Asian elephant in Sumatra Population and Habitat Viability Analysis

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The Directorate General of Forest Protection and Nature Conservation (PHPA) of Indonesia and the IUCN/SSC Captive Breeding Specialist Group convened a workshop on the Population and Habitat Viability Analysis of the Asian Elephant in Sumatra (8-10 Nov. 1993), which was attended by more than 40 participants from Indonesia, Malaysia, Thailand, New Zealand, Australia, United Kingdom, USA, Ireland, India and Sri Lanka. The success of this workshop was largely due to the efforts of Ir Komar Sumarna (Director of Nature Conservation, PHPA), Mr. Widodo Sukohadi Ramono (Director: Species Conservation, PHPA), Dr. Ulysses S. Seal (Chairman: IUCN/SSC Captive Breeding Specialist Group) and Dr. Ronald. L. Tilson (Director of Conservation, Education & Research, Minnesota Zoo, USA). The international zoo community provided a generous grant that enabled many of the overseas participants to attend the workshop.

The workshop provided on opportunity to reassess the status of the Asian elephant in Sumatra in the light of the recent changes in the human demography and forest cover. The last survey of the elephant in Sumatra was carried out almost a decade ago by Blouch & Haryanto (1984), Blouch & Sibolon (1985) and Santiapillai & Suprahman (1984). The total population size of the Asian elephant in Sumatra was estimated tobe between 2,800 and 4,800. Much of the information on the number of elephants in Sumatra was gathered from local villagers and wildlife personnel. The information given by the wildlife chiefs from the provinces of Sumatra during the workshop indicates that there could be anything between 3,600 to 4,500 elephants in Sumatra today. This indicates an increased value for the minimum estimate given earlier but the maximumrecorded is still less than what was projected earlier.

In the past, Santiapillai & Jackson (1990) identified 44 separate populations which by 1992 had been reduced to 41 as three populations of elephants became extinct locally. Subsequent work in the northern province of Aceh indicates the fragmentation of large pupulations so that at the workshop, the PHPA identified 47 populations in Sumatra of which, 9 populations comprised less than 25 animals and were considered nonviable, while the remaining 38 populations with more than 25 animals each are distributed as follows:-

9	in national parks	(963-1,173)
5	in game reserves	(710- 860)
3	in protection forests	(130- 180)
21	in production forests	(1,895-2,320)

The important finding is that the largest number of elephants (1,895-2,320) are found in the Production forests whose status varies. There are 3 kinds of Production forests: (a) limited production forests, (b) permanent production forests, and (c) conversion forests. The latter category can be converted to other land uses (such as agriculture, human settlement, mining etc.). Therefore the long term security of many of the elephants in such production forests appears bleak.

As a result of the decline in the forest cover and increase in the human population growth, the elephant-human conflicts in Sumatra have escalated. In extreme cases, the PHPA had been forced to capture chronic crop raiders and rogue elephants with the view to minimising the human-elephant conflicts. This has led to the establishment of a number of Elephant Training Centres across Sumatra. Table 1 provides data on the status of the elephants in these centres.

Table 1: Number of elephants in captivity in Sumatra

Province	year of establishment	number captured	number at present
Lampung	1985	152	83
Aceh	1987	60	40
Riau	1989	45	41
South Sumatra	1990	40	40
Bengkulu	1992	13	13
Total		310	217

Some of the captured elephants have been trained and are being utilized by logging agencies, zoos and safari park. However, unless there is substantial improvement in the veterinary care of the elephants, and sufficient financial and trained manpower resources are available, such increased capture of elephants cannot be justified. Furthermore, care must be taken to see that the annual off take of elephants in the wild is sustainable.

The population modelling group consisting of Raman Sukumar (India), Zainal-Zahari Zainuddin (Malaysia), Yayu Ramdhani (Indonesia), and Charles Santiapillai (Sri Lanka) used the VORTEX model produced by Robert Lacy (Brookfield Zoo, USA).

Life history variables:

Much of the demographic data on the Asian elephant comes from the studies of Sukumar (1989) in southern India, supplemented with some data on population structure of elephants in Way Kambas, Sumatra, in Santiapillai & Suprahman (1986). It is recognized that life-history variables are likely to be different for the southern Indian and the Sumatran elephant populations, as these inhabit tropical deciduous forest and equatorial rain forest respectively. In particular, it has been argued by Sukumar (1989) that elephants in the moister, more climatically "stable" rain forest habitats are likely to have evolved relatively more "k-selected" traits than would the elephants in the drier, more unpredictable habitats. Life-history variables for the Sumatran elephants thus reflect this expected difference.

The following variables were used in the VORTEX modelling:

Breeding system:

The elephant is a polygynous species. Although males are sexually mature when they are about 15 years old, they may not actually be able to mate until 20 or 25 years due to social reasons. Field studies in India show however that in the absence of older males the younger males can breed from the age of 15 years. Age at first reproduction was thus taken to be 15 years and 20 years under two scenarios modelled. Further, it was assumed that only 80% of the adult males are in the breeding pool in a given year.

Female reproductive rates:

Age at first reproduction in females was taken to be 15 years and 20 years. The latter figure may be more likely to be true of elephants in rain forest habitats (Sukumar 1989). Inter-calving interval has been found to be 4.5 to 5 years in southern India, but some data from Way Kambas indicates that females may reproduce only every 6 years on average (Santiapillai & Suprahman 1986). Thus, birth probability was taken to be 0.16/ mature female / year; this was increased marginally to 0.18/ mature female / year in later instances in order to achieve a higher deterministic instrinsic growth rate. Litter size is taken as 1; twinning is very rare in elephants (c. 1% of births) and therefore, inconsequential.

Maximum longevity:

Elephants in captivity are known to have survived until 75 years or more in the case of females and about 60 years in males. How ever female elephants cease reproduction by about 60 years. Thus the maximum longevity was taken to be 60 years. A precise figure is not very important because the proportion of old elephants in the population would be negligible and thus contribute little to reproduction.

Sex - ratio at birth:

A large sample (>260) of births in captivity shows a slight bias towards male calves although this is not statistically significant. We used a 1:1 sex ratio at birth but also explored the effects of a male biased ratio (55:45).

Correlation between EV (reproduction) and EV (survival):

We assume that a correlation exists between these.

Mortality rates:

Mortality rates were adjusted within small limits in order to vary the (deterministic) intrinsic growth rates. In general mortality of female elephants was taken to be 8-15% (age 0-1 year), 4% (age 1-5 years), 2% (age 5-15 or 20 years) and 1.5 - 2.5% (adult age) per year.

There is evidence that in elephants (as in other polygynous mammals) the mortality of males is higher than that of females under natural conditions. This is reflected in the female-biased sex ratios observed in all elephant populations. Male mortality rates were thus taken to be 15% (age 0-1 year), 5% (age 1-5 years) and 3% (ages above 5 years, including adult) per year.

In populations where selective poaching of males for ivory occurs the mortality rates in sub-adult and adult males should be even higher than the above figures. Simulations were also run with a 5% mortality probability in males above 5 years.

Environmental stochasticity

In VORTEX environmental stochasticity is modelled as variation in annual birth and death probabilities by sampling binomial distributions, with the standard deviation (SD) specifying the extent of variation. SD on both birth and death rates were taken to be 20% of the mean rates. This figure is based on the southern Indian study, assuming that environmental variation in rain forest habitat is lower than in drier habitats. In any case, environmental variation seems to make some change to the final results.

Carrying capacity

Carrying capacity (*K*) was generally set at about 20% higher than the initial population size except in case of a population size of 10 for which it was set at 30. Small variations in

K may again not make any difference to the final outcome and was hence ignored. In one set of simulations a trend in *K* was taken as a loss of 0.5% of *K* per annum for 25 years.

Inbreeding depression

Although there are no data available on inbreeding depression in elephants, several studies on mammals in captivity have shown that it is important. We modelled scenarios without and with inbreeding depression. Inbreeding depression used a Heterosis model with a level of 3.14 lethal equivalents which represents the mean of over 40 mammalian species studied.

Catastrophes

Potential catastrophes affecting elephant populations are drought and disease epidemics. Very low probabilities were assumed for both these factors; serious drought is not likely in rain forests and there is no historical evidence of an epidemic such as anthrax. A 4% probability of drought lowering fertility by 40% and killing 5% of individuals, and a 1% probability of disease killing 10% of individuals were assumed. The probability of drought was later reduced to 2% for populations to achieve a higher deterministic growth rate.

Harvest

Elephants from the Sumatran populations are being captured if they are crop raiders. Some poaching of elephants also occurs. Two rates of harvest were considered. Under a low harvest rate four elephants (1 adult female, 1 juvenile female, 1 juvenile male and 1 adult male) were removed from the population every four years for 25 years, while under a high harvest rate the same number was removed for 50 years.

Population sizes were varied from 10 to 100 elephants as appropriate. All simulations began at stable age distribution and were run 500 times for 100 years.

Results

Basic scenario - Deterministic growth rate close to zero (r=0.002), no inbreeding depression, no harvest.

Under this scenario an initial population of 10 elephants had a 65% chance of surviving for 100 years. Raising this to 25 elephants increased the probability of survival to 95% and to 50 elephants to >99% over 100 years. For the two larger populations for which the carrying capacity was set at levels close to initial population size, the stochastic growth rate was still negative and the surviving populations would continue to reduce in size on average over the 100 year period.

Scenario II - r close to zero (0.002), inbreeding depression, no harvest

The outcomes are not particularly different except in the case of very small populations. Probabilities of survival for different initial sizes are 57% (pop. size 10), 96% (size 25) and >99% (size 50). This seems to indicate that inbreeding depression may not be a major factor in the survival except in very small elephant populations.

Scenario II - r close to zero (0.003), inbreeding depression, low harvest

Probabilities of survival for 100 years are 1% (pop. size 25), 10% (size 50) and >99% (size 100). There is a dramatic difference between initial population sizes 50 and 100 in their chances of survival under conditions of a low harvest as defined earlier. Thus harvest of even one elephant per year on average for 25 years would almost certainly drive any population under 50 to extinction. With a staring population of 100 there is a high chance of survival, but even this population would reduce to about half its original size after 100 years.

Scenario IV - r close to zero (0.003), inbreeding depression, high harvest

When the harvest of four elephants every four years is continued for 50 years, the probabilities of survival decrease to a certain extent. These are 2% (size 50) and 97% (size 100).

Scenario V - r increase to about 1% (0.01), inbreeding depression, no harvest

The probabilities of survival increase as compared to scenario II, these being 80% (size 10), 99% (size 25) and >99% (size 50).

Scenario VI - r about 1% (0.01), inbreeding depression, high harvest

With harvest continuing for 50 years, the chances of survival are 0% (size 25), 3% (size 50), 87% (size 75) and 98% (size 100). The surviving populations would however reduce in size during the 100 year period.

Scenario VII - r increased to about 2% (0.02), inbreeding depression, high harvest

Even with a population that can potentially grow at r=0.02, the probabilities of survival are quite bleak (<5%) for population sizes less than 50 elephants. For higher sizes the chances of survival are 89% (size 75) and >99% (size 100).

Summary of results

Elephant populations smaller than about 25 animals to begin with are at a very high risk of extinction. These populations should be supplemented with captured animals or managed as part of a metapopulation. If harvest of elephants (either through capture or poaching) is not envisaged, then a population of about 40-50 elephants whose habitat is secure would have a high chance of survival. If any harvest is envisaged this would be absorbed only by populations in the vicinity of 100 elephants.

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