Feature Articles

POPULATION STRUCTURE, ACTIVITY AND DENSITY OF ELEPHANTS IN THE RUHUNA NATIONAL PARK, SRI LANKA

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Summary

Block I of Ruhuna National Park with an area of 140 km^2 can support seasonally up to 84 elephants. This gives a crude density of 0.6 elephant per km^2 and an average biomass of 1,086 kg per km^2. The recent survey carried out in June 1991 indicates that since 1978—1980, the elephant biomass may have increased by 29% in Block I. The increase may be due to the influx of animals from other Blocks. The population structure was normal with adult males and females accounting for 53% of the total. Calves formed 13.8% of the population. Of the 29 groups classified, the most frequently observed category was that of the solitary animals (48.28%), 86% of which were adult males. Average herd size was 5.8 — excatly as it was when the survey was carried out in 1978—1980. The largest herd consisted of 10 animals. A total of the 13 herds were classified. Within the herds, the ratio of adult males to adult females was heavily biased in favour of the cows (1: 7.5). But the adult sex ratio in the total number of animals classified was 1: 2.1. The solitary animals showed a bimodal pattern of diurnal activity with peaks at 0800 and 1700 hrs while the herds activity picked up from 1500 hrs and increased up to 1800 hrs when maximum feeding activity was noted. The number of young animals observed indicate that there could be a seasonal pattern in the birth and breeding of elephants in RNP. But this needs further study before it could be confirmed.

Oddly enough there were no tuskers seen throughout the study period. In 1978—1980 there were at least 4 tuskers. The break down in law and order in the recent past in Sri Lanka as a result of guerrilla activity in the north, east, north-west, south and south-east had seriously affected the elephants and their habitat. Many of the tuskers had been killed by poachers. The proposed plan to capture 500 wild elephants in Sri Lanka for domestication is a sure recipe for disaster. The only long-term hope for the elephants in Sri Lanka may lie in the effective protection of their habitat.

1.0 Introduction:

The Asian elephant (*Elephas maximus* L.) represents the largest land mammal in Asia. The subspecies found in Sri Lanka (*Elephas m. maximus* L.) is the forma typica. It would be difficult to imagine Sri Lanka without elephants as they are a part of the island's history, folklore, religion, politics and cultural heritage. Elephants have been in use by man in Sri Lanka for at least

the past 2,000 years (McKay 1973). Before the large scale destruction of forests, elephants enjoyed wide distribution and good numbers in both lowlands as well as the hill country. Tennent (1867) estimated the number of elephants around the 17th century in Sri Lanka (then Ceylon) to be 1.5 million! Elephants were reported from present day urban areas as Colombo, Kandy and Ratnapura between 1669 and 1744 (McKay 1973). Even by the turn of the 19th century, elephants were distributed all over the island from sea level to about 2,500 m altitude (Fernando 1973; Phillips 1935). Today however, except for a small itinerarnt population in the Sinharaja rainforest, elephants are restricted to the low lands (Fig. 1). Over the past 150 years, human land-use has forced the animals from the wet and fertile regions of the south-west to much drier areas (Santiapillai & Jackson 1990). Olivier (1978a) argues that the elephant population in Sri Lanka may have declined by over 67% in the past 200 years.

As far as the Ruhuna National Park is concerned, it appears to have had a high concentration of elephants in the past. Norris (1959, 1967) reported as many as 300–380 elephants in an area of about 300 km^2 on a year-round basis.

The first serious study of the elephants in Ruhuna National Park (RNP) was carried out by the Smithsonian Institution in the late 1960's (see Kurt 1974). It was almost two decades later that Santiapillai *et al.* (1984) carried out a two year study of the elephants in Block I of RNP seasonally from May 1978 to June 1980. It was to re-assess the status of the elephants in Block I as a part of the overall large mammal management and monitoring programme (see Dissanayake *et al.* 1991) that this study was carried out in June 1991.

2.0 Study area:

Ruhuna National Park is one of the major conservation areas in Sri Lanka. The park with its north-adjacent reserves covers an area of about 1,200 km^2 and is situated in the low country dry zone in the South-eastern Sri Lanka just above the 6°N latitude. The entire National Park bounded on the south and east by the sea, consists of forest and saline flats irregularly dotted with natural water holes and man made "tanks". Two rivers Menik Ganga and the Kumbukkan Oya, and a number of seasonal streams drain the area and discharge into the sea through a shifting system of sand dunes and brackish lagoons (Woodford 1979).

Block 1 where the study was carried out is roughly triangular in outline with the Menik Ganga forming the northern boundary separating Block I from Block II (Fig. 2). The annual rainfall is about 1,000 mm of which the greatest (750 mm) falls in November, December and early January (North-east monsoon) and the balance in April and May (South-west monsoon). The dry season extends from June to September. However, rainfall can vary considerably between years.

3.0 Vegetation:

The main vegetation cover is woody, mostly scrub, i.e in canopy below 5-m height, but forests occur as larger and smaller islands within the scrub as a continuous cover inland from the coast (Mueller-Dombois 1972). The coastal area in Block I is characterised by numerous water holes surrounded by grazing areas frequented by the elephant and other herbivores. The grazing grounds are dominated by the halophytic grass *Sporobolous tremulus.* These flats give way, on the landward side, to light jungle dominated by *Salvadora persica, Feronia limonia* and *Cassia fistula* (Woodford 1979). The vegetation of the Park has been classified by Mueller-Dombois (1968) as falling into three physiognomic categories: - (a) forest (with at least 20% of crown biomass above 5 m in height), (b) scrub (less than 20% of crown biomass above 5 m) and (c) grassland or plains (Fig. 2). The dominant tree species are *Manilkara hexandra, Drypetes sepiaria* in well drained soil and *Feronia limonia* (Balasubramaniam *et al.* 1980). In the scrub vegetation, some of the common shrubs and treelets are *Capparis sepiaria, C. zeylanica, Dichrostachys cinerea, Flueggea virosa, Randia dumentorum* and *Cretavia religiosa.* The main components of the grassy plains are *Eragrostris viscosa, Dactylotaenium aegyptium, Sporobolous diandrus, Echinochloa colonum,*

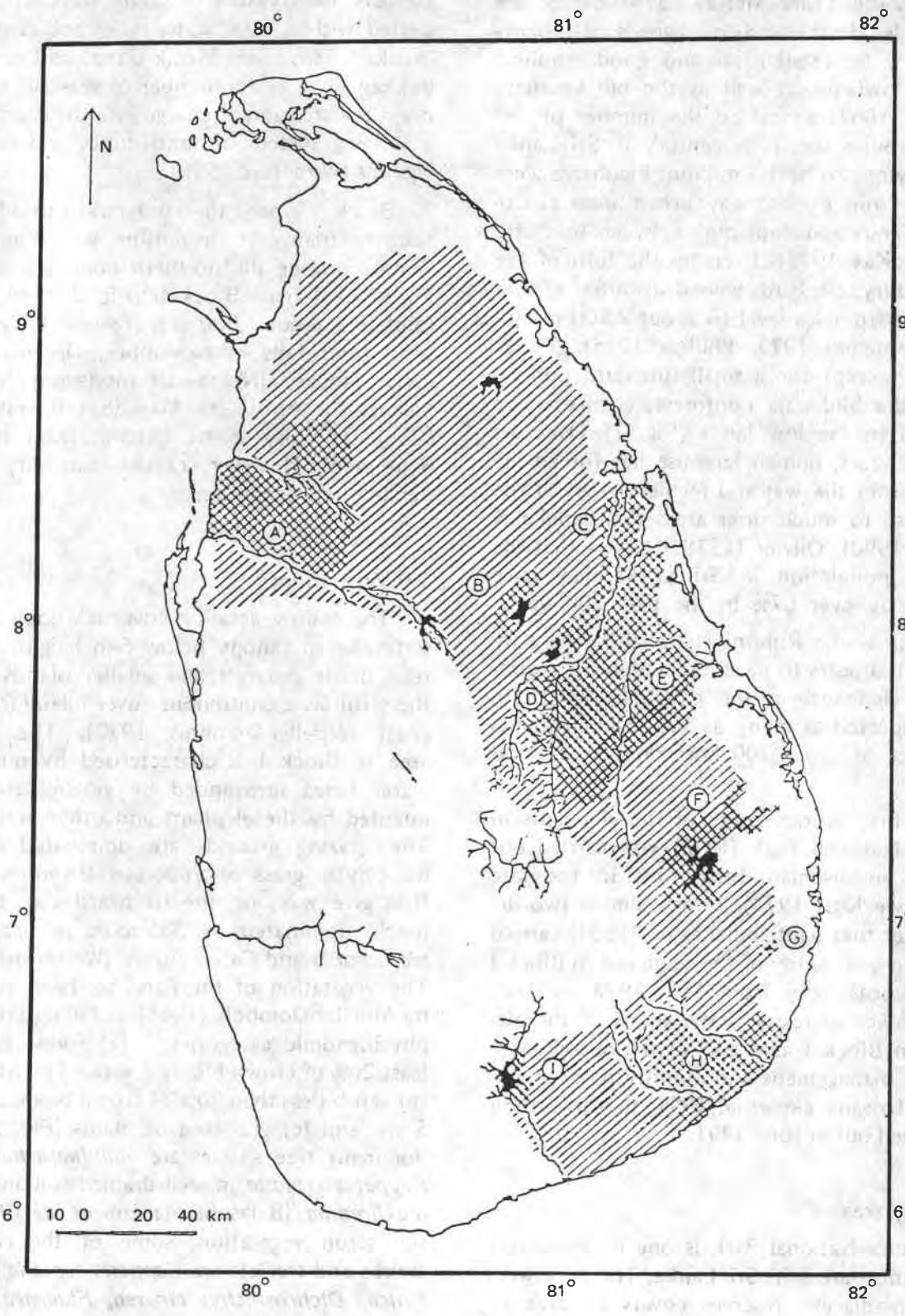


Fig. 1 Map of Sri Lanka to show the approximate maximum extent of the elephant distribution. Ruhuna National Park (H) lies in the southeastern corner.

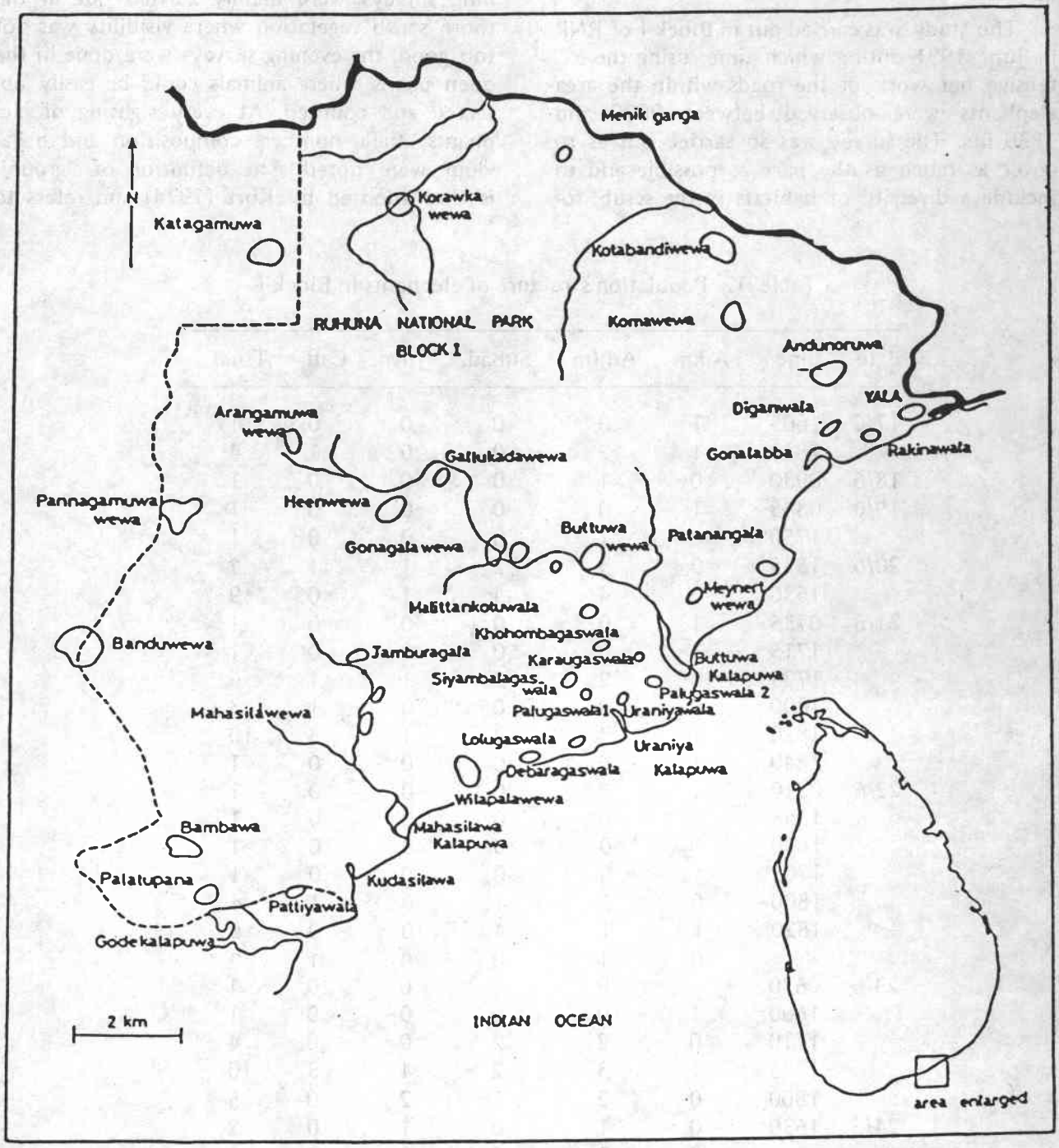


Fig. 2 Map of Block I of Ruhuna National Park, Sri Lanka showing the location of the main water holes.

Setaria pallidifusca. and *Alloteropsis cimicina* (Balasubramaniam *et. al.* 1980).

4.0 **Methods:**

The study was carried out in Block I of RNP in June 1991 during which time, using the extensive net work of the roads within the area elephants were observed between 0600 and 1830 hrs. The survey was so carried out as to cover as much as the park as possible and to include a diversity of habitats in the scrub, forest, grassland and the numerous water holes or villus. Each road transect was approximately 20 km long and was surveyed twice a day in the morning and in the evening. While the morning surveys were mainly carried out in the thorn scrub vegetation where visibility was not too good, the evening surveys were done in the open plains where animals could be easily observed and counted. At every sighting of elephants, their number, composition and behaviour were noted. The definition of "group" is that adopted by Kurt (1974) and refers to

Table 1. Population structure of elephants in Block I

date	time	Ad.m	Ad.fm	Subad.	Juvn.	Calf	Total
17/6	1605	1	0	0	0	0	1
	1830	1	2	0	0	1	4
18/6	0930	0	1	0	0	0	1
19/6	0845	1	0	0	0	0	1
	1750	0	1	0	0	0	1
20/6	1535	0	3	2	1	1	7
	1630	0	4	4	1	0	9
21/6	0735	1	0	0	0	0	1
	1715	1	0	0	0	0	1
	1725	0	2	2	1	1	6
	1800	0	2	0	0	1	3
	1820	1	3	2	1	3	10
	1840	1	0	0	0	0	1
22/6	0810	1	0	0	0	0	1
	1555	1	0	0	0	0	1
	1600	1	0	0	0	0	1
	1705	1	0	0	0	0	1
	1800	0	2	1	0	1	4
	1820	1	1	4	0	0	6
		0	1	0	0	1	2
23/6	0630	1	0	0	0	0	1
	1600	1	0	0	0	0	1
	1710	0	2	2	0	0	4
	1745	1	3	2	1	3	10
	1800	0	2	1	2	0	5
24/6	1630	0	1	0	1	0	2
		0	1	2	0	0	3
	1725	1	0	0	0	0	1
		0	3	1	0	1	5
Total		16	34	23	8	13	94
%		17.0	36.2	24.5	8.5	13.8	100

any temporary aggregation of animals, while a herd is a more cohesive unit seen repeatedly. For the purpose of censussing, nine age-classes (McKay 1973, Ishwaran 1981) were adopted.

5.0 Results:

A total of 94 elephants were counted during the survey (Table 1) of which 14 were solitary animals while the groups accounted for the balance 80. A total of 76 animals were classified in 13 herds (Table 3).

5.1 Population Structure:

As can be seen from Table 1 the number of adult females were twice that of adult males almost identical to the situation Eisenberg & Lockhart (1972) encountered in Wilpattu National Park. The adult males and females account for 17 and 36.2% of the total number (n= 94) counted during the survey. The total number of adults (males and females) make up about 53% of the total number counted. The number of subadults, juveniles and calves account for 24.5, 8.5 and 13.8% respectively.

Out of the 16 adult males that were encountered in Block I in June, there wasn't a single tusker. This was surprising given that there had been some earlier speculation in the park that there were 11 tuskers. The absence of tuskers points to the great risks that elephants still face from poachers. In the recent past a number of tuskers had been shot by poachers as well as insurgents. On the other hand, the animals seem to be breeding well given the fact that calves accounted for 13.8% of the total number observed. By contrast, the number of calves that were encountered in the 1978–1980 survey was much less - calves accounted for only 4% of the population (Santiapillai *et al.* 1984). The high proportion of adults in the population is not unusual among elephants whose life span, gestation period and calving intervals are all long.

5.2 Social Groupings:

There were 29 sightings of elephants in which a total of 94 animals were counted (Table 2). 14 observations were of solitary individuals out of which 12 (86%) were adult bulls while only 2 (14%) represented cows.

Table 2. Frequency of Group Sizes in Block I

Group size	Number of groups	Frequency
1	14	48.28
2	2	6.90
3	2	6.90
4	3	10.34
5	2	6.90
6	2	6.90
7	1	3.45
8	0	0.00
9	1	3.45
10	2	6.90
Total	29	100.00

Solitary animals accounted for 48.28% of all the sightings (Fig. 4). The solitary animals that were encountered were predominantly bulls (Fig. 5). None were subadults. No bull groups were recorded. The commonest grouping was that of 4 animals. Tha largest group consisted of 10 animals. The average herd size was 5.8 exactly the same as it was almost a decade ago (Santiapillai *et al.* 1984).

5.3 Elephant Social Organization:

Elephants are social animals that move about in herds. The most cohesive social unit is the family unit, consisting of an integrated group of closely related elephants of all classes excluding the adult males (Laws 1970). In the Ruhuna National Park, such a unit averages about six animals and is always led by the oldest female or the matriarch (Fig. 6). The family unit is tightly knit both socially and structurally (Moss 1990). The entire unit moves as a whole led by the matriarch and the activities in a family unit are usually synchronised and coordinated by the oldest female. The other small population unit is a loose association of mature males, the bull herd. In Sumatra, the bull herd averages about 4.4 animals with a range of 2 to 9 (Santiapillai & Suprahman 1986). However, during the survey period in Sri Lanka, no bull groups were observed.

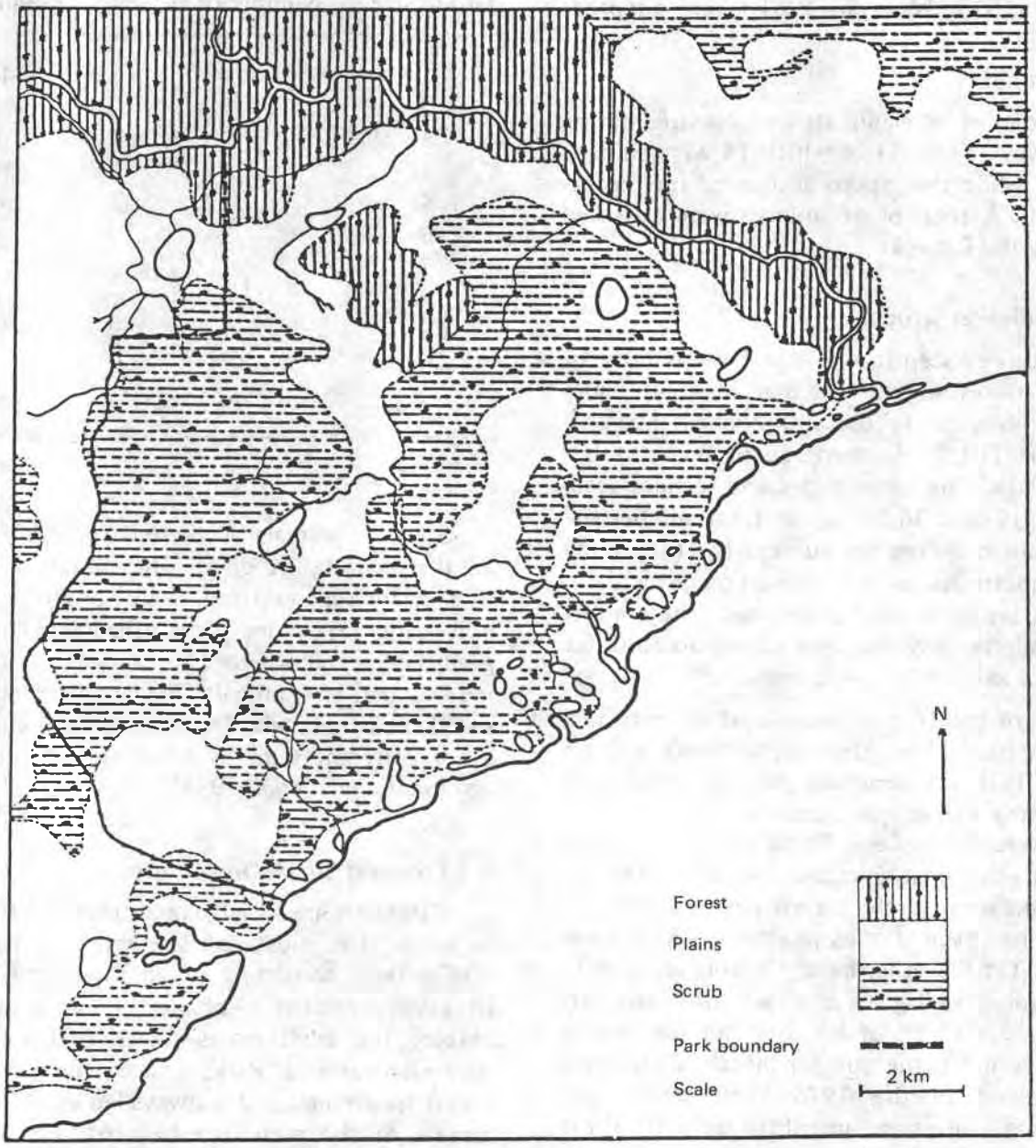


Fig. 3 Generalized vegetation map of Block I of Ruhuna National Park (adapted from Mueller-Dombois 1969).

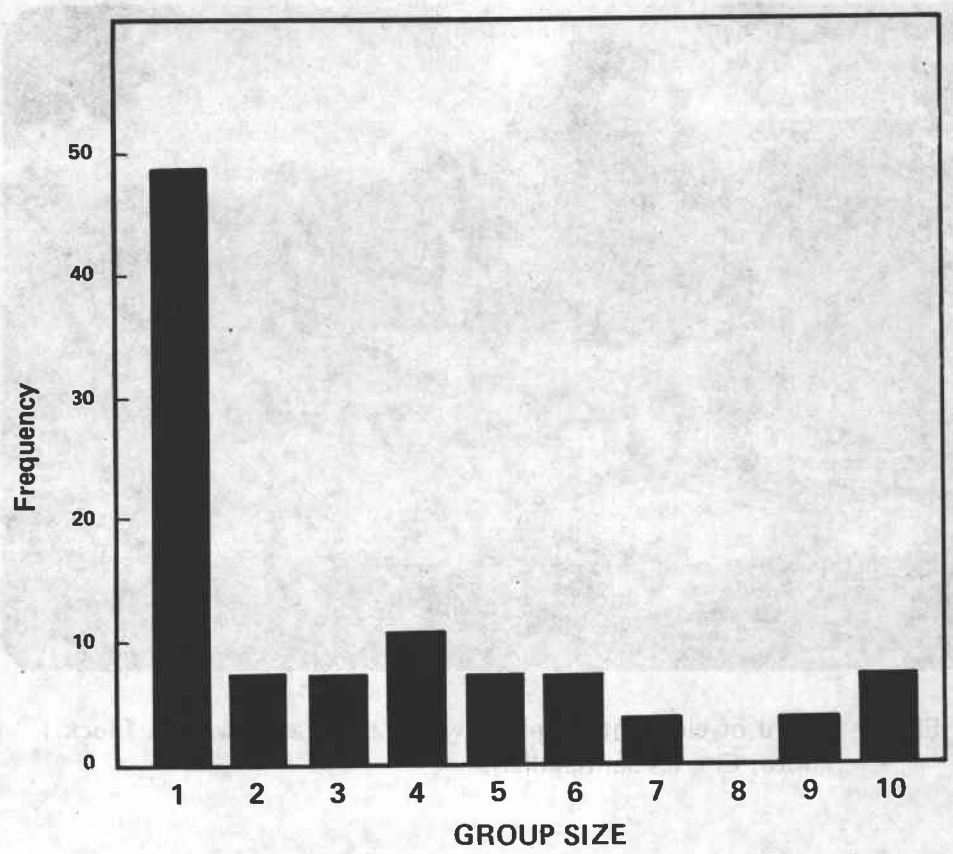


Fig. 4. Frequency of sightings for elephants groupings of various sizes.

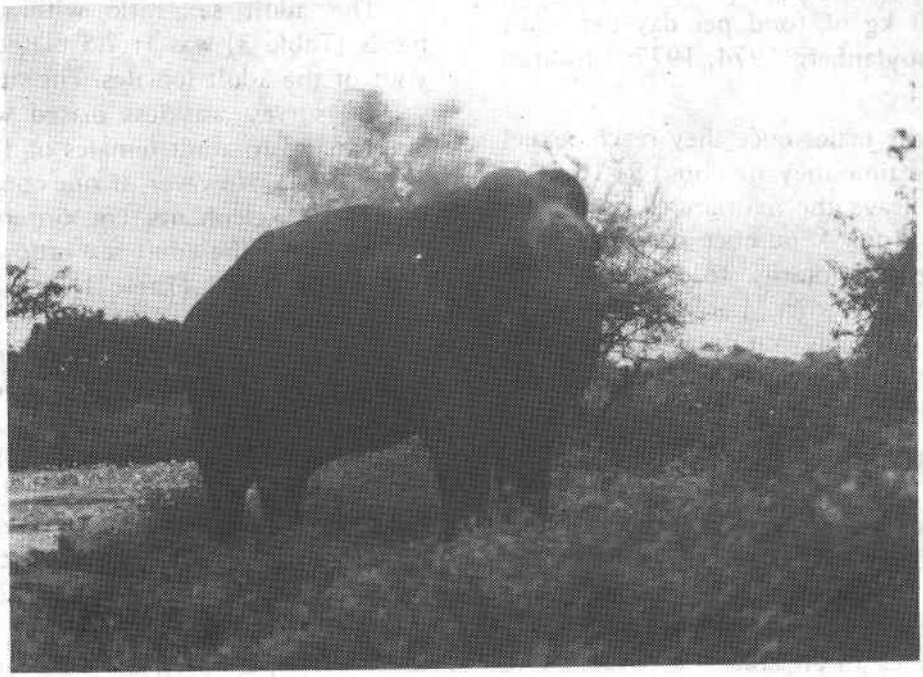


Fig. 5. Solitary adult bull elephant in Block I (Photo: Charles Santiapillai).

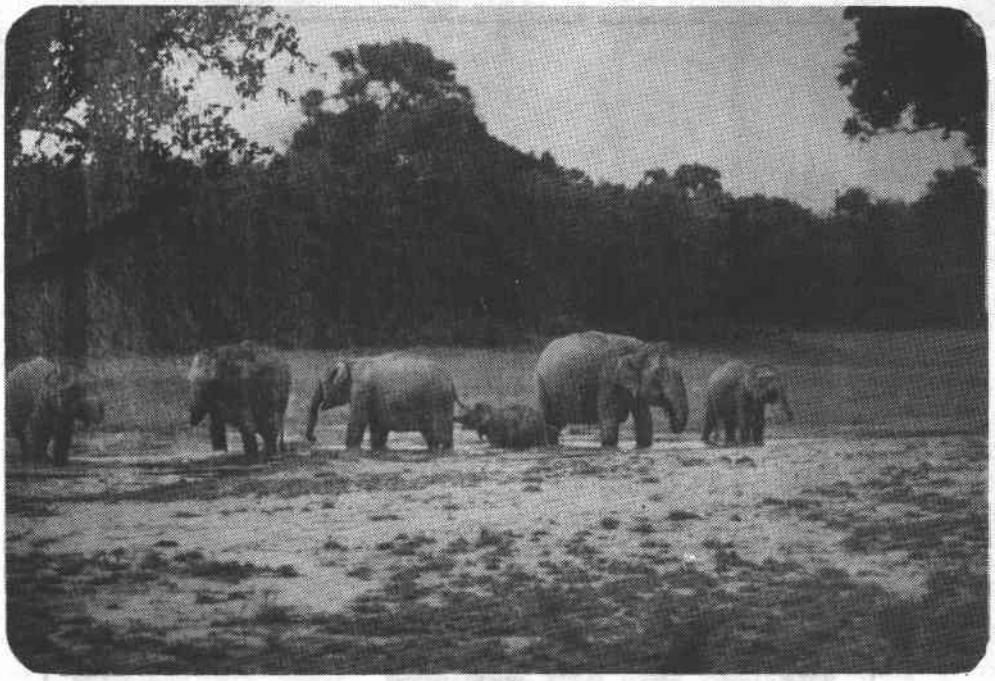


Fig. 6. A herd of elephants drinking water at Karaugaswala in Block I (Photo: Charles Santiapillai).

Matriarchal groups increase in size due to generation overlap (Eisenberg & Lockhart 1972). However the limits to group size increase would be brought about by the need to consume on an average 150 kg of food per day per adult elephant (Vancuylenberg 1974; 1977; Ishwaran 1979).

As a rule, the males once they reach sexual maturity by the time they are about 9–10 years of age, would leave the matriarchal herds and lead a solitary life. A number of such males could associate temporarily to form the bull groups referred to earlier. Large groupings of elephants are probably random aggregations, formed by chance meetings of smaller but stable groups (Ishwaran 1981).

In RNP, elephants go about in small groups during the dry season. However, with the onset of the rains and the sprouting of the short-grass community, the tendency is to form larger groups through merger of a few smaller ones. Another consequence of increased availability of food resources in an area is a reduction in the size of the home range (Olivier 1978b).

The social structure is virtually identical to the herds described for the African elephants by Laws & Parker (1968).

The adult sex ratio within the classified herds (Table 3) was 1: 7.5 biased heavily in favour of the adult females. The situation in 1978–1980 survey was less biased with a ratio of adult males to adult females of 1:4 (Santiapillai *et al.* 1984). However, if one considers the total number of elephants encountered in Block I (94 animals), the adult sex ratio of males to females was 1: 2.1 (Table 1). As far as management of elephants in the Park is concerned, the changes in adult sex ratio must be monitored. A skewed sex ratio biased in favour of the females may indicate heavy poaching pressure. The genetic consequences of a skewed sex ratio should not be overlooked. If too few bulls do all the breeding, there could be problems of inbreeding depression, especially in small populations (Sukumar 1991). The more skewed the adult sex ratio, the lower would be the effective population size. If inbreeding is to be kept below 1% per generation, then an effective

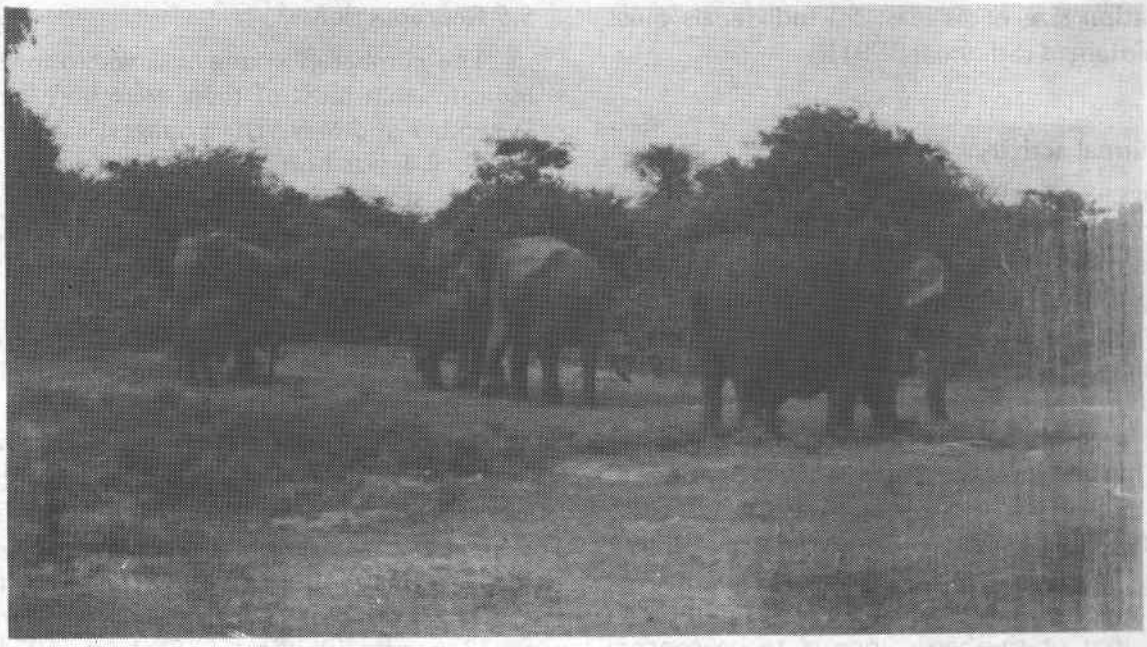


Fig. 7. A herd of three adult females and their young (Photo: Charles Santiapillai).

Table 3. Composition of the classified herds of elephants

Herd	Ad.m	Ad.fm	Subad.	Juvn.	Calf	Total
A	1	2	0	0	1	4
B	0	3	2	1	1	7
C	0	4	4	1	0	9
D	0	2	2	1	1	6
E	0	2	0	0	1	3
F*	1	3	2	1	3	10
G	0	2	1	0	1	4
H	1	1	4	0	0	6
I	0	2	2	0	0	4
J*	1	3	2	1	3	10
K	0	2	1	2	0	5
L	0	1	2	0	0	3
M	0	3	1	0	1	5
Total	4	30	23	7	12	76
%	5.3	39.5	30.2	9.2	15.8	100
per 100 fm	13.3	100	76.6	23.3	40.0	

*F and J represent the same herds.

Average herd size = 5.8 (range 3–10)
Ratio of ad. males: ad. females = 1: 7.5

population size of at least 50 individuals must be maintained (Sukumar 1991).

5.4 Diurnal activity:

Figs. 8 and 9 illustrate the diurnal activity patterns of both solitary animals as well as the groups respectively. These activity patterns refer to the time spent on feeding (either grazing or browsing). It is interesting to note that the solitary animals show a bi-modal pattern with peaks of activity about 0800 and 1700 hrs (Fig. 8) while the groups observed activity begins at 1500 hrs and increases steadily afterwards reaching a peak at 1800 hrs (Fig. 9). This pattern of activity is similar to that observed by McKay (1973) in the RNP. While the activity of the bulls appears to be spread throughout the diel cycle, that of the herds appears to be concentrated near dusk. One possible reason may be that the herds spend a large part of their time during the day within the thorn scrub, under shade, and are noticeable only during the late evenings when they emerge to feed on the open grasslands (Santiapillai *et al.* 1984). Another reason for the late emergence of the herds could be linked to the large number of young ones in the population. Cows with calves rarely take risks and are rather secretive and shy during the day, coming out in the open to graze or bathe in the late afternoon or at night. It is very likely that much of the feeding activity continues late into the night, given the fact that the adults consume on an average about 150 kg of food (Vancuylenberg 1974, 1977). In order to consume such a vast amount of food, the animals spend more than 16 hours in feeding activities (Eisenberg & Lockhart 1972). Feeding is intermittent throughout the 24 hr period.

Grazing occurs predominantly in the late evenings or through the dark hours. Another possible reason for the shift in activity of the herds towards late evenings could be human disturbance. The level of vehicular traffic by tourists is very high in the park vis-a-vis its small size (140 km^2). At the time of the survey in June, there was considerable disturbance to the animals from visitors.

5.5 Reproduction:

The number of young observed in the survey indicates that most of them were born between December and May. The youngest calf observed in Block I was born in May. This points to the possible seasonality in breeding in RNP by elephants. Most of the early workers have concluded that there was no seasonal pattern of breeding in elephants in Sri Lanka (Phillips 1935, Eisenberg & Lockhart 1972, McKay 1973). However both Kurt (1974) and Santiapillai *et al.* (1984) noted the presence of new born calves during the wet season (between December and May). Ishwaran (1981) also recognized a distinct late dry and early wet season birth peak among elephants in one year followed by the absence of such seasonality in the subsequent year. The gestation period in elephant varies from 18 months to 23 months (Phillips 1935). Kurt (1974) estimated it to be 21 months. Considering 20 months as the average gestation period, breeding in RNP appears to extend from March to October (i.e overlapping with the dry season).

Although there appears to be a seasonal pattern of breeding and birth in elephants in RNP, it is too premature to make any firm conclusions from the scanty information gathered during this survey. Observations must be continued for a minimum of eight years in order to establish cyclic patterns if any, in the breeding and birth among elephants (Santiapillai *et al.* 1984). Although it is clear that the females are seasonal breeders, there is yet no positive evidence for cyclical reproductive activity in the male (Hanks 1979). Jainudeen *et al.* (1972) have shown that musth occurs once a year in all adult male Asian elephants at a time when the male hormone testosterone is at a very high level. Musth should be restricted to the post-pubertal male Asian elephants, where it is characterised by aggressive behaviour and a discharge from the temporal gland. Jainudeen *et al.* (1972) hypothesize that musth in Asian elephants is a vestige of a truly seasonal rut which may have existed at some previous time in the evolutionary history of the species.

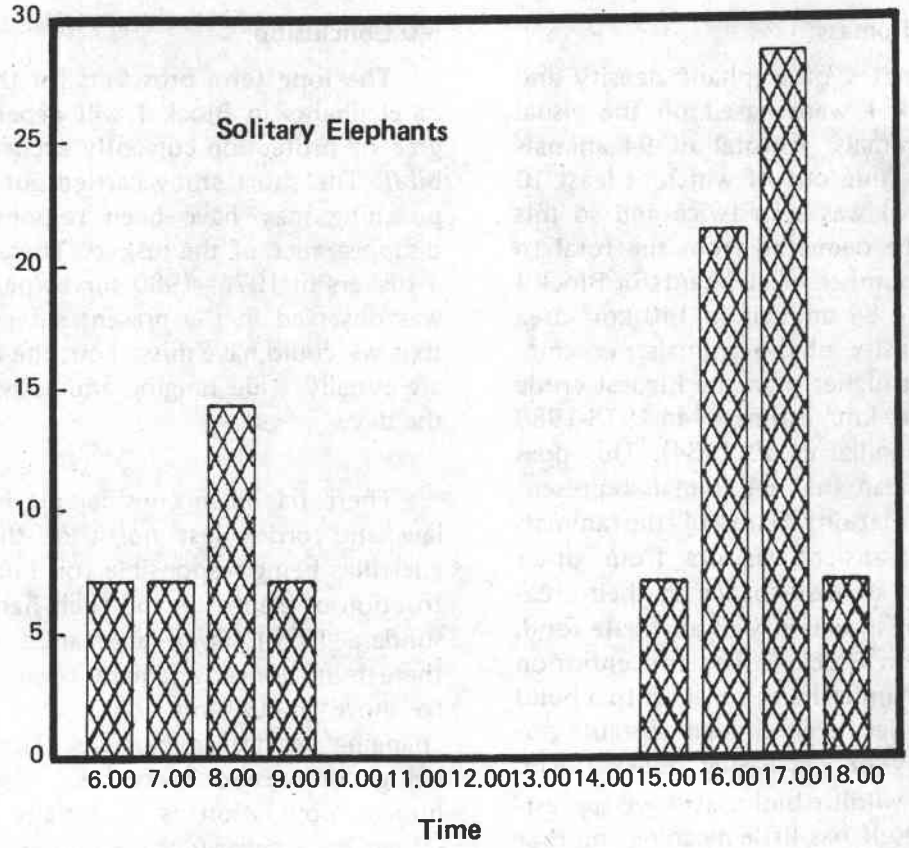


Fig. 8 Activity pattern of solitary elephants in Block I of Ruhuna National Park.

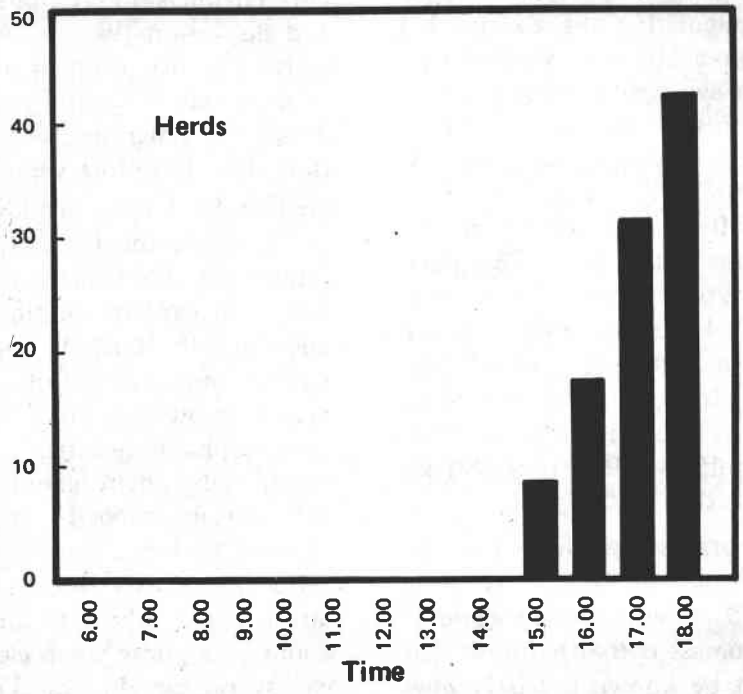


Fig. 9 Activity pattern of the groups of elephants in Block I of Ruhuna National Park.

5.6 Density and Biomass:

Average estimates of elephant density and biomass in Block I were based on the visual counts of the animals. A total of 94 animals were counted in June out of which at least 10 animals (one herd) was seen twice and so this number should be deducted from the total to obtain the total number of elephants in Block I in June. Thus the 84 animals in 140 km^2 area gives a crude density of 0.6 animals per km^2. This is somewhat higher than the highest crude density of 0.46 per km^2 estimated in 1978-1980 in Block I (Santiapillai *et al.* 1984). This does not necessarily mean that 84 animals represent the resident population. Many of the animals could well be transient visitors from other Blocks as a result of disturbance in their areas or attracted by the availability of adequate food, water and cover in Block I. The concentration of elephants in a limited area can lead to a build up in their densities, even though absolute population size may be decreasing (Laws 1981).

A number of wildlife biologists have suggested that density itself has little meaning and that it is biomass (the mass of animals) which is important to an understanding of animal-habitat interrelationships (Spinage 1982). If biomass estimates are needed then they should not be derived by simply calculating the density by adult weight. A more realistic estimate could be obtained by using an average value of the elephant's body weigt adjusted with respect to percentage of age and sex classes, as suggested by Eisenberg & Lockhart (1972). Thus using their average value of 1,810 kg the biomass of elephants in Block I works out to be 1,086 kg per km^2 at a peak density of 0.6/km^2. The estimated biomass in 1978–1980 was 840.3 kg per km^2 (Santiapillai *et al.* 1984). Therefore, between 1978 and 1991, it appears that there had been a 29% increase in elephant biomass (from 840.3 kg per km^2 in 1978–1980 to 1,086 kg per km^2) in Block I of RNP.

The most useful parameter with the greatest scope for comparison however is density. It is also most widely used in wildlife management. The problem with biomass is that before it can be compared, it must be known precisely how different workers have derived their estimates (Spinage 1982).

6.0 Conclusion:

The long term prospects for the population of elephants in Block I will depend on the degree of protection currently accorded to its habitat. The short study carried out suggests that poaching may have been responsible for the disappearance of the tuskers. There were at least 4 tuskers in 1978–1980 survey period but none was observed in the present survey. It is likely that we could have missed out the tuskers which are usually wide ranging and active throughout the day.

There has been considerable breakdown of law and order just north of the RNP with guerrillas being responsible for much of the destruction of elephants and their habitat (Wanigasundara 1990). Over large areas in Sri Lanka, there is no longer adequate room for elephants to move about and adjust their densities to changing vegetation patterns. Their ranges are being compressed every year. The expanding human population is essentially being maintained by a subsistence economy. The changes in the land-use patterns are therefore resulting in continuous contraction of habitat available to the elephant. This serves also to cut off certain channels of response such as emigration and dispersion (Watson & Bell 1969). The animals have lost so much of their original habitat to man, that emigration can no longer be considered a mechanism for regulating the population size. Therefore what is happening in many areas in Sri Lanka, including RNP is that instead of elephants moving out, most elephant populations are experiencing rapid immigration. This may well explain for the increase in density of elephants in Block I. The danger from uncontrolled immigration of elephants into a few secure protected areas comes from the fact that elephant densities can become vulnerable to changing environmental conditions. Suppose the carrying capacity of the area were to be reduced by lower rainfall or destruction of vegetation at a faster rate than the elephant population could adjust to the change, then there could be a phase when elephant densities are in excess of carrying capacity when the rate of habitat destruction would accelerate (Laws 1981).

The main reason for initiating the survey of elephants in Block I was to enable the park authorities to constantly monitor such changes in density and habitat utilization. At the present crude density of 0.6 animals per km^2 there is no immediate danger of elephants destroying their habitat in Block I. RNP has always sustained high elephant numbers in the past (Norris 1959, 1967). High density in itself need not become a regulatory mechanism. In Lake Manyara area is one of the highest known elephant densities in Africa with about 5 animals per km^2. Yet, here too the mean calving interval is about 4.5 years and the mean age at puberty is 11 years (Hanks 1979). What is more important than density in regulating elephant numbers is food supply.

Future surveys must pay special attention to the sex ratio of the adults in Block I. In small populations, the gene frequencies change randomly from generation to generation with a fixation or a loss of alleles. This process is known as genetic drift. The leakage of alleles will eventually lead to an increase in homozygosity in the population (Frankel & Soule 1981). Sukumar (1985) points out that if the male mortality rate due to both natural causes and poaching can be kept below 8% per annum, then the adult sex ratio could be pegged at 1 male to 5 females.

Despite the disparate sex ratio in the herds observed in Block I (1 male to 7.5 females), the reproductive performance of the animals appears good from the proportion of the calves (15.8%) in the population (Table 3). In any polygynous mammalian society there will always be surplus males, since one male can mate with several females. Therefore the opreational sex ratio would not be as disperate as the observed sex ratio in the elephant populations and so a normally disperate sex ratio can still ensure that most if not all the mature females in oestrus are mated (Sukumar 1989). Indiscriminate capture of crop raiding bulls (as recommended in a recent insane project proposal prepared by a consultant from abroad that calls for the capture of 500 such animals from the wild for domestication and sale as a means of reducing elephant crop depredations) can therefore seriously affect the long-term survival of especially small populations in the wild.

Another consideration for managers must be the long-term viability of small populations of elephants. In general, the smaller the population size, the greater is its vulnerability to demographic, environmental and genetic stochasticity (Shaffer 1981, Gilpin & Soule 1986). For long-term viability an effective population size of 500 has been suggested (Franklin 1980, Frankel & Soule 1981). However, not all small populations are necessarily doomed. Although the effects of inbreeding depression are real but transitory. They are minimised if numbers recover quickly from bottlenecks. The population of 40± wild cattle at Chillingham in England after 800 years (about 120 generations) of continuous inbreeding are fit and thriving (Whitehead 1953). In elephants, given their longevity, and longer generation interval, it would take much longer for any inbreeding to accumulate to an appreciable deleterious level.

A population of long-lived elephants would require a very small genetically effective population size (Ne), while a short-lived species such a field mouse may require a large one to preserve 90% heterozygosity after 200 years. The only long-term hope for the elephants in Sri Lanka may lie in the effective protection of small, isolated populations.

In the meantime, what is needed in RNP is the continuation of the monitoring programme that was started in June 1991 to warn managers when the species is in trouble. The solution that we propose will depend on how much we know about the species.

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MANAGING ELEPHANT DEPREDATION IN PLANTATIONS IN SABAH

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SUMMARY

Wild elephants cause enormous losses in Sabah by destroying plantation crops, notably oil palm. An ecological approach to minimising such damage, through such measures as careful siting of Reserves and plantations, offers limited prospects in the state, because bounda-