RNP (Eisenberg & Lockhart, 1972; McKay, 1973; Nettasinghe, 1973; Kurt, 1974; Ishwaran, 1981, 1993; Santiapillai *et al.*, 1984; Hendavitharana *et al.*, 1994; de Silva, *et al.*, 1995, 1997; de Silva *et al.*, (in press); Katugaha *et al.,* 1998).

The Ruhuna National Park (RNP) is situated in the south-eastern part of Sri Lanka (Figs.1 & 2) and has an extent of 979 km². The Block I (RNP-I) is in its south-western corner and has an extent of 141 km². It is the area of the RNP that is usually open to visitors for viewing animals. The present paper concentrates on the RNP-I, and deals with dung densities determined in variable-width transects. It also examines the advantages and disadvantages of the dung-count method and reviews the previous elephant density studies in Sri Lanka.

Study area and habitats

Ruhuna National Park (RNP) is divided into five blocks for administrative purposes but not with much attention to its ecology. Block I contains a variety of habitats and a good network of roads and tracks (Fig. 3). Its vegetation consists mainly of thorny-scrub and associated grassland, and dry evergreen forest.

The area of RNP has a known history of about 2,500 years and had once been a flourishing area of agriculture. It had an extensive system of irrigation reservoirs and rice fields and well developed human settlements by the 5th century AD, lasting until about the 12th century. Thus the forest cover in the area at present, whatever the type may be, is essentially secondary in character, developed during the last 500 years or so and has a very mixed composition. The area is scattered with irrigation reservoirs of varying sizes, most of which are in a completely dilapidated state and have developed into grassy-scrub areas; where there were extensive rice fields, grasslands have replaced them to day.

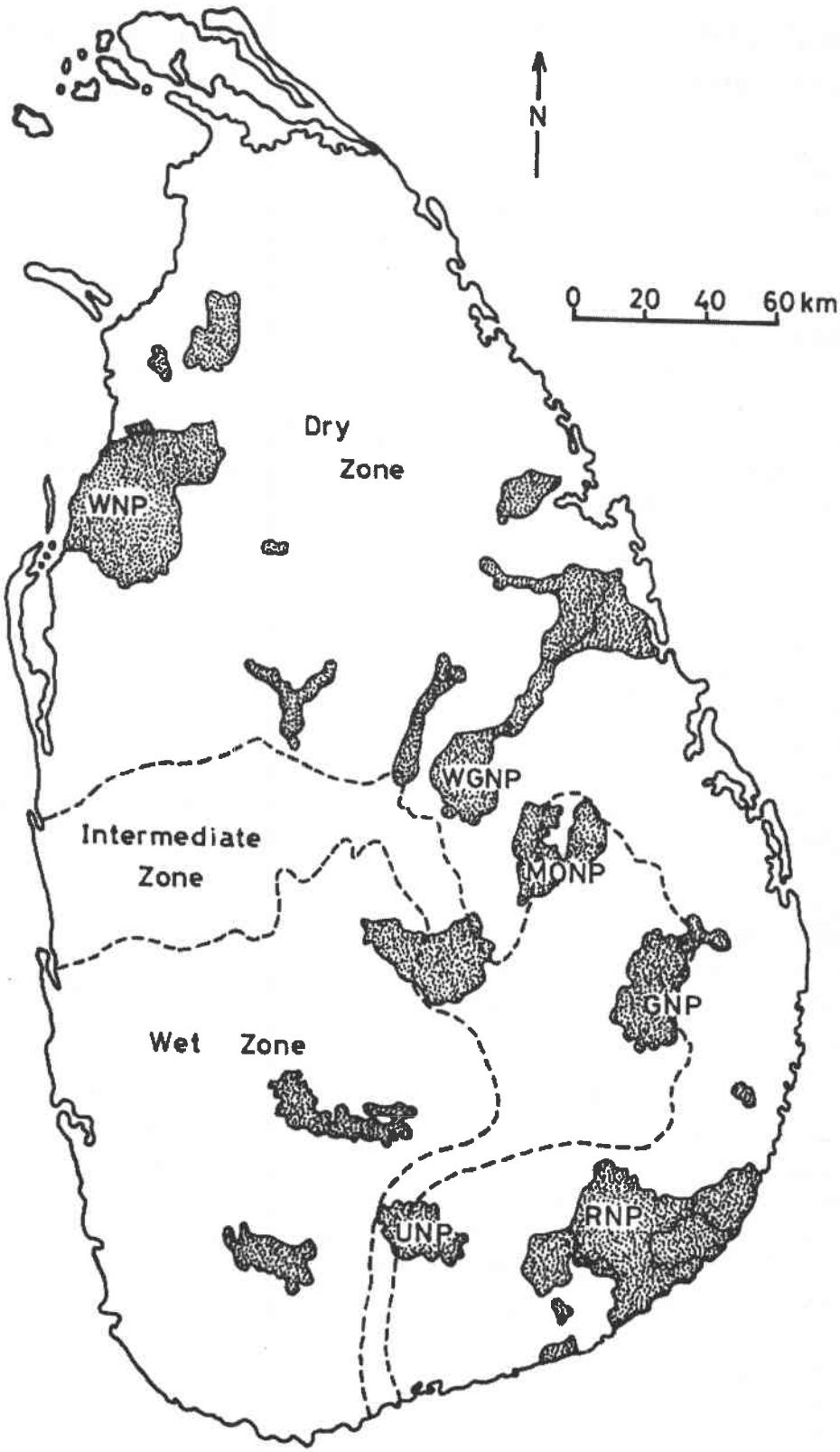

Fig. 1. Eco-climatic Zones and the major Protected Areas of Sri Lanka. GNP-Gal Oya National Park (NP); MONP-Maduru Oya NP; RNP- Ruhuna NP; UNP- Uda Walawe NP; WGNP- Wasgomuwa NP; WNP- Wilpattu NP

The vegetation of YPC is usually a mosaic of small areas of physiognomic types, some minor types occurring in small patches within a large area of a major type. The major physiognomic habitat types in RNP-I are the tropical thorn forest (thorn scrub), dry evergreen forest, riparian forest, forest-scrub, open scrub, grass-scrub, grassland with scattered trees, seasonally submerged grasslands, and sand dunes.

Methods

The study was carried out in August 1996, during the dry season (Fig. 4). In five transects (numbered 1-5 in Fig. 3) the perpendicular distance from a dung pile to the central line of each transect was measured. All transects were 2 km long except the 1st, which was 2.5 km. Elephant density was estimated as E = Yr/D, where E, Y, r and D are

$$\text{Elephant density} = \frac{\text{Dung density per km}^2}{\text{No. of days for total decomposition X No. of defecations per day}}$$

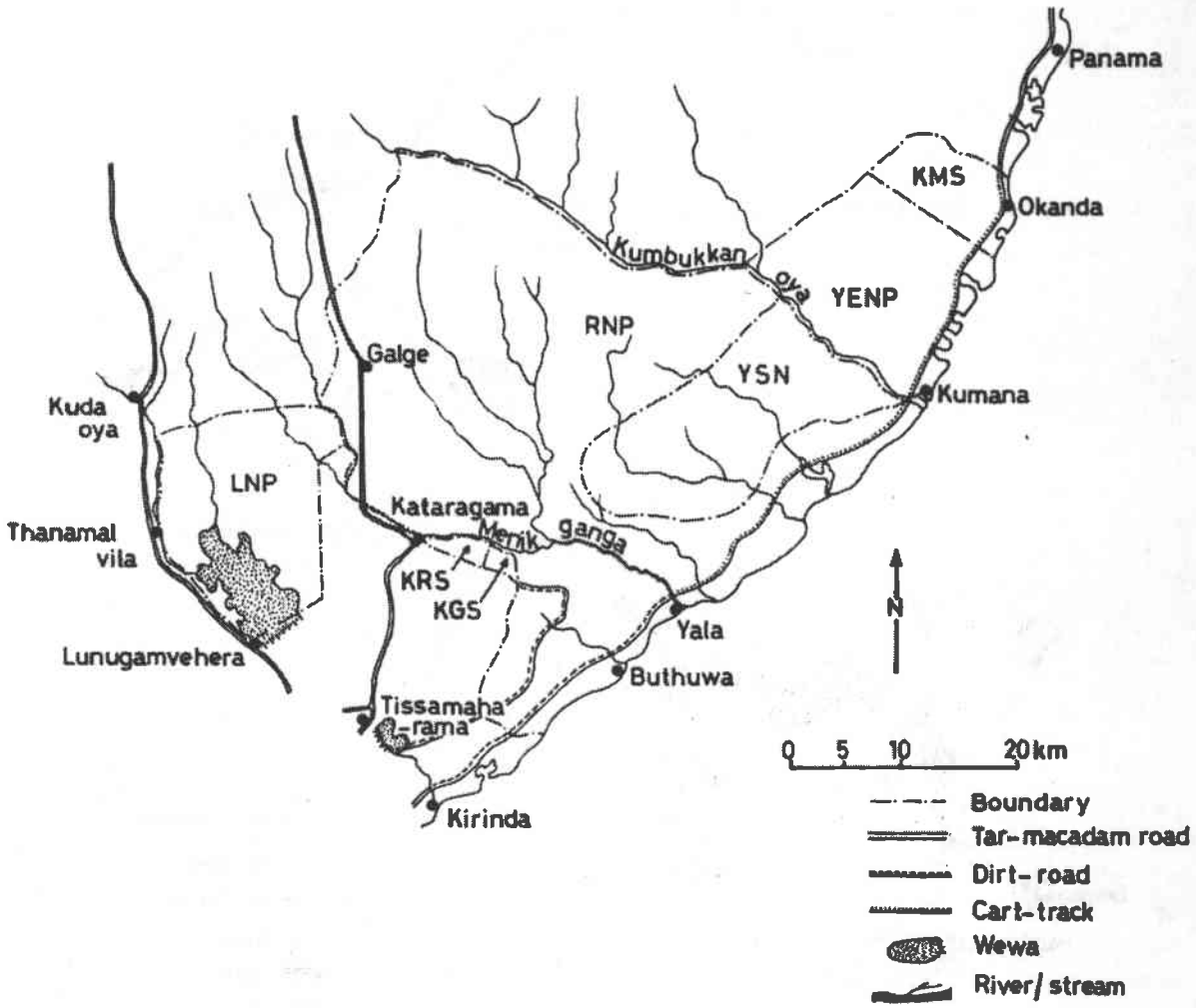

Fig. 2. Map of Ruhuna National Park and other adjacent Protected Areas
KGS- Kataragama Sanctuary; KMS- Kudumbigala Sanctuary; KRS- Katagamuwa Sanctuary; LMP- Lunugamvehera NP; RNP- Ruhuna NP; YENP- Yala East NP; YSN- Yala Strict Natural reserve

elephant density per km², dung density per km², dung decomposition rate per day and defecation rate per day, respectively.

The overall dung density of the variable-width transects was estimated using the computer software ELEPHANT from the Wildlife Institute of India at Dehra Dun. The average time taken for the total decomposition of dung and the average defecation rate were taken as 39.7 (Standard Error 1.0) days and 15.3 (Standard Error 3.1) times per day respectively, from a previous study (de Silva, 1999). The standard error (SE) of the mean density was estimated according to N.V. Joshi (in Varman *et al.*, 1995) using the formula,

$$(SE(E))^2 = (SE(Y) \times r/D)^2 + (SE(r) \times Y/D)^2 + (SE(D) \times Yr/D^2)^2.$$

Since the study was carried out within a single month, it was assumed that the dung piles would remain for approximately the same number of days in different habitats.

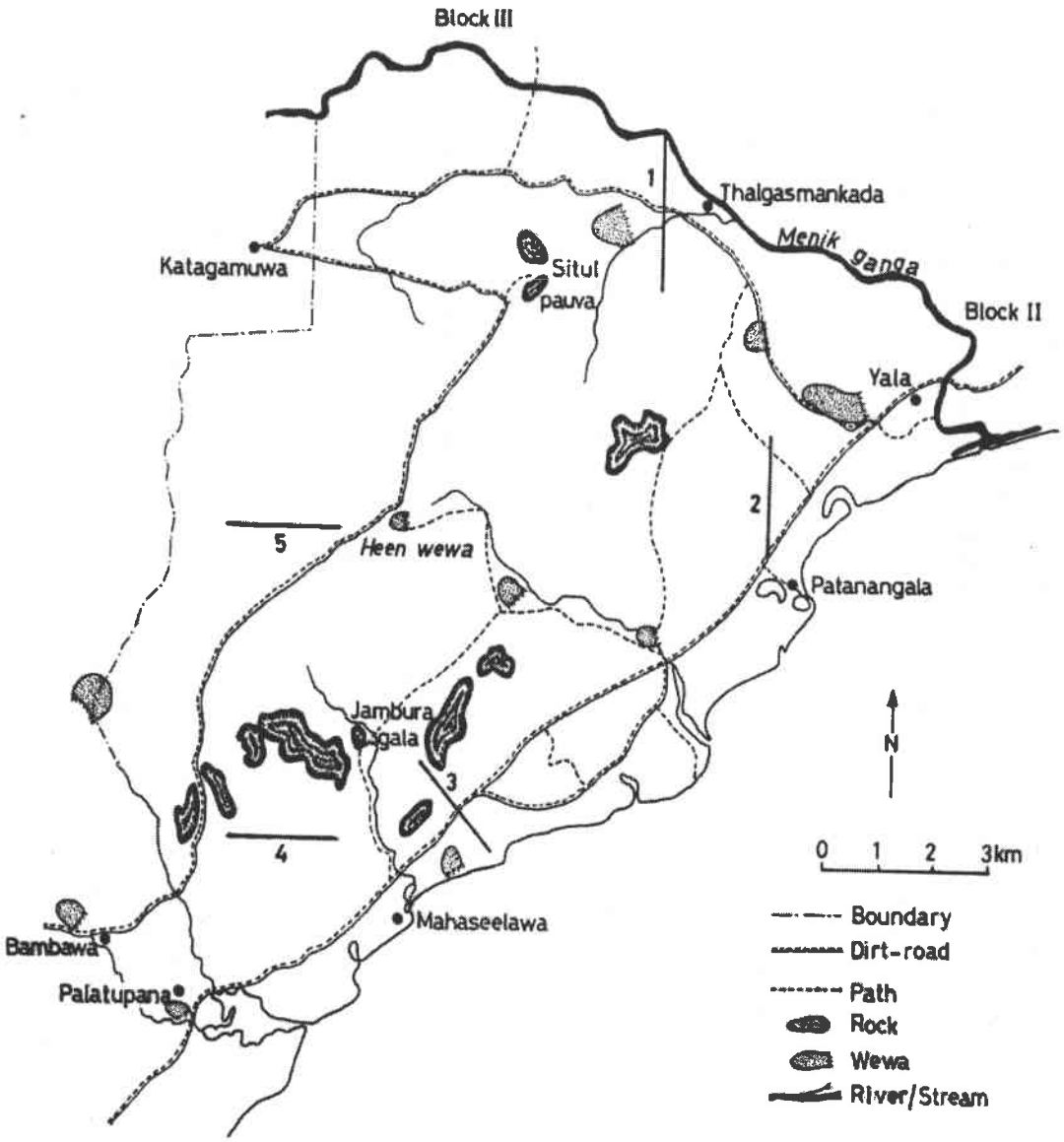

Fig. 3. Block I of Ruhuna National Park showing the locations of the five transects studied

Results

The mean dung density was 527.10 (SE 71.52). Therefore the elephant density works out to be 0.87 (SE 0.12) km^{-2}. Since the area of the Block I of the RNP is 141 km^2, the probable number of elephants in the area appears to be 123.

Discussion

Direct-count methods depending on the visual observation of animals, as well as indirect methods depending on the surveys of dung and other signs of activity have been used to estimate elephant densities in various habitats (Barnes & Jensen, 1987; Dawson, 1993; Dekker *et al.*, 1991; de Silva *et al,* 1995; Hendavitharana *et al.*, 1994; McKay, 1973; Sukumar, 1989).

Direct count methods could broadly be categorised into three types, viz. those using visual observations,

(a) on individuals and herds in defined areas,
(b) at waterholes, and
(c) along transects.

Indirect count methods could be broadly categorised into two types, viz. those using dung counts,

(d) in defined areas and belt transects, and
(e) along transects of variable width.

(a) Visual observations on individuals and herds in a particular area is the common method that has been used in Sri Lanka by many workers. The workers are familiar with a particular area and its elephant population. Thus, they could make a good estimate of the elephant number in that area. Usually, it takes much time, often more than a year to familiarize one with the elephants in a particular area. Tuskers are easy to identify from the characteristics of their tusks (de Silva *et al.*, 1997). Adult males also

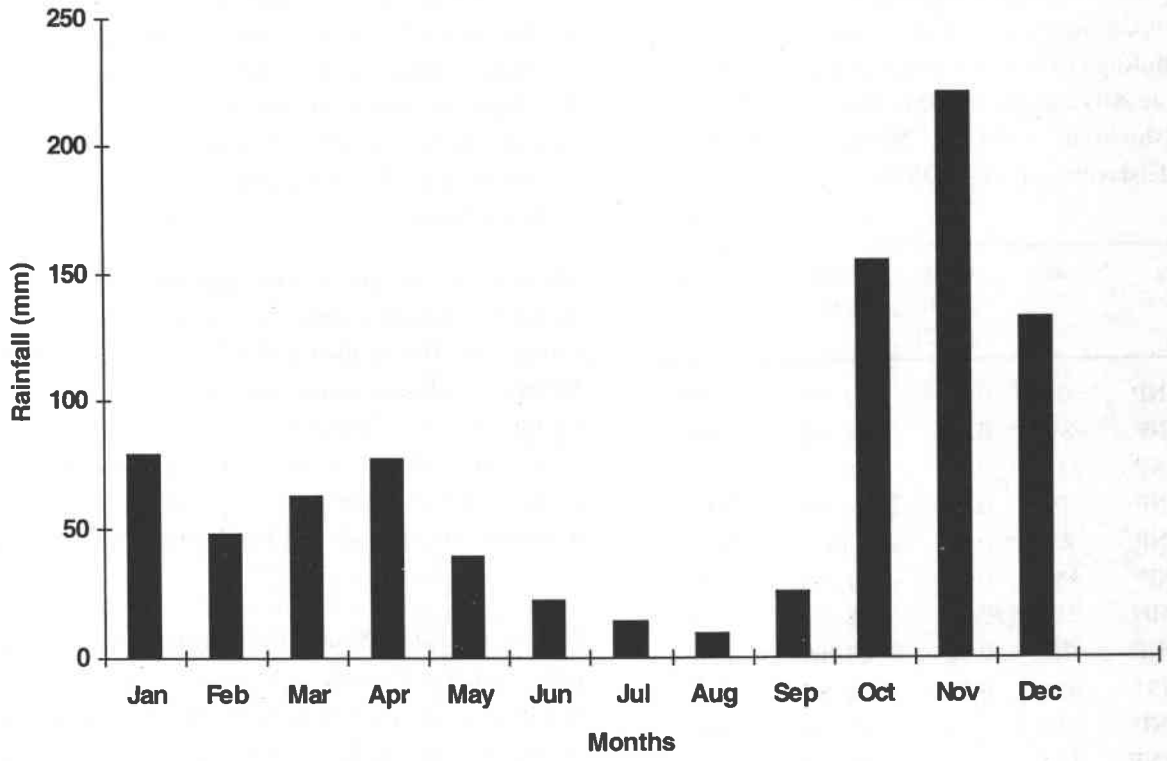

Fig. 4. The mean monthly rainfall at Palatupana (Block I) for the 15 year period 1980-1994

can be characterized by morphological as well as behavioural features. The herds can be identified by the number of juveniles and infants, characteristics of the adult females, and sometimes those of others. The method could be successfully used for a protected area or other demarcated areas.

Eisenberg & Lockhart (1972) were the first to use such individual identifications to work out the elephant density in the Wilpattu NP in northwest of Sri Lanka. Their study was followed by those of McKay (1973) in Gal Oya NP and environs and Ruhuna NP (Blocks I & II), Nettasinghe (1973) in Thamankaduwa area, and Kurt (1974) in Ruhuna NP (Table 1). The densities that were thus worked out for one or more areas sometimes have been extended to estimate the elephant population of the entire country by various workers (for a discussion see de Silva 1998).

Table 1 Estimates of densities of various elephant populations of Sri Lanka. (GNP:Galoya NP; LKNP:Lahugala-Kitulana NP; RNP:Ruhuna NP (Block I); RNP*:Ruhuna NP (Blocks I & II); WNP:Wilpattu N.P.; WsNP:Wasgomuwa N.P., TMN:Thamankaduwa area; YPC:Yala Protected Area complex). AN:Nettasinghe (1973); CS:Santiapillai *et al.* (1984); FK:Kurt (1974); GM:McKay (1973); JE:Eisenberg & Lockhart (1972); MS1:de Silva et al. (1995); MS2:de Silva (1999); NI1:Ishwaran (1981); NI2:Ishwaran (1993); WH:Hendavitharana *et al.* (1994).

Area	Number	Crude density (km^{-2})	Study period	Authority
GNP	310	0.19	'67-'69	GM
RNP	89	0.64	'68-'69	FK
RNP	21.6	0.15	'78-'80	CS
RNP	75	0.54	'91-'93	MS1
RNP	85	0.61	1993	WH
RNP*	150	0.63	'67-'69	GM
TMN	213	0.16	'68-'71	AN
WNP	70	0.12	'68-'69	JE
YPC	656	0.51	'95-'97	MS2
GNP	230		'75-'76	NI1
LKNP	150		'67-'69	GM
WsNP	65.8		'80-'82	NI2

(b) Waterhole counting method is based on the assumption that elephants will gather at waterholes for drinking. During the peak of the dry season only a few waterholes will contain water and the elephants will gather at these, particularly in the evenings, and are then easy to count. A method similar to this was carried out by the Department of Wildlife Conservation (DWC) in June 1993 (beginning of the dry season). The elephants were counted at various locations (not only at waterholes), mainly in the protected areas, by the DWC officials and local people who have a sound knowledge on where the elephants could be found during the period. The elephants were counted for six days in all 'elephant areas' of Sri Lanka except the northern region. The study involved some 800 individuals, including personnel from NGOs, who spent more than 57,000 man-hours in the field, recording elephants. The results indicated that there were *a minimum* of 1,967 animals in the regions surveyed (Hendavitharana *et al.*, 1994). It must be pointed out that in some regions only the readily accessible areas were subjected to the survey. For instance, in Blocks II, III, IV and V of RNP were only partially surveyed and that too only from the few available roads; the Yala Protected Area Complex, Yala SNR, Yala East NP and Kudumbigala sanctuary were not surveyed at all. Thus the survey resulted in only a partial count in some areas. But, this work remains the one and only attempt to estimate the elephant densities of the entire island by simultaneously studying the movement of elephant populations in different areas.

The method could give good results if proper precautions are taken, although it cannot be subjected to rigorous scientific tests. This method will also give demographic information on the population structure, group structure, etc., information that cannot be obtained by the indirect dung-count method. The method would obviously *underestimate* the population size since it is highly unlikely that all animals could be observed within the brief survey period.

de Silva *et al.*, (1995) used the daily observations of the park officials and guides to determine the monthly crude density of elephants in Ruhuna NP (Block I). In analyzing the observations, on the first run, they took weekly observations and eliminated the apparent repetitive observations by different game guards at the same time and same place.

The total number, the presence and number of tuskers, calves and juveniles in a group helped to eliminate the repeat observations of such groups. The times at which observations were made at different places also helped to determine the number of groups when two or more groups of similar composition were observed on the same day. After eliminating the apparent repetitions in the weekly observations, in the second run, the monthly observations were again examined and the apparent repetitions were eliminated. Such analysis indicated that the number of elephants monthly frequenting RNP-Block I varied from 36 to 108 with an average of 75. Therefore, the average crude density of elephants in the area was apparently 0.53 km^{-2} (range 0.26-0.77). The average crude density of adult elephants (including subadults) was 0.37 km^{-2}. These estimations give a *minimum* crude density as there could always be animals that were missed in the surveys.

(c) A better method is the visual counting of animals along transects (Dawson & Dekker, 1992). The method is good for areas where elephants could be seen easily. However, the method is quite impractical in the Sri Lankan situation because of poor visibility in scrub and forest habitats and the natural shyness of these animals. The groups (rather than the number of individuals within groups) are counted, each solitary individual being considered a group of one. From these, the mean group size is calculated. The sighting angle and sighting distance of each group are recorded from which the perpendicular distance from the centre of transect to the group sighted is calculated. From

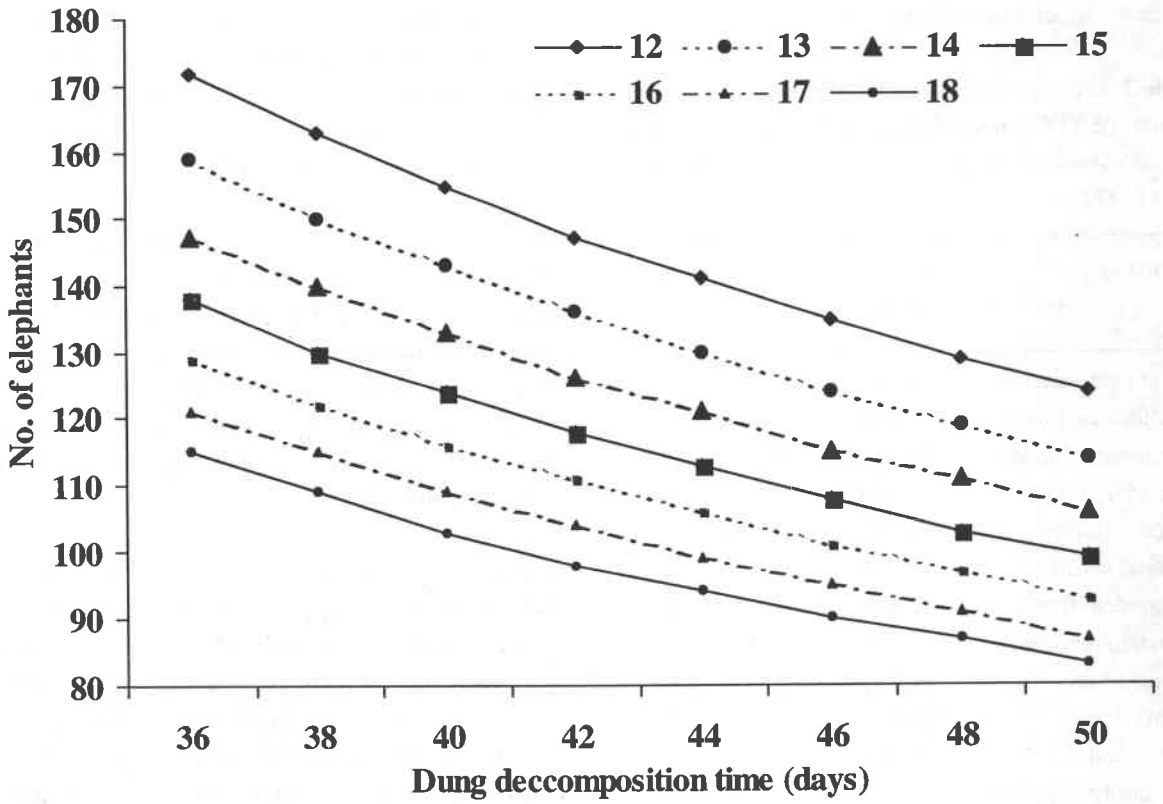

Fig. 5. The estimated number of elephants in Block I according to different defecation rates (12 - 18 times per day) and dung decomposition times

the perpendicular distances, the mean width and therefore the area of the transect can be computed. Since the number of groups in the transect is known, the density of groups in the transect can be estimated. The density of elephants in the transect is obtained by multiplying the density of groups by mean group size. The computations could be easily carried out using the computer software programme ELEPHANT (Wildlife Institute of India, Dehra Dun).

(d) In the dung count method, basically the dung piles of a particular area are counted and the density of elephants is worked out using the decomposition rate of dung and defecation rate. de Silva (1999) studied a total of 43 belt transects of varying length in twelve habitats in the Yala Protected Area Complex (YPC), transect width varying according to visibility within habitat. He worked out the elephant density for each habitat (Table 2) and from this the overall density for the YPC and its component reserves (Table 3) taking into account the approximate extent of each habitat in these. He thus estimated the elephant density in the Block I of the RNP to be 0.80 km^{-2}.

Table 2 The number and density of elephants in different habitats of YPC (except Yala East NP and Kudumbigala SA) as estimated by indirect dung count method by de Silva (1999).

Habitat	Total area in YPC (ha)	Elephant density (km^{-2})	No. of elephants
Semi-evergreen forest	3,329	0.00	0.00
Deciduous forest	31,184	0.21	65.5
Evergreen forest	29,138	0.42	122.4
Riparian forest	2,480	0.08	2.0
Thorn- scrub	4,213	0.91	38.3
Forest- scrub	23,652	0.70	165.6
Degraded forest (abandoned chena)	2,995	0.33	9.8
Open-scrub	14,737	0.58	85.5
Grass-scrub	10,943	1.03	112.7
Grassland	3,960	0.92	36.4
Seasonally submerged Grass cover	1,165	0.72	8.4
Sand-dunes	872	1.02	8.9
Total	**128,628**	**0.51**	**655.5**

Table 3 The average density and number of elephants in the components reserves of the YPC as estimated by de Silva (1999). (SNR:Strict Natural Reserve; SA:Sanctuary).

Component	Density (km^{-2})	Number
Yala SNR	0.61	176
RNP-Block I	0.80	113
RNP-Block II	0.70	70
RNP-Block III	0.52	212
RNP-Block IV	0.31	82
RNP-Block V	0.45	30
Kataragama SA & Katagamuwa SA	0.50	9
Total	**0.54**	**692**

(e) Dung piles can also be counted along transects of variable width. The perpendicular distance from each dung pile to the midline of the transect is measured and from these measurements the effective width of the transect is calculated. It is recommended that (a) a minimum of five transects from each stratum should be studied, (b) the transect length should not be less than 2 km, and (c) the total number of dung piles observed should not be less than 40 (Dawson & Dekker, 1992).

The accuracy of density estimates by dung count methods depends on the knowledge of defecation rates and dung decomposition rates. The representative defecation rate depends on the amount and nature of the food taken, and varies over a narrow and numerically low range (e.g. 12–18 times per day). Dung decomposition rates, on the other hand, can vary over a much wider and a numerically higher range (e.g. 40–80 days).

de Silva (1999) estimated the time interval between two defecations as 94.1 minutes (Standard Error 3.1, n=52) from daytime observations (0600 to 1830 hours) in RNP. This gives the defecation rate as 15.3 per 24 hours. On data collected from 37 wild elephants in Gal Oya area (situated to the north of RNP) (Fig. 1) in the dry zone, Vancuylenberg (1977) found that an elephant defecates 12 to 18 (modally 15) times a day. His data gives a mean defecation rate of 15.09 per 24 hours (SE 1.89). On the other hand, in the Mudumalai Wildlife Sanctuary (MWS) of southern India a defecation rate of 13.13 per day was

estimated by Dawson (1990) (see Dekker *et al.*, 1991), 15.08 per day by Desai (pers. comm.), and 16.33 per day by Watwe (see Varman *et al.*, 1955). (Dawson (1993) also used the defecation rate of 13.13 per day as an approximation in her study of elephants in Tabin Wildlife Reserve, Malaysia.)

On data from faeces distribution surveys and observations on a captured elephant Vancuylenberg (1977) found that defecation rates during daytime differed from those in the morning and in the night. Aananthasubramaniam (1992) also found defecation rate of domesticated elephants to be higher at night. On the other hand, other studies such as those of Sale *et al.* (1990), Coe (1972) and Wing & Buss (1970) found no temporal differences in the defecation rates.

Defecation rates should be estimated by observing the wild elephants while they feed and move in their natural habitat, a task that is difficult to carry out in most Sri Lankan habitats. Other approximations have been recommended, such as observing acclimatised domestic animals feeding entirely on provided natural fodder or feeding while free-ranging in the habitat(s) under study (Dekker *et al.*, 1991). Clearly, the composition and accessibility of food sources will affect the defecation rates, and environmental conditions will affect both the quality and quantity of food available. Also the defecation rates of different sexes and different age classes differ.

Dung decomposition rates are affected by several factors, mainly by environmental conditions, which could deter-

Table 4 Observations on dung decomposition by Ishwaran (1984) in the north-eastern part of Sri Lanka.

season	habitat	no. of dung piles	dung piles remaining after 30 days	status of dung piles at the end of observation period
Wet	Forest	7	4	4 remaining after 61days
		7	7	6 remaining after 52days
	Grassland	38	38	18 remaining after 52 days
Dry	Forest	8	8	8 remaining after 97 days
		4	4	4 remaining after 101 days
	Grass-Scrub	18	16	15 remaining after 98 days
	Grassland	7	7	1 remaining after 64 days
		7	7	7 remaining after 98 days
		2	2	2 remaining after 97 days
		2	2	2 remaining after 61 days

Table 5 Elephant density in the Block I of RNP according to different methods of estimation using dung count method. (* Density was computed by taking into account the dung densities in different habitats of YPC and the extent of each habitat in RNP-I). [1 & 2] de Silva (1999), [3] present study.

method	densities in different habitats[1]	transects of constant width[2]	transects of variable width[3]
Dung density(km^{-2}) (SE)	485.92*	460.15 (55.80)	527.10 (71.52)
Decay rate/day (SE)	0.0252 (0.0007)	same as in 1	same as in 1
Defecation rate/day (SE)	15.3066 (0.4655)	same as in 1	same as in 1
Elephant density (SE)	0.80	0.76 (0.09)	0.87 (0.12)

Table 6 Seasonal elephant density in Mudumalai Wildlife Sanctuary (Source: Varman *et al.*, 1955)

Season	Dry	Wet I	Wet II	Overall
Dung density (km^{-2}) (SE)	2126 (76.3)	3069 (148.9)	2706 (182.4)	2561
Decay rate/day (SE)	0.01 (0.0012)	0.013 (0.0013)	0.007 (0.0004)	0.0097 (0.002)
Defecation rate/day	16.33 16.33	16.33 16.33		
Elephant density (95%CI)	1.32 (1.19-1.47)	2.58 (2.26-2.86)	1.30 (1.10-1.46)	1.54 (1.01-2.08)
SE (Elephant density)	0.07	0.14	0.08	0.27

mine the activity of dung decomposition agents such as dung beetles, termites and even micro-organisms. For instance, dung decomposition in forest habitats appeared to be more rapid than in grassland habitats in RNP (de Silva, 1999). On the other hand, Ishwaran (1984) found that the dung decomposition is more rapid in the grassland habitat than in the forest habitats in the north-eastern part of Sri Lanka (Table 4). The difference is probably due to the nature of grassland; grasslands in the RNP being dominated by short grass species and those of the north-eastern part of Sri Lanka being dominated by tall grass species. Also the temperatures in the grasslands of RNP are higher. During the main rainy season (October to January) a dung pile in RNP would disappear in as little as a week (heavy rains tend to disintegrate and erode dung pellets; this also accelerates decomposition). Heavy rain especially affects 'amorphous-mass' dung piles at Stage D of decomposition (Dawson & Decker, 1992). Ishwaran (1984) also found that the dung decomposition rates in the north-eastern part of Sri Lanka during the wet season are higher than those during the dry season (Table 4). On the other hand drought conditions with high temperatures may reduce the decomposition process, even reducing the activity of micro-organisms. It was observed that in sand dunes of RNP, the total decomposition may take 80 days or more and that the macro-decomposing organisms such as beetles and their larvae, and termites, were not present (de Silva, 1999). Dawson (1993) found that for the total decomposition of elephant dung during the dry season in Tabin Wildlife Reserve in Malaysia, it took on average, 140.84 days and that there was a total absence of the activity of macro-decomposing agents such as dung beetles and termites.

The average time taken for the total decomposition of 25 dung piles in the grassland and grass-scrub habitats of the RNP was found to be 39.7 (Standard Error 1.0) days (de Silva 1999). On the other hand, the average time required for total decomposition of elephant dung in Mudumalai Wildlife Sanctuary (MWS) has been estimated as 78.74 days (i.e an average decomposition rate of 0.0127 day^{-1}) by Dawson 1990 see Dekker, 1991), 57.14 days (average decomposition rate of 0.0175) by Desai (pers. comm.) and 103.1 days (average decomposition rate of 0.0097) by Varman *et al.* (1995). In fact, the last authors note that the time taken for total dung decomposition in MWS could vary from 5 days to 273 days.

The dung count method assumes constant environmental conditions or a steady state so that dung decomposition rates as well as defecation rates remain constant. The number of dung piles deposited each day is assumed to be equal to the number of dung piles disappearing the same day. Furthermore, seasonal movements of elephants from area to area between seasons could affect the dung densities in a particular area. Therefore it is important to complete the survey in as short a time as possible within one season.

Subject to these limitations, the method could be used to estimate approximate mean densities. It provides a *rapid* and *crude* technique to estimate density and the *time* the animals spend in each habitat type (de Silva, 1999). However in MWS, the estimation of elephant density by direct counts (3.09 km^{-2}) was twice that estimated by dung count method (1.54 km^{-2}) (Varman *et al.*, 1995).

The elephant population in the in RNP-I is the most studied in Sri Lanka (Table 1). Most workers attempted to assess the elephant population by visual observations and thus obtained a minimum density. de Silva (1999) in assessing the elephant density in the entire YPC complex by dung count method, found the density in RNP-I to be 0.80 km^{-2} (Table 3). [In his study de Silva (1999) estimated the

dung densities in different habitats and used these dung densities to estimate the elephant densities in different components of the YPC (including RNP-I), taking into account the extent of each habitat in each component.]

When the number of dung piles in each of the nine transects in RNP-I (excluding the transects in the sand dune habitat because the latter were very short transects) in the previous study (de Silva 1999) were used to estimate the elephant densities without reference to the habitat, the density works out to be 0.76 km^{-2} (Table 5), which is slightly less than that calculated when the habitats were taken into consideration. [In the present study in the dry season of 1996, the five transects were positioned more or less in the same positions of five of the nine transects of the previous study, but the transect lengths were increased to 2 km or more, where necessary. The present study gave a higher density of 0.87 km^{-2}].

Obviously, the estimated elephant densities depend on the accuracy and applicability of dung decomposition rates and defecation rates to the particular study. The variation in the elephant number of RNP-I on different dung decomposition rates and defecation rates is shown in Fig. 5.

More elephants were observed in RNP-I during and following the main rainy season of October-December (de Silva *et al.*, 1955, 1957). McKay (1973) found that during the wet season there were about 1.7 times as many elephants as during the dry season in Gal Oya area and that this factor was more than six times in Lahugala area of Sri Lanka. Varman *et al.* (1995) showed that the elephant densities in the Mudumalai Wildlife Sanctuary differ in different seasons (Table 6). On the other hand, in Wasgomuwa National Park area of Sri Lanka, Ishwaran (1993) observed about twice as many elephants during the dry season as during the wet season.

Different densities in different seasons indicate that at least some elephants move from area to area when the season changes, obviously in search of more and better quality food, and more importantly water. In RNP, elephants used to move from Blocks III, IV and V of the RNP to Handapanagala area (outside RNP) because of the perennial irrigation reservoir in the latter area. Unfortunately, this route is now closed because of the development of the intervening area as a sugar plantation. Thus, it is interesting to study the distribution of the elephants in the component reserves of the YPC during the wet season.

Acknowledgements

I am grateful to the former Directors of the Department of Wildlife Conservation of Sri Lanka, Messrs W.A. Jayasinghe and C.P. Attanayake, for granting permission to carry out this work, and to Messrs B.A. Muthubanda (former Park Warden of the Ruhuna National Park), B.V.R. Jayaratne (former Deputy Park Warden of Ruhuna National Park) and W. A. Sarath, (former Wildlife Ranger, Moneragala) for their help during the study. Thanks are also due to various Wildlife Guards, especially Mr Wimal Kodituwakku who accompanied my team to different areas of YPC and helped us in many ways during the study. Figures 1 to 3 were drawn by Mr T.S.B. Alagoda of Dept. of Zoology, University of Peradeniya.

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COMMENTARY

Abusing the elephant: pseudo-specification and prognostication in ancient elephant lore

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This review of mine will restrict itself to a few observations - I fear, not of a very favourable nature - on some old manuscripts on elephants which have gathered together folklore once prevalent in India and Sri Lanka, but which, perhaps from sentimental reasons, have so far not been shown up by scholars for what they really are - a lot of baloney! I will look at these works from two aspects - firstly, their attempt to distinguish elephants, not on the zoological basis of genus and species, as should be, but on a pernicious classification into caste familiar to India and our society, and secondly, their concern with the animal's anatomy, not out of a biological or physiological interest, as we find in Aristotle several centuries before, but from pseudo-scientific pretensions that by its peculiarities it could presage the destinies of men and empires. I will however both enter and exit from my cursory review of these texts with brief etymological exegeses which could be of some relevance to elephants in this context.

Though elephants, including the now extinct *Mammuthus* ranged the plains and forests of the world with the first men, who, as you know, either avoided or fled them, or on occasion surrounded and hunted down individual beasts, the nomenclature by which the animal is identified, is not merely of relatively recent origin, but has an interesting etymology in the Greek. For, with the Greeks *elephas* originally applied not to the animal himself but to "ivory" or "tusk", which came to them as an item of commerce, which they procured and crafted long before they had any idea of the nature of the beast which produced it. For, by the time the poets, Homer, Hesiod and Pindar were using it in that sense in the seventh and sixth centuries B.C.[1] the Syrian (an *Elephas maximus*) and the Egyptian (a *Loxodonta africana*) were both extinct in those lands, the former by the 9th century B.C. the latter, even before the dynastic period of Egypt (pre 3200 B.C.). Greek travellers of the like of Hecateus, Hellanicus, Skylax and Herodotus had still to begin visiting distant lands. Nor had the Greeks started sending out colonies to places where they could have encountered people coming from elephant countries, who could give them a clear notion of the source of the ivory they called *elephas.*

Of recent times there has been a certain amount of conjecture on the etymology of *"elephant"* itself (the word for the animal that passed into many of the European languages) and naturally also on *"elephas"* (ivory) that made its appearance in Greek before Homer. The closest of these is that *elephas* comes from the Semitic *aleph,* which also gives us, through the Phoenicians, the first letter of the Greek and Roman, hence other European alphabets. The only difficulty is that without qualification it simply referred to "ox".[2] The Arabic *fil,* with the article *al* prefixed has been suggested (hence *al-fil*)[3], but of greater likelihood is the Hebrew *ibah,* which itself strongly recalls the Sanskrit *ibha(s),* and with *el,* the definite article in Semitic (hence *el-ibah=el-ibhas(s))* gives a convincing phonetic equivalent of the Greek *el-ephas.*[4] As for the *ant* in *elephant,* which unaccountably bothered Sri Emerson Tennent and led him to consider Pott's suggestion that is possibly derived from *"hindi",* i.e. *"Indian",*[5] I have shown that it comes simply (and quite meaningfully at that) from the genitive case in Greek of *elephas,* i.e. *elephantos.*[6]

If then Greek *elephas* for "tusk" or "ivory" which gave rise to the word "elephant" and which the Greeks themselves used to cover the two extant species (they did not observe a distinction) of the sub-family Elephantinae, i.e. the *Loxodonta africana* (the African elephant-which Herodotus mentions) and the *Elephas*

maximus (the Asian elephant - which Aristotle examined), this etymology, pursued a bit further has an even more interesting possibility re elephants *a propos* tusks - and nowhere else than in our Sri Lankan scenario. For, in the same way that the Sanskrit *ibhas,* with Arab *el* prefixed passed through the Arab trade in Indian ivory into Greek to give *el-ephas, al-ibha(s)* could have given rise to the word *aliya* as is used among us. Evidence of this is the fact that *aliya* is of late appearance in Sinhala (c. 16th century B.C.). The regular words for elephants had been such as *hasti, gaja, atha.* Besides, *aliya* would have, like the Tamil *aliyan,* which is derived from it, originated in the region of the Wanni where from antiquity Arabs and their descendants, the intrepid panikkeas, trapped and traded in elephants and ivory,[7] and hence would have employed this new term for the purpose (for them most useful) of distinguishing the tuskless of the species from the tusker.

Thus it is that with no zoological difference, a distinction has been struck between two animals of the same species on the basis of what is no more than an "accident" - the possession and non-possession of tusks. As is well known, the value of the tusker over the non-tusker is both utilitarian and cosmetic - tusks are valued as merchandise, the animal himself for ceremonial - and both (as far as the Asian elephant is concerned) have depleted their number, either by killing them off or withdrawing them from reproduction in the wild.

With this distinction of *aliya* from *atha* in the Sri Lankan and indeed Asian context, and considering that around 94% are tuskless as against 94% being tusked among African elephants, there arises the question - what are its tusks to the elephant, an evolutionary perk, with which the *aliya* has sadly not been gifted, or an evolutionary relict, which the *aliya* is well rid of? Here however we must leave this question well alone as it is of no direct relevance to the present discussion.[8]

Of the *Loxodonta,* two species are scientifically acknowledged, the *L. africana africana,* or bush elephant the largest living land mammal, and the *L. africana cyclotis* or forest elephant, a smaller animal once exploited by the Cathragenians for war, and to which surely belonged those elephants which Hannibal brought over the Alps into Rome in 218 B.C. not to mention that formidable battle-elephant with just one tusk *(alter dente multilato)* whom the Romans nicknamed Surus, or "the Stake".[9] Like these sub-species of the African, the three sub-species recognized of the Asian i.e. the Sri Lankan *Elephas maximus maximus,* the mainland *E. maximus indicus* and the Sumatran *E. maximus sumatranus* manifest little difference except in size, pigment or hirsuteness, and so are popularly designated in terms of the habitat countries. Despite this, one now and again sees a palaeontologist or zoologist resorting to scanty or frivolous evidence (even pictorial, as from prehistoric cave-paintings), to identify new subspecies when such difference can sufficiently be accounted for on the basis of climate, terrain, fodder or some hereditary or genetic aberration, as much as if found among human beings.[10]

Still, to the extent that such overspecification claims to be grounded on science, however subtle the considerations be, they can well be left to elephantologists to agree or disagree. As far as I am concerned, and here, the issues of overspecification based on dubious claims directs my attention to a bunch of elephant lore from India and Sri Lanka, which, likewise basing themselves on such trivia or accidental features of the elephant's physiognomy, assigns castes to each and every animal, going even beyond this to read off them such things as the animal's psychology, intelligence and longevity, culminating in an esoteric exercise of making prognostications on the owner, his wife, his son, even his wretched mahout,- and that too to an amazing degree of pinpointedness!

To this range of pseudo-sciences may belong whole corpus of elephant *mantrams,* the wanted *nila sastra*[11] and perhaps a good deal of the so-called *ali vedakama,* including its pharmacology, which are still held in dumb admiration by a credulous public from a failure on the part of researchers to test them out for what they are worth. For, in my opinion, it may be that by posing as true knowledge, it was this kind of heresiology that kept a true science of the elephant

from evolving in this country and India, the like of which one saw possible in the studies of Aristotle, Aetius and others in classical Greece, even when the animal was so alien to the land. It may be equally true that such bigotry even deprived the animal himself of the true understanding and sympathy he really deserved in countries where his service to mankind during their long history has been inestimable. For, as will be seen, quite apart from misreading signs and symptoms which they manifest or develop, often enough elephants have been deemed to presage misfortune to people and indeed as often to be deemed to be the cause for them!

Pernicious as the caste system has been among men, it seems even more baseless and perverse to have foisted it on elephants, as in fact it has been done in India and Sri Lanka. Besides, caste is not, in the case of elephants, derived from their heredity - for nearly all elephants have been captured from the wild, and of those few born in captivity itself from already pregnant females, only the mother could be known with certainty. (This perhaps is the reason why we are told of Dutthagamini's royal mount, Kandula, that his father was seen and recognized as a Chaddanta when he brought him and left him by a watering place at the birth of the prince).[12] In general however the assignation of caste is to individual animals, and made upon casual features and a pretentious wisdom concerning them.

The Indian *Gaja Sastra* distributes elephants into three castes - *Bhadra,* which is the highest, *Manda* the next, and *Mirga,* the lowest, identifying each by a distinctive set of physical and psychological qualities. So far so good. But then it goes on to admit mixtures of two of these primary castes, calling the result *Misra,* and of all three of them, calling them *Sankirna.* Thus it is possible that, as Deraniyagala's evidence shows,[13] an animal may be in the chimerical plight of possessing the point of one caste anteriorly, those of another posteriorly; others may have the head of one caste, the belly of second, the hind quatrers of a third, while in yet others the head and back may be of those of one caste, the trunk, belly, limbs and tail those of another. Recognition of caste features is based on surface anatomy, and the scrutiny is effected by dividing the elephant's body horizontally and vertically into a grid of nine segments.

This is all very well as when a butcher carves a carcase into "cuts", or when one tries to spot the points a cross-bred dog has inherited from either parent, perhaps even the features a child had genetically come by from this side and that - here in the case of elephants even using the mythological prototypes for the identifications. But to grade them in general as superior or inferior on the mode of arrangement of the parts reflecting one or the other caste is scientifically meaningless and totally prejudicial. For example we are told:

> "Those with *Bhadra* characters in front, *Manda* characters in the middle and *Mirga* posteriorly are good. If the animal is *Manda* in front, *Mirga* in the middle and *Bhadra* posteriorly, the animal is mediocre, and if *Mirga* anteriorly and *Bhadra* mesially it is inferior."[14]

How ridiculous such caste-based schemata are seen if *mutatis mutandis,* they are applied to the Indians themselves - a man's head might be *Kshatriya,* his chest *Brahmin,* belly *Sudra* and his limbs *Vaisya.* Or to look at it from the caste system in our own country- head *Karava,* chest *Govi,* belly *Salagama,* limbs etc. some other. Such men might be deemed superior, while a reshuffling of caste and parts might render them mediocre or inferior!

Making confusion worse confounded are the further Indian divisions of elephants according to seven *amsa* - *Brahma, Indramsa, Varuna, Chandra* etc, each with to own characteristics and attributes, and again into ten *satvas* (e.g. *Deva, Kshatriya, Sudra, Sarpa* etc.), also with their own distinctive physical qualities and behavioural tendencies.[15] Of the *Vaisya satva* elephants it is said that the are,

> "patient, endure heat or cold equally well, eager to eat flesh, drunkards, mischievous, cowardly, very willing learners,"[16]

and of the *Sarpa satva,*

"gait zig-zag like the track of a snake, will attack a friend without provocation. Continually hisses like a snake, will not feed when in rut. Odor bad, resembling sponge, toddy, mud, or flesh."[17]

Cutting across these bases of categorization come yet others, this time classifying elephants according to colour, smell, ability to transport loads, patience and locality of capture. [18]

"Good elephants smell like lotus, khus-khus or jasmine. Bad ones smell like mutton, crow, tortoise, fish, toddy, rut water, perspiration, saliva, urine and dung."[19]

"Elephants suited for war or the hunt possessing brown hair all over, especially on the face and emitting a body odor resembling Kalagaru occur in the Eastern Punjab and Thaneshwar."[20]

Finally, the life of the individual elephant itself is divided into twelve ten-year periods (*dasā*), each period manifesting different characteristics, while the first *dasā* is even treated year by year. Of the eighth year of this first *dasā* (i.e. when the animal is eight years old) the description is:

"Penis often erect, will stand beside females. Passion causes them to injure their trunk and limbs. Rut water will ooze from their temples. They have a high immunity from disease, wounds heal rapidly. Temper serene, fit for all types of work but not for arena combat."[21]

Such detailed testimonia would sound almost like astrological analyses and forecasts, did they not pose off as the result of scientific observations. By themselves and simply, they may pretend to be something of the latter, but taken together with the kinds of accompanying projections we have seen, which have their own respective qualities, *caste, amsa, satvas* etc. the elephant presents itself as a giant jig-saw puzzle in which similar (sometimes identical) pieces of five or six lesser jig-saws are all mixed up, not just physical ones but also psychological, behavioural and indeed, (as we shall see), even prognostic.

Not to be outdone by Indian elephant lore are the Sinhala treatises of some antiquity such as the *Gajayoga Satakaya,* the *Hasti Lakshana Vidyawa,* the *Gajatu Lakshanaya,* the *Maha Gaja Lakshana Sangarahava* and the *Atunge Lakshana,* which make even more fantastic claims of reading the elephant, starting with caste and graduating to a charlatan science that renders the animal a walking oracle-more often than not, a walking calamity.

The first four of these texts distribute elephants into ten castes, assigning them names such as *Gangeia* (Gangetic or rivery), *Tambara* (coppery), *Pingala (tawny), Mangala (auspicious),* of which the *Chaddanta* (six-tusked) was surely the noblest. This last is described as follows:

"Body and eyes golden in colour, nails resemble light-coloured sealing wax, eyes elongate, limbs of medium length, hands and feet elongate, not very hairy; trunk, penis, tail touch the ground; age 200 years."[22]

and in the *Maha Gaja Lakshana Sngarava* as:

"Trunk and tail elongate, tall or medium-sized body, forehead and bump slope upwards, tusks thick, ears curved, hair appears like golden chains upon the body, nails shaped like the waxing moon. Does not lose temper even when molested, fond of dainty food; span of life 120 years. Brings fame and honour to the king."[23]

Descriptions of this nature sometimes border on the poetic, lifting the elephant out of the world of reality and into a demesne like that of the *Chaddanta Jataka* (No 514), in which fantasy reigns. The *Maha Gaja Lakshana Sangarahava* alludes to a psychology of the breed and indeed to a prognosis concerning its owner - the sort of thing Indian lore also dabbled in, and of which the *Atunge Lakshana* abounds. For, this last mentioned work gives a catalogue of *subha lakunu* (propitious characteristics) and *asubha lakunu* (unpropitious characteristics) which may be found in elephants, much as if they were lines on the palm of one's hand of planetary positions determined by one's horoscope, which go on to presage, not only about the

elephant himself (sometimes that he will soon die) but about the king who owns him, his queen, his sons, his ministers, has country or even the lowly mahout.[24] For example one finds among the *subha lakunu:*

"Elephants having reddish lips, tongue and mouth. Thin eyes similar to those of the house sparrow, perfect mouth, long and straight tail; and the elephants having a large frontal bump (*kumbasthala*), two broad ears and perfect mouth, will bring wealth to your Mjesty" (No.2)

"O king, elephants answering the following descriptions are suitable for you to ride on - Right tusk having elevated tips, face and long trunk covered with reddish coloured spots. Unseen limb joints and well-formed hind part of body." (No,3)

"Soft tusks and nails. Long tail and trunk. Eyes like emeralds. Reddish spotted face and trunk. Elephants possessing the above characters will live long." (No.4)

To this list is added a subscript, and quite sensibly, saying, "Out of a thousand there cannot be found even one possessing all the above qualities and no single elephant will possess all these characters." For my part, I feel that many of these aberrations and symptoms deserve the speedy attention of a vet. Instead, in the recounting of the *asubha lakunu,* there are a whole lot more of this nature.[25]

"The elephant whose colour is similar to that of a red earthworm will bring disaster to the kingdom through fire. Also elephants having conspicuous testicle area and white and multi-coloured spots on the body will bring disaster to the country." (No. 3)

"A double-nailed elephant should be discarded immediately. It will bring disaster to the king and the entire court." (No. 7)

"There will be continuous sorrow and weeping in the house of the owner of an ugly elephant from whose eyes tears trickle down always." (No. 13)

"The possession of an elephant with a narrow right cheek will result in the owner having frequent quarrels with his sons." (No.21)

"If the left check is narrow, then the king will disagree with his ministers." (No. 22)

"A dumb elephant will cause lack of rain." (No 23)

"A deaf elephant will cause loss of wealth and induce fear through enemies. (No.24)

An elephant with a single tusk will ruin the king's people." (No. 35)

"O King, the elephant that casts no shadow will cause trouble to your friends." (No. 25)

"Any elephant with a rough scrotum will ruin its owner's tribe and destroy the king's wealth." (No. 31)

"The possession of an elephant with a small penis, spots of itch on its body, smellers, nails and trunk, will result in the death of the owner and his relations through want of food." (No. 32)

"An elephant with hair on his head and tail and a charred-looking skin will result in the destruction of his mahout's house by fire." (No.15)

This time I would like to add my own subscript: "What would the situation be if the king, or anyone else for that matter, possessed several elephants at the same who possessed diverse characteristics presaging contradictory happening?"[26]

A great deal of this *hasti astra* is, it will be seen, based on a belief in sympathetic magic and is nothing more than gross superstition. Information of the nature that we have here could only have been gathered by scientific experiment, repeated observation, divine dispensation or simply fetid imaginings. It is for elephant scientists (if indeed they would consider it worth their while!) to take a few of these and test them for their

degree of veracity, and this is what I suggest be done, as I would in the case of the *nila* hypothesis. The results would declare whether our ancients were in possession of some remarkable knowledge of elephants or had been gulled, and gulled others all these centuries with a farrago of stupidities that gave pretence as knowledge acquired by a serious science of elephantology in this island. On the other hand, if they are what I think they are, all these ancient works that have provided this information are only a literature of make-believe, with in some cases adverse repercussions on the innocent elephant. It is only by inquiry, however cursory that be-that this literature will be seen in its true perspective, rather than by letting it survive uncommented upon out of a misplaced sense of patriotism - or whatever. It is even possible that, as with some Sinhala folk beliefs re elephants that have how been established scientificaly;[27] there may be a degree of factuality (as some claim for the *nila* theory) in at least one or two items that have drifted to our times with this great deal of floatsam and jetsam, that are worthy of our notice.

As I stated at the outset, I would like to conclude on an etymological note. This time it is on the name of one of the castes the Sinhalese identify in elephants, in fact the most well known of them for having also a mythical dimension - I mean the *Chaddanta.* For Wilhelm Geiger translates *chaddanta* when he refers to Kandula, the most famous of the breed and perhaps the most famous elephant in all history, whom King Dutthagamini road to victory over the Damilas in the first century B.C. as "of the six-tusked race", even though the realistic tradition makes him very much a two-tusked animal.[28] This ambiguity inherent in the name also looks back to that much-loved of jatakas I referred to, the *Chaddanta Jataka,* in which the Bodhisatta, born as a majestic elephant of that breed, lived with his herd close to a lake also called "Chaddanta", and was killed for his resplendent tusks.

Now, it is quite unlikely that the herd got its name from the lake - for whoever heard of a six-tusked lake? If, on the other hand, the lake was named after the elephants who frequented it, the name of the breed or caste must be older than the fourth/third century, B.C., when the majority of the jatakas were composed and inspired probably by Airavanta, four-tusked and winged elephant of Indian mythology, the king of elephants and mount of the god, Indra.[29] the scholiast on the jataka explains the Pali *chabbisāna* (Skt. *shadvishāna*) "six tusked" as *chabbanna,* meaning six-coloured perhaps, as H.T.Francis says, "more completely to identify the hero of the story with the Buddha."[30] But this is awkward, as the tusks are at the same time being called "white without flaw" (*seta subhāseta*). So we are left with a six-tusked elephant, of which the queen in the story wanted a pair, or simply a two-tusked animal, the origin of whose *kula* - name goes way beyond the jataka itself, and to a different origin.

This I find in a simpler and more ready-at-hand explanation of *chaddanta,* only it takes the romance out of this particular variety of elephant and makes him just another elephant. This is to take the more immediate meaning of *chaddanta* as "six-toothed". For tushes or tusks excepted, the Asian elephant manifests a total of six teeth - two molars on the upper jaw which grind against four on the jaw.

However, in his *History of Animals* Aristotle, directing his attention to the elephant's teeth, had observed:

> "The elephant has four teeth on either side, by which it munches its food, grinding it like so much barley-meal; and besides it has two large teeth (or tusks)"[31]
>
> *Ho d' elephas odontas men echei tettaras eph' hekatera, hois katergazetai tën trophën (learner d' hōsper krimna), chōris de toutōn. allous duo tous megalous.*

By Aristotle's reckoning the elephant would then have (beside the tusks) eight teeth-or to put it differently, four molars on the upper. jaw which grind against four on the lower jaw. As may be guessed, the error has arisen from Aristotle's unawareness of the phenomenon of molar succession and the fact of having had but one animal or two for his study.[32]

So then, if by *chaddanta* was meant "six-toothed", not "six-tusked", credit may be recovered for Indian antiq-

uity through the right reckoning of the elephants dentistry - only, it renders not just one caste of elephants as *Chaddanta* but every single animal - a lesson from elephants a caste-ridden society could profitably turn upon itself!

Little then is left of the *Chaddanta's* description if its poetic quality of gold-coloured body, hair and eyes, nails of sealing-wax colour resembling the waxing moon and a few other distinctive qualities are excepted. It is not even an exceptionally large animal, notwithstanding the epithet *saddanta* used in Sinhala for an extra large person. All that we would in the circumstances be left with for the *Chaddanta* would be from our classic example, Kandula, which are probably the psychological quality of self-control under pain, as when he was scalded by molten lead at the seige of Vijithanagara, and the psychic quality of bringing fame and honour to the king who rode him.[33] And both these, belonging as they do, to that mass of folklore that I have just focused attention on this paper, brings us back to where we began - the need to comb through such literature to determine what material has resulted from realistic inquiry or observation worthy of science, and what needs to be swept away as superstition and fantasy.

References

1 Liddell and Scott *Greek - English Lexicon* s.v.

2 Hence the old Latin *bos Lucas* i.e. "Lucanian ox" (Lucr. v. 1301) as Pausanias calls the rhinoceros *tauros aithiopikos.*

3 Bochart; see. J.E.Tennent *Ceylon. An Account of the Island, Physical, Historical and Topographical,* vol. II part VIII 'The Elephant', London (1860) ch. 1p. 271 n.1

4 And refers to the elephant itself without the ambiguity of a derivation from the purely Semitic *eleph* ("ox"). Supported by Benary, see Tennent *loc.cit.* See also Liddel and Scott *loc.cit.*

5 On the parallel of *tamar-hindi* = "indian date" i.e. tamarind. See Tennent *loc.cit.*

6 Like Gk. *gigas - gigantos* - giant, or *Aias - Aiantos* = Ajax, See my 'A note on the Etymology of Elephant', *Journal of the R.A.S. (Sri Lanka)* vol. XXXVIII p.164 - 168.

7 The Sinhala *aliya* makes its first appearance in the *Yogaratnakaraya,* dated to the 16th century, and afterwards in the 18th century *Sangarajasadadhuchariyava.* For Tamil *aliyan* and its derviation from Sinhala, see S. Gnanapragasar publ. *The Etymological* and *Comparative Lexicon of the Tamil Language,* Chunnakam (1938) p. 153. Tamil too used it for the tuskless elephant. Elsewhere in Asia the tuskless bull was called a *mukna.* On the panikkeas, see Tennent *op.cit.* p. 335, also p. 336-337

8 See however my "The Irony of Ivory" *Loris* vol. XX, no. 2, (Dec. 1993) p. 56-60

9 See Pliny *N.H.* viii. 11 who mentions the bravery of the animal. A pun on his name is found in a verse of Ennius - *unus surus surum ferre, tamen defendere possent,* while a humorous description of Pseudolus posing off as a slave called Surus in Plautus' comedy *Pseudolus* (vs. 1218 f.) emulates that of an elephant.

10 See Richard Carrington *Elephants* Pelican Books (1958). Each of these two species (African and Asiatic) shows local variations in structure and habits in diferent regions, and these are sometimes accompanied by important differences in external appearance. If the variations are very marked, scientists regard the animals as a distinct subdivisions of the species, and a third name is added to the specific name to distinguish it". (p.25). "Subspecies of both these elephants are recognized, but only the African forest elephant *(Loxodonta africana cyclotis)* has any special claim to importance." (p.28). "The differences between the various Asiatics ubspecies are in any case so trivial that it will not be necessary ..... to make further distinction between them." (p.28)

11 See my "Nila in Elephants: Physical Fact or Human Input", *Loris,* vol. XIX, No. 6, (Dec. 1992) p. 199-203

[12] *Mahavamsa,* xxii. 60-63.

[13] For the contents of the Ancient and Medieval Indian and Sri Lankan texts referred to in this article I rely completely on the English summaries given of them by P.E.P.Deraniyagala in *Some Extinct Elephants, their Relatives and the Two Living Species,* Govt. Press, Ceylon (August 1955). Appendix I and II p. 130-139. On nila, see p. 140-142, on medicaments p. 142-146 and on charms, p. 146-147.

[14] Deraniyagala *op.cit.* p.130. The elephant, according to Indian folklore, is a devolution, not evolution - and from Iravata (Ariyavanta), a four-tusked winged male, and Abhramu, a tuskless winged female. The *Manda* caste resulted from the curse of a sage whose hermitage was wercked by falling branches when a Bhadra elephant perched on a tree above it! Deraniyagala *op.cit.* p.132.

[15] Deraniyagala *op.cit.* p. 133-134.

[16] Deraniyagala p. 133: *Satvas* no. 5. Elephants do not eat flesh. The idea possibly have risen from the sight of an elephant holding a torn limb in its mouth. Carrington *op.cit.* p. 81 ("The fear of rouge elephants has even on occasion caused them to be branded man-eaters.") and my 'Man-Eating Elephant: Reply', in *Loris* vol. XXII no. 1 (June 1985) Letters p, 30. But a flesh-eating elephant is nothing surprising here - among the *asubha lakunu* is one which does not cast a shadow!

[17] Deraniyagala *loc.cit. Satvas* no. 9. The parallelism in this case, as in the elephants equated to other *satvas* (living beings) is obvious. Cp. *Deva,* beautiful, shiny, strong, or *Sudra .....* wil eat garbage and dry twigs, emit a smell like black scorpions etc.

[18] Deraniyagala, p. 134-135.

[19] Deraniyagala, p. 134 item (b).

[20] Deraniyagala, p. 132 item (5)

[21] Deraniyagala, p. 132 (eighth year)

[22] Deraniyagala, p. 136 item (10)

[23] Deraniyagala, p. 137 item (10)

[24] The Medieval A *tunge Lakshana,* says Deraniyagala, was sent to him by Mr. N.G. Ikangantileke. For the *subha lakunu,* see Deraniyagala *op.cit.* p. 137-138.

[25] Deraniyagala, *op.cit.* p. 138-139.

[26] Compare the ancient Greek and Roman practice of reading the entralis - especially the liver of a sacrifical victim, or the flight, direction and cry of birds. Here however only a single and otherwise undisclosed omen was read in any given crisis.

[27] For instance the popular belief confirmed by T.A. Bongso *et.al.* 'Estimation of shoulder Height from Forefoot Circumference in the Asian Elephant, *Elephas maximus' Ceylon Journal. of Sci.* (Bio.Sec.) vol. 1 XIV nos 1 & 2 (April 1981) p. 79-82. (This had already been checked in 1881 by a Mr. Mitchell, Secretary, on a single female in the Regents Park Zoo) (see Tennent *op.cit.* p.337 footnote). Also the folklore preserved in *An Historical Relation of Ceylon,* p.22 on the elephants' care of the young and allomothering, the last of which was recently researched on African elephants by P.C. Lee ('Allomothering among African Elephants' in *Animal Behaviour* vl. XXXV. p. 278-291)

[28] *Mahavamsa loc.cit.* In a freak case, an elephant may develop a split tusk; see Carrington *loc.cit.* Prehistoric Gomphetheridae has tusks on both upper nd lower jaws. One wonders whether (leaving his wings alone) the conception of the mythological Airavanta as a four-tusked elephant was not all imagination but owed itself to Gomphotherid fossil - find in antiquity. (Shortly after I wrote this note, my attention was drawn to a similar conjecture expressed by Bob Bloomfield of the Natural History Museum of London that Cyclops, the one-eyed giant of Horner's Odyssey. could well have been imagined from the fossiled head of a dwarf elephant)

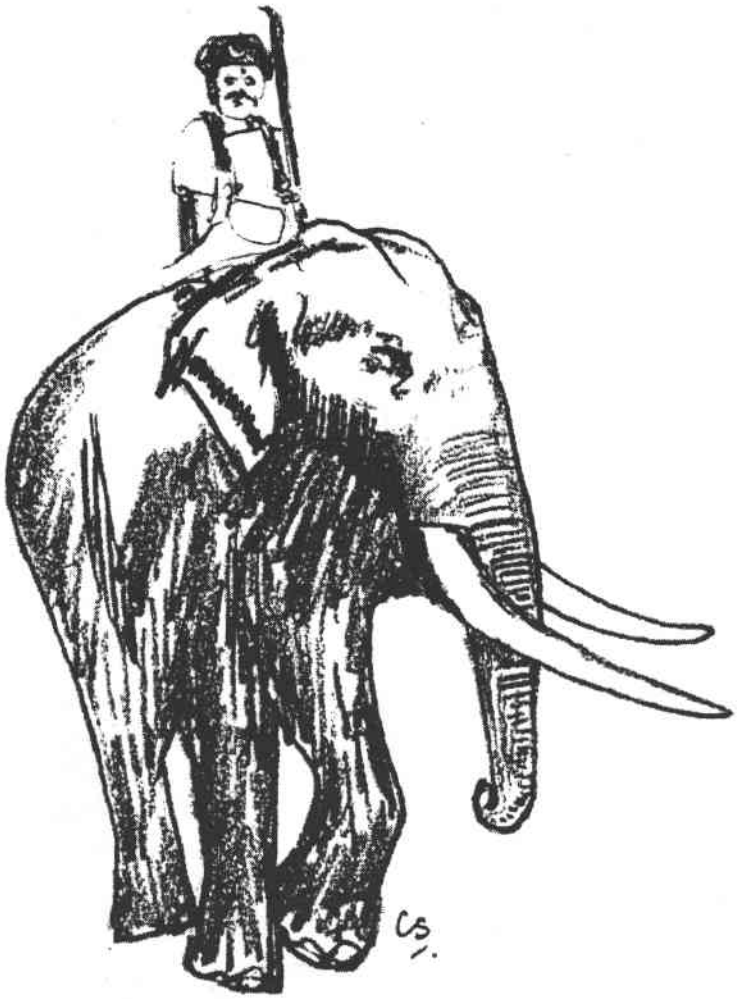
[29] See n, 28 above. Interesting Pictet (see Tennent *loc. cit.*) sought to derive the word "elephant" from *Airavanta* (or *Ailavanta*). But it is hardly likely that the Greeks or anyone else would have rummaged in Indian mythology for a word for elephant when there would already have been one easily available in the ordinary parlance of the Indians.

[30] E.B. Cowell transl. The *Jataka* vol. London (1975) p. footnote.

[31] *H.A.* ii. 5. 50lb 30-33. Aristotle goes on to say that the male's tusks are upturned, while those of the female, which are small, turn downawards. He adds that when the young are born they already have teeth - which shows he had seen one or more at birth as well.

[32] It is possible that in the elephants studied by Aristotle the succeeding upper jaw molars had already come into play as in a skull of a elephant examined by me recently at the temple at Aukana.

[33] For the Vijithanagara episode see *Mahavamsa* xxv. 28-40. As for the wisdom of fighting from elephant-back, history is not all supportive. Certinly some kings did have their reservations, and fighting from horseback, lived to fight another day- even prince Dutthagamini himself upon his Sindhi mare Dhigathunika, in which episode Kandula did not come off well (*see Mahavamsa* xxiv. 12-21 and my 'Kandula: Elucidations on the Sinhala War Elephant' Journal *R.A.S. (Sri Lanka)* vol.XXX (N.S) (1985 - 86) p. 47f.)



SHORT COMMUNICATION

Temporal gland secretions in the female Asian elephant

H. I. E. Katugaha
285/1, Talatuoya Road, Ampitiya, Kandy, Sri Lanka

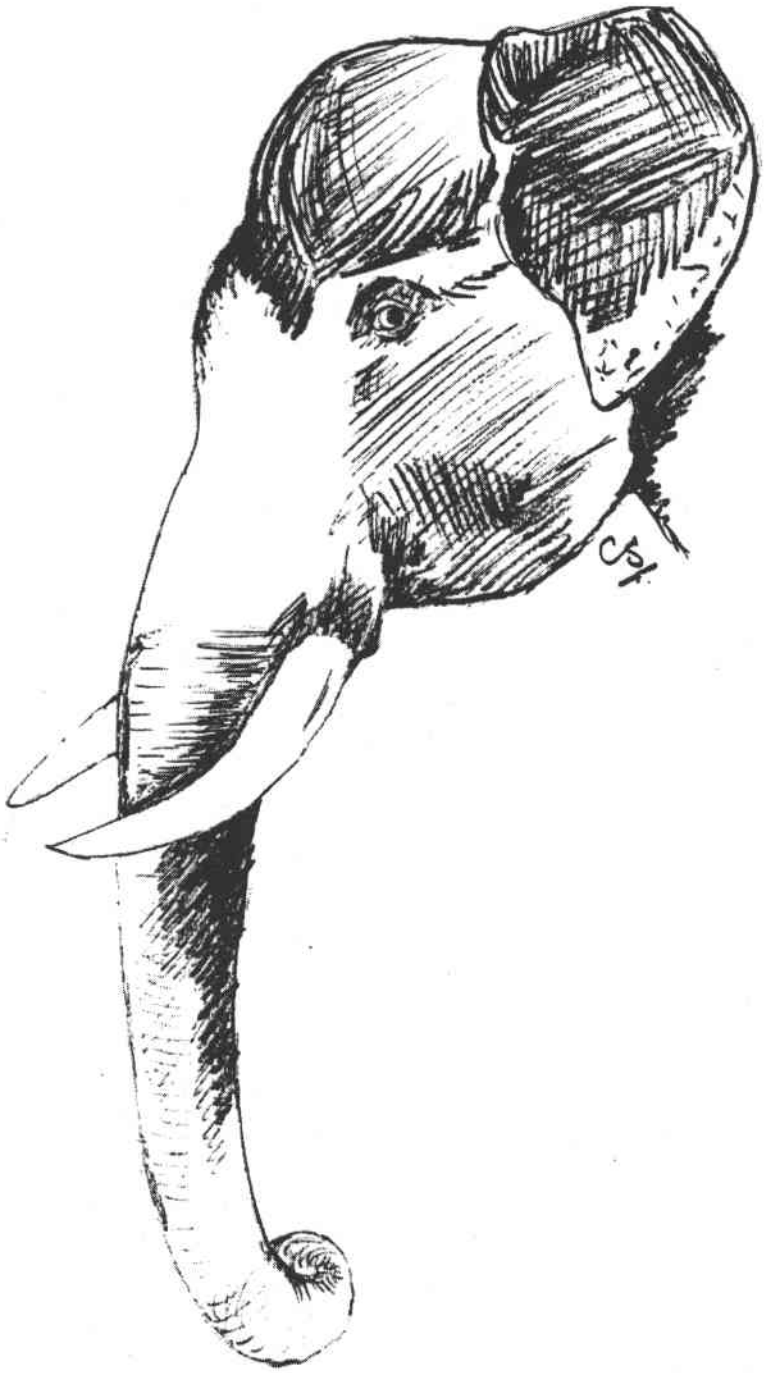
It was on 21 January 2000, while visiting the Ruhunu National Park that we came across four elephants standing quietly on the far side of the Buttuwa Lagoon. Two adult females and two calves were soon joined by another female and her calf. We stopped our vehicle and waited as we were sure they would cross the lagoon and come over towards us. They crossed the lagoon at 0930h and came over to a vehicle that had been parked in front of us. The leading female, obviously the matriarch, looked agitated though we did not disturb her in any way. She circled the vehicle in front of us and then came to our vehicle with the calf running behind her. When she was going around our vehicle, we noticed that she was secreting from her temporal glands. She was no more than five feet from our vehicle and kept circling us making a peculiar sound that can only be described as *"Kek Kek Kek Kek"*. She was clearly agitated though she did not show any aggression. When another vehicle came up behind us, she went over to that and repeated her performance. Then another female and calves came across the lagoon and joined the herd. They milled around our vehicles for a good half an hour before they moved off into the jungle.

Our tracker was astonished. He had never seen this before in a female elephant. The last time I saw a female having temporal gland secretions was nearly fifty years ago, again in the Ruhunu National Park. Walking was allowed in the park in those days as there was no road network as we see today. Our party consisted of the late Sam Elapata Dissawe. The late A. H. E. Molamure, our camp cook David, Tracker Pinoris and myself, than a school boy. A herd of seven elephants was seen along the Jamburagala road with the Matriarch showing copious secretion issuing from her temporal glands. While we were observing the herd a large male came along. He was not in musth. He approached the female and began stroking her temples and them tasting the secretions. Each time he did this, he gave a shrill trumpet. This was repeated over fifteen times and the herd along with the male moved off into the jungle. Our tracker Pinoris predicted that the male would certainly come into musth, in a day or two. Though we tried to locate the herd for two days we could not get at it to test our trackers prediction. He had seen females showing temporal gland secretions on two previous occasions.

It is well known that in the African elephant, both males and females show temporal gland secretions. Both Cynthia Moss and Joyce Poole have observed that female African elephants show copious secretion when excited, especially when two herds meet up after a temporary separation. It is very marked in the "Greeting Ceremony" as descried by them.

This phenomenon is rare in the female Asian elephant. So far the reason for this is not known. R. Sukumar states that "female Asiatic elephants occasionally secrete from their temporal glands, although the precise significance of this is not clear. I have seen cows secreting in an advanced state of pregnancy or calving"

Though the condition of musth has been known in the Asian elephant for centuries, it was recognized in Africa only recently after the work done on the male elephants in Amboseli by Joyce Poole and Cynthia Moss. I am informed by elephant owners that some female elephants in captivity too have shown periodic temporal gland secretions though not as copious as in the males.



SHORT COMMUNICATION

Elephants in stone

H. I. E. Katugaha
285/1, Talatuoya Road, Ampitiya, Kandy, Sri Lanka

In Asia elephants have been associated with man for several centuries. Ever since elephants were captured and used by man, they have been loved, hated and even worshiped. Kings and nobles kept large numbers of them in captivity. They were used in temple ceremonies. It is therefore quite natural that the elephant has come to play a role in history, culture, art, religion, folklore and folk tales of most of the Asian countries.

In Sri Lanka too elephants have been tamed and used in captivity for over two thousand years. They were used in war, and our ancient kings had special establishments for their welfare and training. Our capital has shifted from place to place and wherever there had been a capital, we see historical remains even today. It is in these ruins of ancient places that we see the elephants in stone.

In Anuradhapura we come across several examples of elephants beautifully carved in granite. One of the most beautiful is the herd of elephants coming to water, carved on a rock by the rock pool. These elephants are carved showing a herd coming to water with one young tusker sporting in the water. The artist has captured the mood of the elephants and the expression of the one in water is classic (Fig. 1) This is attributed to the period circa 4th century.

The elephant has been utilized as a decorative motif either singly or in groups with tremendous effect at the entrances to temples, basements of the dagobas, and on pillars. The Anuradhapura kingdom remained stable from the 4th century BC to 993 AD when the capital shifted to Polonnaruwa.

One of the most beautiful carvings of elephants are

Fig. 1. Stone carving of a young tusker at Isurumuniya, Sri Lanka. c. 4th century BC

found in the moonstones. Though carved steps are found in India the Moonstone is peculiar to Sri Lanka. The elephants are found carved in rows or in rows with other animals, usually the bull, horse and the lion (Fig.2). It is interesting to note that the bull is absent from the moonstones in Polonnaruwa. This is owing to the Chola influence where the bull is a sacred animal not fit to be tread upon. There are several beautifully carved moonstones in the ancient city of Anuradhapura that can be seen today - an artist's expression that had withstood that test of time. It is interesting to note that in a moonstone discovered at Lahugala Magul Maha Vihare some of the elephants carved are dressed and a few of them have riders on them. To my knowledge this is the only moonstone yet discovered to have riders on some of the elephants. Elephants are seen carved in stone at Mihintale too. Here there is a basement depicting lions and elephants.

The carvings of elephants during the Polonnaruwa period are even more fascinating. They are in a better state of preservation. Here again they are found on beautifully carved moonstones. The Chola influence is clearly seen as the bull is absent from moonstones and we come across, for the first time, a very good carving of "Gaja Lakshmi", on the side of the famous Gal Potha (Rock Book) of King Nissanka Malla, (Fig 3) Goddess Lakshmi is depicted holding flower while two elephants, one on either side, are seen pouring water. The Polonnaruwa period was from 1017 to 1275 AD. There is a row of elephants carved at the site of King Parakrama Bahu's council chamber. It is astonishing to note the accuracy of the anatomical details shown on these carvings.

The elephant has become a part of our lives here in Sri Lanka and it is certainly not surprising to see the elephant used in the most exquisite manner. Where ever we go to any ancient place, we are sure to find carvings of elephants in stone. Where any of our kings created a place of worship, the elephant became a symbol to be seen at the entrance. During a much

Fig. 2. Moonstone, Anuradhapura period. c. 4th century BC.

later time when stone work gave way to wood work, as in the Kandyan Period, we come across another work of art depicting an elephant. Two beautifully carved elephants in stone, were seen at the entrance to the Temple of the Tooth (Fig. 4). These sculptures were not originally found here. They were found among the remains of the palace of King Narendra Singha at Kundasale (18th century). The date when they were brought to Kandy is not certain. The carving of the elephants is exquisite. Unfortunately these two superb specimens were blown up when the Temple of the Tooth was attacked by terrorists from the north in January 1998.

Wherever you go in Asia to see the cities of the past, you will come across elephants in stone. Some of the finest sculptures of elephants in the world are found in India. Many are found in Burma and Thailand. The association between man and elephant has come down the centuries. Today the Asian Elephant is endangered species. We can only hope that the conservation efforts that are now being made will succeed.

Fig.3. Gaja Lakshmi, Polonnaruwa period. 1017 - 1275 BC.

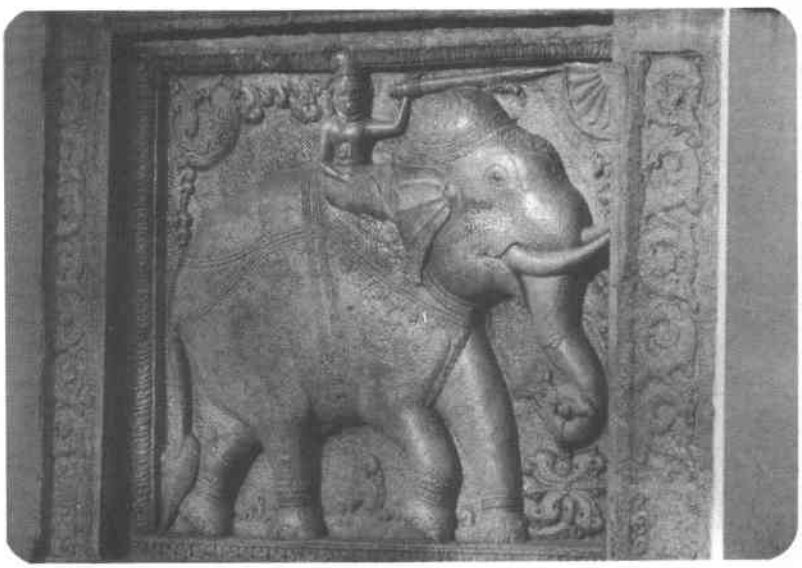
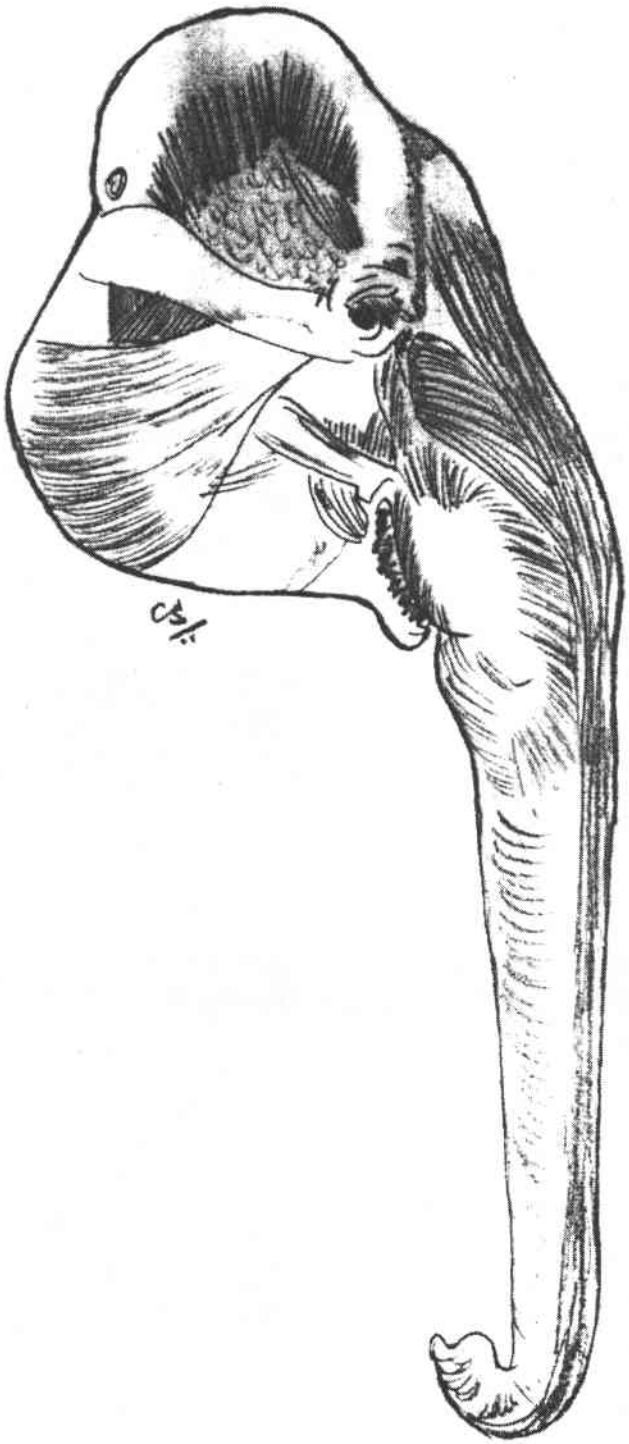


Fig. 4. Stone carving of a tusker and its mahout, at the entrance to the sacred Temple of the Tooth, Kandy. 18th century AD. From King Narandrasinghe's palace, Kundasala.



SHORT COMMUNICATION

Saving elephants by helping people - a community integrated pilot project to resolve human-elephant conflict in Sri Lanka

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The Sri Lankan elephant (*Elephas maximus maximus*), which has shared a special cultural bond with the people of Sri Lanka for centuries, now faces an uncertain future. Reduced to fewer than 3,500 in the wild, the elephant has suffered from habitat loss, habitat fragmentation, habitat degradation and poaching for ivory. Dedicated conservation efforts, backed by political will and commitment and adequate financial support, are needed to halt these threats and ensure the long-term conservation of the elephant. The conservation benefits would be far-reaching not only for the Sri Lankan elephant, but also for the many other species of plants and animals that share the elephant's range and the human communities that have co-existed with the elephant for so long.

Perhaps no other wild animal in Sri Lanka has had such a close relationship with people as the elephant. In Asia, this unique relationship between people and elephants runs deep and dates back as far as 4,000 years, when elephants were first captured and trained as draft animals and for use in warfare and religious ceremonies. Beyond this unique relationship with human beings, the Asian elephant is a flagship for the conservation of the tropical forest habitats in which it is found. Elephants range over long distances and across a variety of habitats that are home to numerous other wildlife species. As they need very large areas to survive, effective conservation and management of elephants can deliver widespread benefits for other endangered species.

Conflict between humans and elephants is not a new phenomenon, elephants have been raiding crops since time immemorial. However, the reverence people had for elephants in Sri Lanka historically ensured its peaceful coexistence and made them tolerant of the occasional intrusion. In recent times however, human settlements have been encroaching further and further into elephant habitat, and the incidence of crop-raiding has increased phenomenally, leading to the destruction of crops, human homes and lives. Most of the large scale clearings of jungle for agriculture have not given due consideration to the ecological needs of the elephant and other wildlife. As people have suffered escalating losses to elephants, their tolerance has given way to anger and frustration. Every year hundreds of acres of agricultural crops, considerable number of houses and other property are destroyed by elephants looking for food.

On average every year about 100-150 elephants die in Sri Lanka due to intense human-elephant conflict. Conflict is widespread throughout the elephant's range wherever human settlements abut elephant habitat. The reasons for conflict too varies from region to region. It is unlikely that just one solution will help resolve human-elephant conflict. New ideas should be tried out as pilot projects and refined to suit regional issues. It is important to involve the local people from the very beginning. Consideration should be given to their plight as well as to the elephant's if these projects are to succeed. Public participation is crucial not only to resolve human-elephant conflict but also to ensure the long-term survival of the Sri Lankan elephant. A farmer who can reap the benefits of his labor would be more benevolent towards the elephant than one whose life, family, property and crops are under constant threat from it.

The project, "Saving Elephants by Helping People" at Gamburu Oya/Pussellayaya, at Wasgomuwa in the North Central Province of Sri Lanka was initiated in 1998 by Ravi Corea of New Jersey, USA. The project at Gamburu Oya/Pussellayaya is based on a preliminary field study that he conducted in 1997 to assess the extent of the human-elephant conflict and its resolution in Sri Lanka. The initial field survey was part of his study program at the Center for Environmental Research and Conservation (CERC) at

the Columbia University of New York. It was funded by CERC with additional financial support from the Asia Program of the Wildlife Conservation Society/Bronx Zoo of New York. Based on the report that ensued from this survey, the Wildlife Preservation Trust International, USA (now known as the Wildlife Trust), and the Disney Wildlife Conservation Fund gave two grants to establish a pilot project in Sri Lanka, this was intended to integrate community participation into human-elephant conflict management. It was the first time such a project has been attempted in Sri Lanka. The project was approved by the Sri Lanka Department of Wildlife Conservation (DWLC) and by Drs. Raman Sukumar and Charles Santiapillai of the Asian Elephant Specialist Group (AESG) of The World Conservation Union (IUCN). The Deputy Director DWLC, Dr. Nandana Atapattu provided the project with advice and guidance. Lyn de Alwis, the former Director of the Dehiwala Zoological Gardens and the Department of Wildlife Conservation gave valuable advice during the initial field survey.

The Wasgomuwa National Park and its environs, the Maduru Oya National Park to the southeast and the areas north of Wasgomuwa that are designated as protected areas (Minneriya-Giritale, Kaudulla, Flood Plains and Somawathiya) may offer some of the best opportunities for the long term conservation and management of the Sri Lankan elephant. This whole region is supposed to have a population of 650-700 elephants. A series of buffers consisting of electric fenced villages in strategic locations in this region will not only help reduce conflict, but also leave more room for the elephants to wander without hindrance. The village of Gamburu Oya/Pussellayaya is situated in the North Central Province two kilometers south of the Wasgomuwa National Park along the main Hettipola-Wasgomuwa Road. The village was also identified by the Biodiversity and Elephant Conservation Trust of Sri Lanka as having intense human-elephant conflict. In 1997 alone nearly 30 houses in the village were destroyed by marauding elephants. Many elephants too had either got injured or lost their lives while raiding crops in the village fields. In 1998, as publicized by a local newspaper, the villagers of Gamburu Oya/Pussellayaya at the lack of official response to their complaints, were planning to blockade the road to the Wasgomuwa National Park to bring public and official attention to their plight.

Fig. 1 A cultural and religious icon and a flagship of Sri Lanka's biodiversity lies dead in 1998 at Gamburu Oya/Pussellayaya killed by and irate farmer. (Photo: Ravi Corea)

THE OBJECTIVES OF THE PROJECT:

1. Focus on the human aspects of human-elephant conflict, and try to resolve them with the participation of the villagers who are victims of elephant crop raiding. By helping the farmers to initially protect their crops and property, the project will build the credibility and integrity of the conservation process in the communities whose support is essential to the long term conservation and management of the Sri Lankan elephant.

2. Help protect the Sri Lankan elephant by providing management strategies for its conservation.

3. Develop processes to integrate community participation into human-elephant conflict management.

4. Develop an integrated human-elephant conflict management process which can be applied island-wide wherever there is conflict.

5. Bring economic relief to the farmer and help raise their standard of living by helping to stop crop depredation by elephants. A farmer who can reap the benefit of his endeavours would be more tolerant of the elephant, and more willing to help towards its long term conservation.

6. Increase public awareness as to the plight of the elephant and help garner its support for elephant conservation.

7. Develop activities that would help the farmers to benefit from elephants. Introduce the concept of eco-tourism. Such activities will help show the elephant as a resource rather than a liability and a deadly adversary.

8. Develop the project as a model for possible replication in other range countries of the Asian elephant.

9. Generate interest among other international bilateral and multi-lateral aid agencies of the need to fund Asian elephant conservation.

Fig. 2 The completed electric fence along the main road leading to Wasgomuwa National Park (Photo: Ravi Corea)

ANTICIPATED BENEFITS AND OUTPUTS

It is hoped that the project can demonstrate that it is possible to:

1. develop a successful human-elephant conflict management program using electric fences on large agriculture settlements to reduce human-elephant conflict.
2. release more land for elephant conservation, especially in buffers around parks.
3. bring economic benefit to the farmers.
4. obtain the support of the farmers and the general public for long-term elephant conservation.
5. obtain empirical data on the annual economic and social costs caused to a village by crop raiding elephants.
6. establish the credibility and integrity of the conservation process.
7. educate the public and create a deeper awareness of environmental issues and the need to conserve the elephant.
8. enhance the prospects for long-term elephant conservation in Sir Lanka.
9. publish and promote the results of the project including: project development, implementation, administration, management, methods and procedures, outcomes, discussions and conclusions.
10. publish a manual for developing integrated community participating programs for human-elephant conflict management.

The concept behind the project was simple. All attempts by the Department of Wildlife Conservation to fence elephants in National Parks have met with various degrees of failure. The primary reason is the lack of manpower and resources needed to maintain hundreds of kilometers of electric fencing on an ongoing basis. The second reason is that most of the electric fences erected by the Department of Wildlife Conservation are along administrative boundaries which means nothing to elephants who move along their own well established cultural and ecological boundaries. This traditional and instinctive urge to move makes the elephants determined to breach electric fences and other deterrents such as ditches and trenches that obstruct their path. So, the less maintained and managed these electric fences are, the easier they becom for the elephants to break through. Most of the private electric fences protecting large and small scale plantations have a much better success rate due to rigorous maintenance and management procedures. The project has attempted to merge these two strategies of using electric fencing to reduce crop raiding, and stringent fence maintenance procedures of the private sector and apply them to the resolution of crop raiding in village settlements. The project proposed to fully integrate community participation to successfully manage human-elephant conflict near a national park by erecting a solar powered electric fence around a village and its fields. Rather than fence elephants "IN," the project proposed to keep elephants "OUT" from certain areas and leave them room to roam unhindered in the land between settlements outside of the national park when they needed to. Another benefit of having a buffer of fenced villages along the boundary of a national park would be to stop illegal encroachers from further settling in and around national parks since they would not be guaranteed safety from marauding elephants.

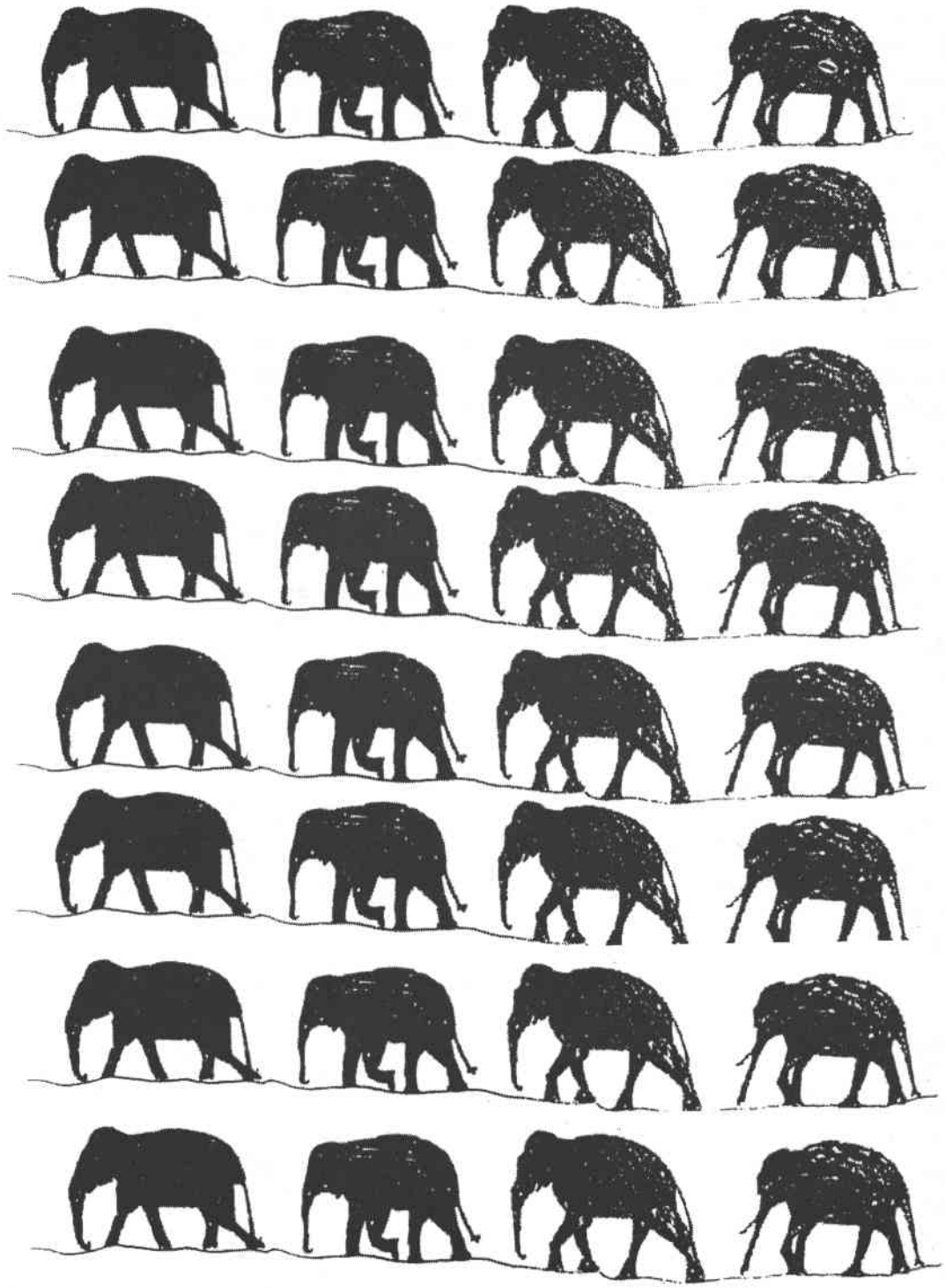
A major objective of the project was to get the villagers to take an active part in protecting their properties and crops by participating from the inception to erect a solar powered electric fence around their village provided by the project, and learn how to maintain and manage it permanently over the long term. The project provided equipment and material for nearly 9.5 kilometers of electric fencing, and met all the initial expenses involved in erecting the fence. The technical contractor for the project who supplied all the fence material, Sunpower Systems (Pvt) Ltd of Sri Lanka, donated all the control room equipment needed for the electric fence. Sunpower Systems also provided the project with a support staff consisting of: CEO, Ravi Weerasekera, Manager, Thushara Seneviratne; Field Technicians, Sunil Liyanage, Sarath Gunawardene, Gamini Sisira Kumara and K.W. Podiralahamy and Drivers, Wimalaratne and C. Kaluarachchi.

The total cost of the project so far has exceeded US $50,000. A Sri Lankan team was assembled to coordinate and oversee the project work. Project Field Officers, Mr. Jayantha Jayewardena, who is a Managing Trustee of the

Biodiversity and Elephant Conservation Trust (BECT), and Mr. Chandeep Corea who is a Field Officer of the Sri Lanka Wildlife Conservation Society (SLWCS) oversaw and administered the ground operations, and helped coordinate the project work. The individual and combined experience and knowledge of Jayantha and Chandeep was a major asset to the project. BECT and SLWCS which are both committed to the conservation of the Sri Lankan elephant provided office space and facilities for the administration of the project in Sri Lanka. BECT Managing Trustee, Jayantha Jayewardene is also an internationally renown expert and author on the Sri Lankan elephant and a member of the IUCN/AESG. His contributions to the project has been invaluable. Mr. Thushara Ranasinghe who was recruited from the Hadungamuwa village in Wasgomuwa coordinated all the work at the village level and acted as the local liaison for the project. Since one of the main objectives of the project was to ensure that the money from the project contributed to the village economy, building material for the control room and concrete posts for the fence was contracted from the village. September, 2000, marked the end of the first phase of the project, which was the completion of the fence. The 2nd phase will be the monitoring of the fence for one year and observing the ability and commitment of the villagers to maintain and manage the fence as part of their day-to-day activities. The success of the fence mainly depends on how well it is maintained. Before the fence was erected over 70% of the village land was abandoned due to high incidence of crop depredation by elephants. Since the fence was completed the villagers have been cultivating one hundred percent of the land. According to the DWLC personnel at the Wasgomuwa National Park there has been no complaints of elephant depredation from this village since the fence was completed. The fence initially has proven to be very effective and there have been several requests from adjoining villages to provide them with similar electric fences. At the request of the villagers from the neighboring village of Hadungamuwa, additional fence material has been made available to extend the fence one kilometer along the western boundary up to the Hadungamuwa Junction. This section of the electric fence will be built entirely by the combined efforts of the villagers of Gamburu Oya/ Pussellayaya and the Hadungamuwa villages. A testimony to the success of the project so far. Though the project was not without its' setbacks, the commitment and dedication of all who were involved in it ensured that the project achieved its goals and objectives. This is proof of how people from widely different backgrounds such as; technical contractors, rural farmers, elephant experts and international funding agencies can communicate and work together, and thereby reach the common goal of saving such a critically endangered species as the Sri Lankan elephant.

At the end of August 2001 a socio-economic survey of the village will be taken and this information will be compared with information of the initial socio-economic survey conducted in 1999 prior to establishment of the fence. If there are significant improvements in the socio-economic life of the villagers, including reduction of crop and property losses to elephants, and no incidence of harassment, injury or death to elephants by these villagers, it will prove the ability of rural villagers to maintain and manage electric fences as a part of their day-to-day life. This also supports the idea of establishing a buffer zone of fenced villagers along National Park Boundaries as a deterrent to crop raiding elephants, and to reduce conflict in the more intense areas. Such buffers can also be used in areas that offer the best opportunity for the long-term conservation of the Sri Lankan elephant.

The Project Initiator and Manager, Ravi Corea; Field Officers, Jayantha Jayewardena and Chandeep Corea; Field Liaison, Thushara Ranasinghe and all of the villagers of Gamburu Oya/Pussellayaya are very grateful to the Wildlife Trust and the Disney Wildlife Conservation Fund of the U.S.A. for their financial support. The project team also gratefully acknowledges the support given to the project by the Member of Parliament for Wasgomuwa, the Honorable Monty Gopallawa, all the local and regional government officers, Pradeshiya Sabaha officers, engineers of the Road Development Authority and the Irrigation Department of Wasgomuwa, the Department of Wildlife Conservation, especially Deputy Director, Dr. Nandana Atapattu; Assistant Director, Vasantha Ratnayake and Senior Game Ranger, Jayatilleke of the Wasgomuwa National Park, the Venerable Maragamuwe Gunananda Himi of the Gamburu Oya/Pussellayaya Temple, the villagers of Gamburu Oya/Pussellayaya, Drs. Raman Sukumar and Charles Santiapillai of the IUCN/AESG; and Messrs. Ravi Weerasekera and Thushara Seneviratne of Sunpower Systems (Pvt) Ltd. For further information about the project Ravi Corea can be contacted at: RaviCorea@aol.com



NGO ACTIVITIES

Biodiversity & Elephant Conservation Trust

Jayantha Jayewardene (BECT)
615/32, Rajagiriya Gardens,
Nawala Road, Rajagiriya, Sri Lanka.

The Biodiversity & Elephant Conservation Trust (BECT) was established following the successful 1st National Symposium on Elephant Management & Conservation held in May 1998. The Trust has been able to achieve a lot during the short period of its existence. Given below are some of the activities that the Trust has been engaged in.

1. Tour of Thailand

The Trust organised a two-week study tour in Thailand for two government officials working with elephants. They were Dr. Taraka Prasad, veterinary surgeon of the Department of Wildlife Conservation based in the Anuradhapura district, and Mr. S.S.M. Seelaratne, Curator of the Elephant Orphanage at Pinnawela. They spent two weeks on tour visiting the Elephant Training Camp and the Elephant Hospital in Lampang. They also observed the operation of the mobile elephant hospital run by the Friends of the Asian Elephant (FAE).

2. Schools Awareness Programme

The Trust, based on one of the recommendations made at the Elephant Symposium, embarked on the Schools Awareness Programme in the Anuradhapura district, where there are several incidents of human-elephant conflict. The purpose of this programme is to make the children living in these areas become aware of the value of the elephants and why they should be conserved for the future. It is with the knowledge that elephants cause much depredation and destruction in these areas that the material for the programme was selected. The programme is implemented through lectures, slide presentations, discussions and question and answer sessions. The villagers are also informed as to how they could benefit from the presence of elephants, e.g. eco–tourism.

BECT is grateful to the Sri Lanka Wildlife Conservation Society, Woodland Park Zoo and the Oregon Zoo, all of which are in the United States, for their support.

Posters: Lanka Bell sponsored a poster in Sinhala and English, designed to educate the school children about elephants. Another poster, designed to prevent the purchase of ivory products and thus save our tuskers from poachers, is sponsored by the Oregon University in the United States.

Video on Elephants: Young Asia TV made a video film on elephants in Sinhala for use in the Schools Awareness Programme. This is an educational film for children between the age 8-15 years and is shown with the school programme.

Books: BECT has also purchased some books, a set of which is presented to each school after the programme.

Joint Schools Programme: The Wildlife & Nature Protection Society has suggested that BECT ought to join them in their programme with the schools nature clubs. Such a move would be beneficial to both organisations in respect of the work that each is doing in the schools.

3. Public Lecture

BECT organised a talk on the taming and training of African elephants by Mr. Uttum Corea, who is from Botswana and owns four African elephants. His talk, illustrated with coloured overhead transparencies, was based on his experience with these four elephants.

4. BECT: an Associate of the AESG

The Chairman of the Asian Elephant Specialist Group of IUCN, Dr. Raman Sukumar, has agreed to have the Biodiversity and Elephant Conservation Trust as its associate in Sri Lanka. The work that AESG carries out in Sri Lanka will be in association with and assistance of the BECT.

5. Development of the Elephant Orphanage at Pinnawela

The Trust decided that it should assist the authorities to develop the Elephant Orphanage at Pinnawela, along the lines suggested at the May Symposium. Jayantha Jayewardene met the Minister of Tourism & Aviation and the Secretary to the Ministry, under whom the orphanage is being managed and presented the proposals to them. The Minister mentioned that an overall plan for the development of the whole of the Pinnawela area as a tourist zone was being formulated. This includes the setting up of a zoo very close to the orphanage. He promised that a representative of the BECT will be included in the committee set up to plan the new development.

6. Photo - tracking of Wild Elephants

A basic requirement for the conservation and management of elephants is the long-term monitoring of elephant movements and habitat use. An effective, low-cost way of doing this is to maintain a photo-catalogue of elephants, which would allow anyone to identify individual animals on the basis of unique markings. By recording the location and date of sightings (of individual animals and herds) it may be possible to get a good idea of elephant movements, and thus develop management strategies.

BECT invited all enthusiasts who photograph elephants to assist in this programme by providing information and photographs, and monitoring movements of elephants. All they have to do is to photograph the elephants; identify individuals from unique markings; maintain a personal photo-catalogue; and contribute to a project catalogue and database. A short workshop will be held to initiate all those who are interested in photo-cataloguing elephants. Dr Prithiviraj Fernando and Ms Manori Gunawardene, who maintain the main photo-catalogues agreed to help in this venture.

7. Development of a National Policy for Elephant Conservation

The Department of Wildlife Conservation convened a Preparatory Meeting on 19th November 1998 to formulate a national policy for elephant conservation. Charles Santiapillai and Jayantha Jayewardene were requested by the Department of Wildlife Conservation to prepare a Working Paper for use at this meeting..

8. Meeting with HE the President

Jayantha Jayewardene was granted an interview with Her Excellency the President on 6 August 1999, during which he briefed her on the present situation with regard to wildlife conservation in general and elephant conservation in particular. She was also briefed on the 1998 Symposium and its outcome and the 11 proposals that were formulated, based on the symposium participants' suggestions, were also given to her. It was explained to Her Excellency what these proposals entailed and the benefits that would accrue to the conservation effort, if they were implemented. Her Excellency was very interested in the current situation vis a vis wildlife conservation and promised to look at the proposals and see how they could be implemented.

9. Awards Ceremony

The valuable services rendered by a number of people in Sri Lank for wildlife conservation have mainly gone unnoticed and unrecognised. The Biodiversity & Elephant Conservation Trust thought it fit that some of these persons should be recognised and rewarded. A panel of judges met to choose two recipients for the Conservation Award for the years 1998 and 1999. They chose Mr. Ainsley B. Fernando for the Conservation Award for 1998 and Mr. Christy Wickremasinghe for 1999. Both these gentlemen have worked for a long time with the Department of Wildlife Conservation and are now in retirement. At the Awards Ceremoney held on 20 May 1999, The Director General of the World Conservation union (IUCN) sent a citation to Mr. A. B. Fernando, while the Director General of the World Wide Fund for Nature (WWF) sent one to Mr. Christy Wickremasinghe. These citations were read out and presented to the recipients of the awards. Both were then presented with a Gold Medal.

10. Walk for Elephant Conservation

The Rotary Club of Mount Lavinia organised a Sponsored Walk for Elephant Conservation the proceeds of which were to be given to the Biodiversity & Elephant Conservation Trust for its projects and programmes. Despite a heavy downpour on that day, many turned up and joined in the walk. An elephant, kindly lent by the Rev Galaboda Gnanissara of the Gangaramaya temple, also took part. The Rotary Club has completed its accounts and sent us Rs 100,000/- being the collection.

11. Documentation.

As there are many records and publications regarding wild elephants, their capture, taming, export etc, the BECT hopes to document these as a publication on how elephants were managed in the past. Back numbers of the journal *Loris*, Administration Reports of the Directors of the Wildlife Department and other documents contain much useful information, and volunteers are needed to extract it.

Ms Manel Tampoe, who has agreed to collect material from past issues of *Loris*, needs assistance. If anyone who would like to assist her, please contact her. Since this is a big undertaking she will appreciate all the assistance that she can get. If anyone has access to old records, publications, books etc. please get in touch with BECT.

12. Training of Veterinarians

Instances of human-elephant conflict are on the increase in various parts of the country. The conflict has brought injury and death to both humans and elephants. There are constant reports of dead elephants lying in various parts of the country and also of elephants that have been injured.

The requests for veterinary services to treat such injured elephants may come from different parts of the island at the same time. This puts a lot of pressure on the inadequate veterinary staff of the Department of Wildlife Conservation. As a result it may not be possible to enlist the services of the veterinary section of the department to treat injured elephants in time. This may lead not only to the death of the elephant, but may also increase the criticism that is directed at the Department of Wildlife Conservation (DWC).

The Biodiversity & Elephant Conservation Trust organised a training programme for veterinary staff of the Department of Animal Production and Health in the treatment of elephants. The trainers were from the Faculty of Veterinary Medicine, University of Peradeniya and included an expert from India and two from Thailand along with another veterinarian from Denmark. The programme was conducted at the Pinnawela Elephant Orphanage from 27 to 31 October 1999. This training will now enable them, if there were a delay on the part of the DWLC veterinary surgeon getting to any injured animal on time, to treat elephants immediately.

13. Electric Fence

The President of the Sri Lanka Wildlife Conservation Society, based in New York, Mr. Ravi Corea has obtained funds to erect an electric fence around an area that is subject to elephant depredation. After looking at many locations and having many discussions with Charles Santiapillai and Jayantha Jayewardene, it was decided to erect this fence around the village of Pusselyaya very close to the southern boundary of the Wasgomuwa National Park. Elephants from the Wasgomuwa NP come regularly to this village and cause damage to crops, houses and the people. They also cause a lot of trouble in the adjacent villages but Pusselyaya was the worst affected. The work on the fence has now been completed and the fence appears to be effective in keeping elephants out.

14. Policy for Elephant Conservation in Sri Lanka

The Secretary to the Ministry of Plantation Industries and Public Administration formed a committee to evolve a policy for elephant conservation in Sri Lanka. This committee met a number of times, often under the chairmanship of the Secretary. Later the committee was reduced to Dr Devaka Weerakoon, Mr. Sunil Liyanage and Jayantha Jayewardene. The report of the committee has been given to the Secretary to be given to the Minister who will place it before the Cabinet of Ministers.

15. Motorola contributes to BECT

In an effort to find a pragmatic solution to the ongoing and escalating human-elephant conflict, two employees of Motorola, Lalith Seneviratne, (based in Colombo) and Greg Roseel (USA based but currently in Singapore), teamed up and are developing and testing a non-intrusive warning and deterrent system to keep the elephants off cultivated areas. In recognition of their ongoing work, Lalith and Greg have been selected as the team winners of the 1999 Motorola CEO Award for Volunteerism, the highest recognition an individual or a team of Motorola employees can receive for community involvement.

As part of the award, the team gets to nominate a non-profit organisation of its choice to receive a contribution from the Motorola Foundation, and the Biodiversity & Elephant Conservation Trust has been nominated by the team. Mr Jayantha Jayewardene received the contribution on behalf of BECT, at the Motorola office in Colombo on 26 June 2000.

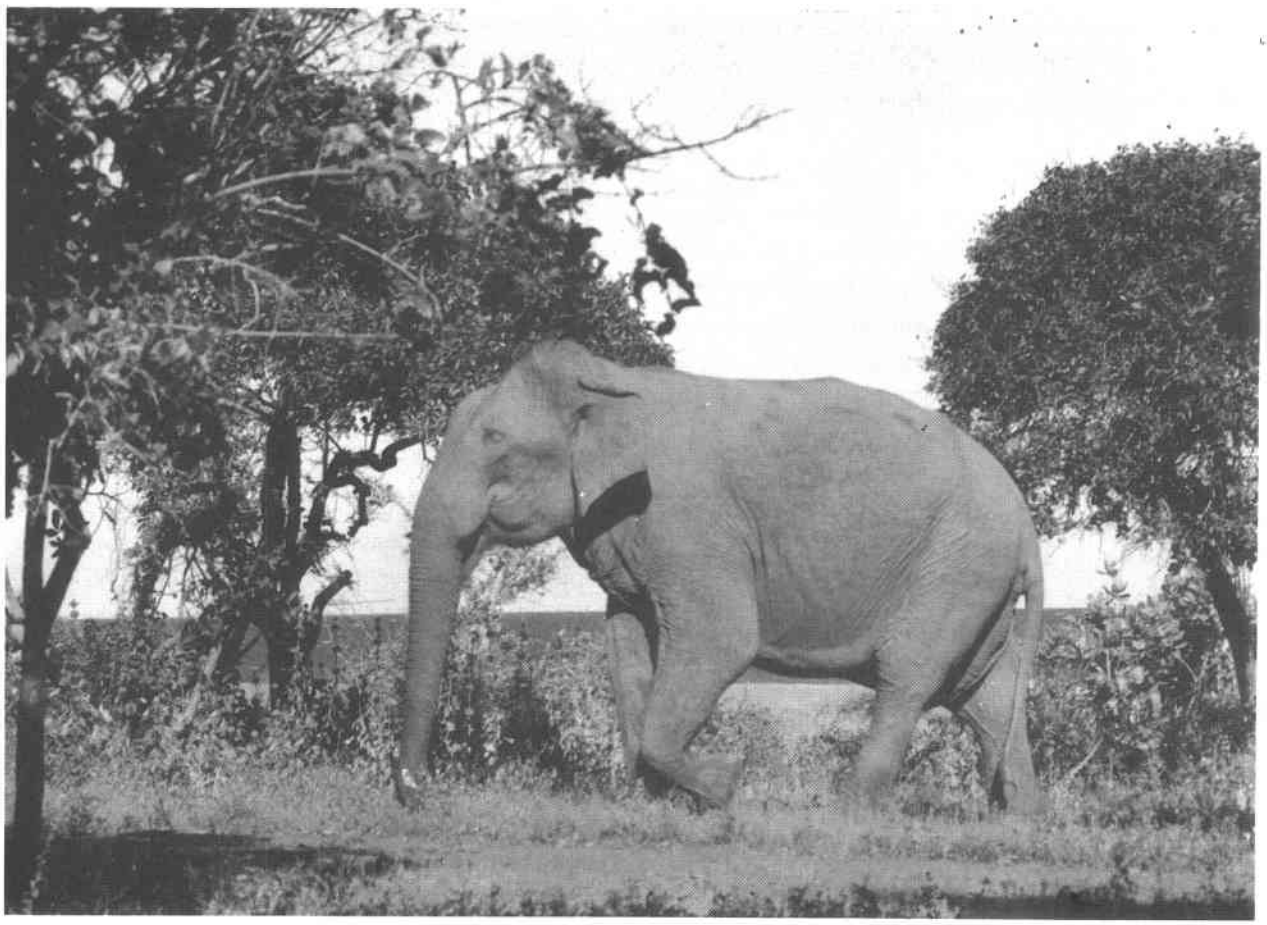
16. Policy for Protected Area Management and Wildlife Conservation

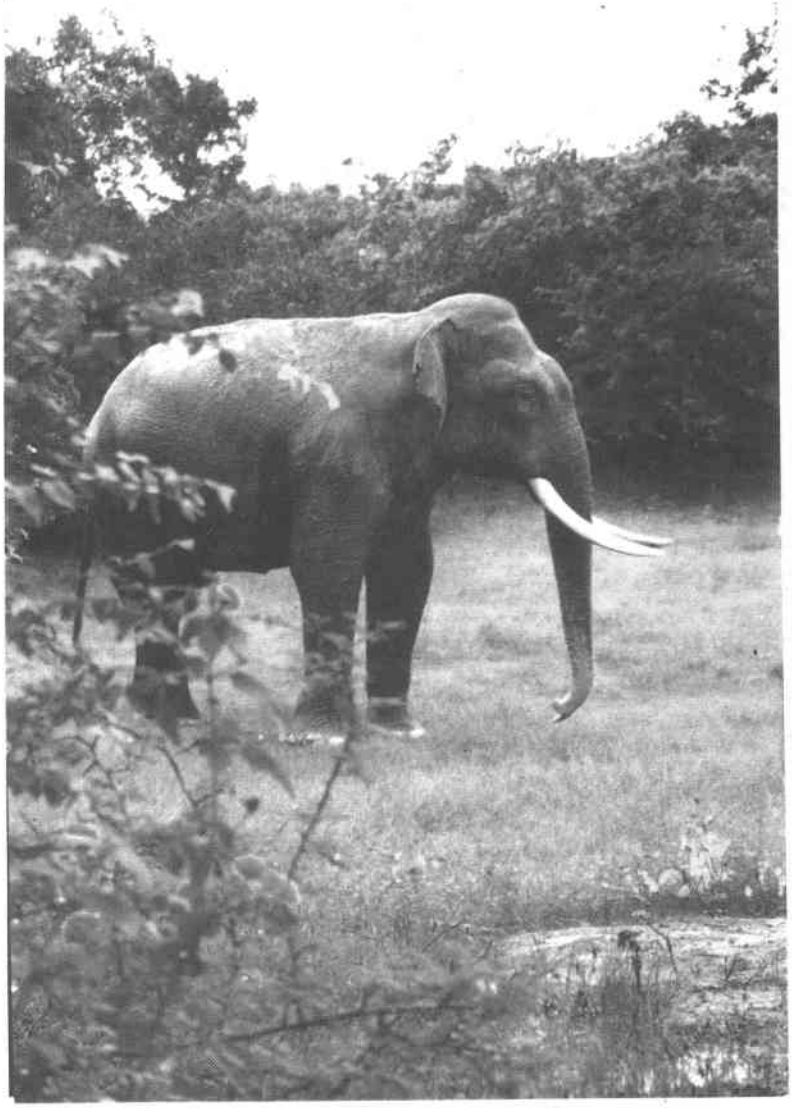
The Minister of Public Administration and Plantation Industries set up a Task Force to go into the present National Policy on Wildlife Conservation, which was approved in 1990 and make suggestions for any changes that are needed. Changes seemed necessary especially in the context of the Convention on Biological Diversity (CBD), which Sri Lanka ratified in 1994. CBD emphasises the three themes conservation, sustainable use and benefit sharing.

Dr Sarath Kotagama, Messrs Rohan Pethiyagoda and Jayantha Jayewardene, amongst others, were appointed to this Task Force, which has met over 12 times and formulated new policies for protected area management and wildlife conservation. The Cabinet of Ministers has approved the final document.

17. Presidential Task Force.

Her Excellency has appointed a Presidential Task Force for Wildlife Development. Rohan Pethiyagoda, Sarath Kotagama and Jayantha Jayewardene are members of this Task Force, whose first duty is to formulate an action plan based on the policies for protected area management and wildlife conservation that the government has adopted recently.





Computer Type Setting & Offset Printing
Bravi Press - Kandy. 08 - 222720

GAJAH

JOURNAL OF
THE ASIAN ELEPHANT SPECIALIST GROUP

Number 20
January 2001
ISSN : 1391 - 1996

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