Population & Habitat Viability Assessment

Workshop, Mysore, 11 - 13 October 1992

Manipur brow-antlered deer *(Cervus eldi eldi)* Sangai

REPORT

Forest Department of Manipur

IUCN CBSG

C.B.S.G. India

IZDA INDIAN ZOO DIRECTORS ASSOCIATION

MYSORE ZOO

ZOO OUTREACH ORGANISATION

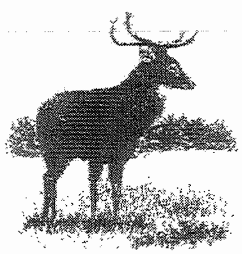
BRITISH AIRWAYS ASSISTING NATURE CONSERVATION

MANIPUR BROW-ANTLERED DEER

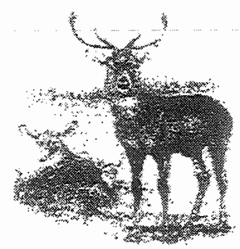
(Cervus eldi eldi)
Locally known as *Sangai*

Population & Habitat Viability Assessment
11 - 13 October, Mysore

Report
August 1994
Coimbatore, India



Edited by
S. Walker



A Collaborative Workshop

Chamarajendra Zoological Gardens, Mysore
Forest Department of Manipur
Indian Zoo Directors' Association
Zoo Outreach Organisation, CBSG, India
Captive Breeding Specialist Group, SSC, IUCN

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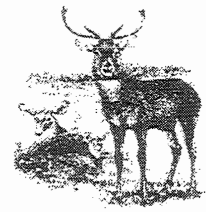
1 August 1995

MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)
Sangai

Report on the
Population & Habitat Viability Assesment

CONTENTS

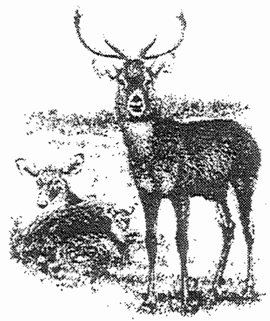


MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)

Sangai

Population & Habitat Viability Assessment Report



11 - 13 October 1992
Mysore

Section 1

EXECUTIVE SUMMARY

ExecutiveSummary

The Manipur Brow-antlered deer *(Cervus eldi eldi)*, locally known as "Sangai" is a critically threatened subspecies of cervid. It is one of four subspecies, the other three of which are found outside India. Just over 100 individuals survive in the wild in a single population inhabiting the Keibul Lamjao National Park in the State of Manipur, India. Although this population has increased over the last ten years, risks to survival persist, including : encroachment on the habitat with exploitation of the deer, difficulty of protecting the area due to local dissatisfaction with the park, floods and other environmental perturbations; epidemic disease and other health threats; and further loss of genetic diversity.

The captive population of about 100 individual was derived from only two pairs of founders and is distributed among 15 Indian zoos in two seperate and distinct blood lines with very little or no interbreeding between them. Lack of exact pedigree information has prevented use of standard methods for genetic analysis of captive population, although the meaningfulness of such analysis considering the paucity of founder stock is questionable. The captive population has fluctuated between 90 and 100 animals over the last decade.

As a single, small wild population, backed up by an inbred and unstable captive population, the Sangai is seriously "at risk".

Evaluation of risk is a major component of the scientific management of endangered species. Planning and implementing strategies to reduce the degree of risk of extinction to an acceptable level is one of the methods of small population recovery through intensive management. Software tools have been developed to assist simulation and quantitative evaluation of risk of extinction and can be used to assess a variety of management scenarios. Identification and ordering of risks can clarify options for management action.

Anomalies with regard to census of wild population, political difficulties, and conflicting views on habitat options, use of captive population and reintroduction protocol, combined with a lack of coordination between the *in situ* and *ex situ* managers had created a need for an assessment of a whole spectrum of possibilities and probabilities with regard to this species.

Historically Sangai occurs only in the southern part of Manipur and today only in the protected area of the National Park. The area is practically inaccessible by human beings, consisting of floating grass mats called "phumdis" of varying thickness, instead of solid ground. Narrow canals negotiated by small dug-out boats divide various size "islands" or mats from one another. Visibility is obstructed much of the year by the height of the grass which grows to more than six feet. Simply seeing Sangai is problematic.

Hence, Sangai was thought to be extinct until a single relict population of less than 100 was discovered mid-century. Subsequently a flood swept through the lake and destroyed many animals, among them Sangai. A census which followed this catastrophe reported only 14 animals. Alarmed authorities notified the area which ultimately resulted in its declaration as a National Park. Vigorous protection measures implemented by the Manipur Forest Department have supported what is believed to be a steady, although small, increase in population. The small size of the population combined with the number and intensity of environmental, ecological, social and political threats have inspired great concern on the part of governmental and non-governmental agencies and individuals for many years.

As early as 1989, workshop on Sangai was proposed to authorities of the Chamarajendra Zoological Gardens by the Zoo Outreach Organisation/CBSG, India, which had conducted captive status and management surveys on the species for some years. The Chamarajendra Zoological Gardens was the first zoo to attempt acquire Sangai from both bloodlines for the purpose of maximising existing genetic potential. When the zoo planned to celebrate its Centenary with a scientific workshop, a Population and Habitat Viability Assessment for Sangai emerged as an appropriate theme. The Forest Department of Manipur was requested to collaborate on the Workshop as well as the Indian Zoo Directors' Association. The Captive Breeding Specialist Group, SSC, IUCN was invited to provide technical support.

A Population and Habitat Viability Assessment (PHVA) was conducted for Sangai at Mysore 11 -14 October 1992. The Workshop was attended by more than seventy wildlife and zoo managers, population biologists, veterinarians, wildlife biologists and wildlife enthusiasts. The goal of the Workshop was to pull together information from both *in situ* and *ex situ* populations to use for developing stochastic population simulation models. The PHVA employed estimated parameters about characteristics of the population and conditions of the environment, including the frequency and severity of different kinds of catastrophes, e.g., floods and deterioration of park protection. Results of the PHVA predicted a 43% probability of extinction of this population in the next 100 years.

A major recommendation to reduce the risk of extinction of the wild population is establishment of additional wild populations using stock produced from the captive population, by translocation from the wild, or some combination. This issue needs further detailed analysis on the sources of stock for the programme, the timing and size of the releases and the effects of removals on the source populations.

A PHVA was also conducted on the captive population under two different scenarios: one of healthy growth such as occurred from inception of the two lineages (1956 and 1962) until 1980; the second of zero growth which more or less characterises the population since 1980. Evidence suggests that unless improved management of the captive population is applied, the zero growh scenario is more probable. Under the zero growth scenario, the PHVA predicted a 15% probability that the captive population will become extinct over the next 100 years. Under the healthy growth scenario, the PHVA simulations predicted a 0% probability of extinction. However, no deleterious effects of loss of genetic diversity, (i.e., inbreeding depression) have been incorporated into the analyses conducted so far. Based on data from other similar small captive populations including another subspecies of Brow-antlered deer *(Cervus eldi thamin)*, it is likely that inbreeding depression is a problem for this population, increasing the probability of extinction. Reproductive anlaysis may be done to determine loss of fertility in females. Identification of individuals and experimental mixing of lineages may be done.

A major recommendation for the captive population is to rapidly increase the number of animals by what ever means can be made practicable such that a sustainable harvest of viable surplus animals will be available to establish new populations in natural habitats. Ideally within the historical range of the subspecies or -- as a last resort -- outside the range in a suitable habitat. There is, however, uncertainty about the utility of the captive population for reintroduction or introduction considering the small number of founders from which it originated. Although nutrition, housing, etc. was felt to be adequate, some experimentation with immproved diets and enclosure design which would make possible more productive social groupings may yield a good result.

The P.H.V.A. Worksho reviewed assembled information about Sangai and forming Working Groups for specialised areas: e.g. In situ Modelling, Habitat Evaluation, Human Impact/Education, Disease/Mortality Group, *Ex situ* Modelling, Husbandry, and Captive Carrying Capacity. This Workshop Report includes recommendations from these groups as well as sections on population history, simulation modelling, and a subsequent follow-up meeting Report.

While the PHVA has reinforced the importance of establishing a second population, the groundwork done here requires follow-up. More specific information is needed to examine some of the questions in greater detail.

This Workshop has laid foundations for further analysis of specific problems that have been identified, with an objective of formulating priorities and determining management action in terms of those priorities. It has been the experience of CBSG that the development of management plans for complex species problems is a step-wise process. Thus, this "final" Report is not final in any sense, but is instead another step towards a more rational methodology for saving the Sangai. Another PHVA should be organised when some of the recommendations in this Report have been carried out, particularly in the area of collection of quantative data on the species, both *in situ* and *ex situ*.

This Report was circulated to all participants and published with their comments as a Second Draft in May, 1993. Further comments were solicited and a Third Draft was circulated previous to the Workshop Followup meeting held in Madras in October 1993. This Final Report was delayed awaiting comments and information which never materialised.

Summary of Major Recommendations

Population Recommendations

1. Alternative populations should be established, ideally within the traditional biogeographic range of the subspecies.

2. The captive population should be enhanced and improved as rapidly possible as breeding stock to insure against catastrophe and for possibly for reintroduction programmes, although the latter was not supported by all in the workshop.

3. The content, consistency and reliability of annual census data, both *in situ* and *ex situ*, should be enhanced including population size, demography and reproductive index.

Wild Population Management Recommendations

1. Monitoring the demography of the wild population should be enhanced, giving a high priority to counting of fawns as an index of reproduction in the population.

2. A process should be set into motion which would result reclamation of genetic material from *in situ* stock. This could be done with the assistance of artificial insemination or embryo transfer.

3. An estimate of confidence limits, or data quality index, should be added to the annual census data report.

Recommendations for Captive Population

1. An enhanced captive population should serve as security against catastrophe and possibly reintroduction programmes. For this, the captive population should be increased as rapidly as possible by improved management assisted by recent advances in reproductive physiology

2. The captive management of the species must include marking of individual animals, scrupulous maintenance of birth, transfer, and death records, including infant mortalities. Demographic and genetic information should be utlised in strategic management and collection planning for the species.

3. The present captive population should be managed for maximum genetic variance through a system of exchange of individuals among zoos. Judicious import from the wild was also recommended although not supported by all in the workshop.

Habitat Management

1. Habitat quality should be improved by judicious adjustment of human interaction and land management, e.g., relocation of enclave, removal of encroachment, demarcation of boundary of the National Park; realignment of roads, enhancement of staff with better equipment and mobility and interface forestry.

2. Fringe populations should be provided with alternative life-styles through eco-development programmes.

Disease / Mortality

1. A thorough analysis of diseases of domestic animals in the surrounding area should be pursued by the veterinary community, supported by appropriate laboratory back-up. Carcases of Sangai encountered in the field should be subjected to detailed necropsy examination to identify the cause of death.

2. The extent and effect of potential nutritional deficiencies, such as mineral deficiency, as well as unwanted additives, such as pesticides which are used for killing fish should be investigated .
3. Preventative and curative captive medical care should be improved, including a protocol for identification and animal health records, development of a centralised data base, in-house and intra-zoo movement to minimise stress, injury and death.

4. Infant mortalities and non-conception by females should be reduced by aggressive and systematic investigation into possible causes, implementation of improved husbandry, and by acquiring technical expertise in handrearing and artificial insemination.

Human Impact / Education / Public Awareness

1. Biotic pressure on Kelbul Lamjao National Park is one of the major threats to Sangai both directly and indirectly,. and should be reduced with suitable precautions to care for the needs of the people living in the area.

2. A full time coordinator for eco-restoration activities should be identified for integrating of various projects and agencies in this type of work.

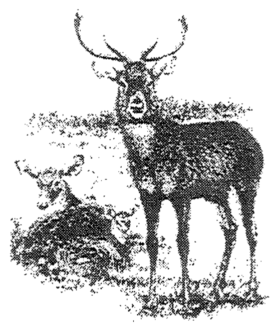
3. Education and awareness programmes should focus first on people living in and around the National Park, integrating attempts to foster local pride with social welfare and eco-development programmes to address problems and reduce destruction of habitat.

4. Meetings and seminars for various levels of officials, administrators, scientists, business people and policy makers should be organised to create awareness and a sense of participation in solving the problems of the National Park and Sangai.

MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)
Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992
Mysore

Section 2

POPULATION MODELLING

MODELLING -- IN SITU POPULATION

Assumptions made for input data

It was decided to run 100 simulations in a time frame of 100 years for the purposes of generating a preliminary VORTEX model for the single population of Sangai that exists at Keibul Lamjao National Park. The social organisation and the required demographic parameters, and estimates of their standard deviations, such as age at first breeding, primary sex ratio, litter size, age-specific surviorships and maximum life expectancy in the wild for both sexes were assumed at the values given in Appendix 1. This was based on past experience of group members in the absence of reliable field data. The starting population was assumed to be 100 deer with 90% of males in the breeding pool. No inbreeding and density independent reproduction were the options selected for lack of field data. From a management perspective, two environmental catastrophic stochastic factors, flood and deterioration in protection due to social instability, were included in the model. Severe flooding was assumed to occur once in 10 years and was assumed to have a severe multiplicative factor of 0.8 on reproduction and 0.7 on survival rates. The probability of deterioration of park protection from social instability was assumed at 0.05. The multiplicative factors relating to reproduction and survival were placed at 0.5 and 0.6 of the base rates. Since this was an initial effort, no harvesting or supplementing of the population was assumed in the input data. Assuming improved habitat protection and management, the potential carrying capacity was set at 300 animals.

RESULTS OF THE SIMULATIONS

The results of the simulations are in Appendices 1 and 2. The ratio of the initial population generated by VORTEX is 45 males and 55 females, whereas, the ratio among adult animals wa 42:54 from the 1991 field census where fawns were not sexed. The population size and extinction probabilities are plotted in Appendix 3. It is seen that the population is declining gradually with a deterministic 'r' of 0.005 and a stochastic 'r' of 0.0231. Of the hundred simulations, there was a 43% chance of extinction in 100 years under the existing management scenario.

RECOMMENDATIONS FOR FUTURE MANAGEMENT

1. Since the existing population appears to be below the assumed potential carrying capacity, and in view of the model results, we recommend top priority for improved protection and enhancement of habitat quality. Specifically we suggest

    1.1 Elimination of human activities such as fishing, poaching, grazing, etc.
    1.2 Rehabilitation of human settlements and enlargement of park area.

2. It is necessary to monitor the demography of this cricial Sangai population, using standard methodologies to collect reliable information on population density, size, structure and dynamics.

3. Considering the potential for catastrophic extinction of this single population, we recommend establishment of new populations within the traditional biogeographic range of the subspecies using captive stock.

MODELLING -- EX SITU POPULATION

Sangai are maintained in 15 zoos in India. These are Calcutta, Delhi, Mysore, Kanpur, Hyderabad, Ahmedabad, Madras, Assam, Manipur, Bhilai, Chhatbir, Lucknow, Jaipur, Nandankanan, and Trivandrum.

The entire captive population is derived from just four animals taken from the wild, two (1.1) taken to Calcutta in 1956 and two (1.1) taken to Delhi in 1962. The present population of Sangai in the zoos totals 100 animals.

From the first introduction of Sangai into the zoos until about 1980 the population grew at a fairly high rate reaching a total of 91 in 1980. Since then the population has tended to fluctuate, initially declining slightly but later increasing to the present level of about 100 animals. One possible reason for this observed pattern of growth is that initially the Sangai had sufficient space for expansion but later as the populations expanded and the zoos became more crowded, intrinsic factors could have resulted in lower birth rates, higher death rates and hence a near 0 population growth. A second possible reason could be increased conflict among individuals, especially male aggression towards males and females, that could have increased the mortality rates.

We carried out a PHVA for the captive population treating all the animals in all the 15 zoos as a single population. The simulations began with an age structure that reflected the actual age and sex distribution of the captive population. Similarly, we calculated fertility and mortality rates based on available data from the Report and Studbook-like listing. We modeled two scenarios for the captive population, one in which the population would potentially increase under deterministic conditions [that parallels the observed growth rate seen during the initial years] and the other in which the population would remain stable with a deterministic model [that corresponds to the observed pattern during the later phase during 1980 to 1992.] We did not consider the possibility of any catastrophe because the population was scattered widely and no single factor was likely to affect them as a whole. We assumed a carrying capacity of 200 individuals for the zoos [this is twice the present level]. The birth and death probabilities for the two scenarios were as follows:

<u>Scenario I:</u>
Females began reproducing at age three and males at age four and continued to do so until death. The maximum potential life span of both sexes was taken to be 12 years. Sex ratio at birth was presumed to be equal. In a given year an adult female had a ninety percent probability of producing one offspring. Death probabilities were as follows: for females 30% from age 0 to 1 and 10% annually from age 1 onwards; and for males, 40 % from age 0 -1 and 15 % annually from age 1 onwards, and for males, 40 % from age 0 -1 and 15 % annually from age 1 onwards. The deterministic growth rate (r) under this scenario was r = 0.08.

Scenario II:

Females began reproducing at age three and males at age four and continued to do so until death. The maximum potential life span of both sexes was taken to be 12 years. Sex ratio at birth was presumed to be equal. In a given year an adult female had a sixty percent probabiility of producing one offspring. Death probabilities were as follows: for females : 25 % from age 0 to 1 and 20 % from age one to two, 14 % from age two to three and 10% annually from age 3 onwards; and for males, 40 % from age 0 -1 and 15 % annually from age 1 onwards. and for males, 40 % from age 0 -1 and 15 % annually from age 1 onwards. Environmental stochasticity was modeled by taking a Standard Deviation of 40% of the annual birth and death probabilities. The deterministic population growth rate (r) under this scenario was 0.

All simulations were run 100 times for 100 years.

Results of the Modelling:

Under scenario I, no population became extinct within 100 years, implying a close to 100 % probability of survival for this period. Under scenario II 15% of the population became extinct while 86% survived over a 100 year period. This gives a 85% probability of survival for 100 years. Of those going extinct mean time to extinction was 76 years [standard error = 5.2].

Scenario II seems to be a more realistic one as it is based on the observed demography of the captive population over the past decade.

Recommendations

1. The observation that the captive population has only 85% probability of survival over the next 100 years clearly points to the need for better management of these animals. However the captive population is not in any immediate danger as the extinction probabilities increase as the modeling shows an increase likelihood after the 50th year.

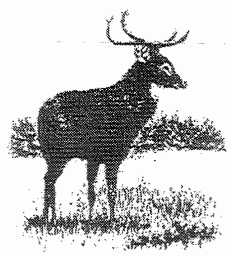
2. Mortality rates have to be reduced by increasing space, removal of aggressive males, improved sanitation, etc.

3. Increased space may also improve the birth rate.

4. As the present population is derived from very few animals [the Calcutta and New Delhi lines] It would be prudent to manage the population for maximum genetic variance through a system of exchange of individuals among zoos, combined perhaps with judicious import from the wild.

5. As observed from the population growth rate from the period around 1960 - 1980 the captive Sangai population in zoos could potentially serve as breeding stock for programmes of reintroduction into the wild. The levels of harvest possible and management practices that would support the harvest can be worked out by a further PHVA.

6. The data on which we have based the modeling exercise are very incomplete as reliable records are not available from the zoos. It is crucial, therefore, that the zoos mark their animals so that they can be recognised individually and maintain scrupulous records of births, transfers, and deaths including infant mortalities so that correct demographic and genetic information about the herd can be extracted..



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VORTEX -- simulation of genetic and demographic stochasticity

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  1 population(s) simulated for 100 years, 10 runs

  No inbreeding depression

  First age of reproduction for females: 3   for males: 5
  Age of senescence (death): 11
  Sex ratio at birth (proportion males): 0.5000


Population 1:

  Polygynous mating; 90.00 percent of adult males in the breeding pool.

  Reproduction is assumed to be density independent.

    20.00 (EV = 10.00 SD) percent of adult females produce litters of size 0
    80.00 percent of adult females produce litters of size 1

   50.00 (EV = 10.00 SD) percent mortality of females between ages 0 and 1
   10.00 (EV = 5.00 SD) percent mortality of females between ages 1 and 2
   10.00 (EV = 2.00 SD) percent mortality of females between ages 2 and 3
   10.00 (EV = 0.50 SD) percent annual mortality of adult females (3<=age<=11
   50.00 (EV = 10.00 SD) percent mortality of males between ages 0 and 1
   10.00 (EV = 5.00 SD) percent mortality of males between ages 1 and 2
   10.00 (EV = 2.00 SD) percent mortality of males between ages 2 and 3
   10.00 (EV = 2.00 SD) percent mortality of males between ages 3 and 4
   10.00 (EV = 2.00 SD) percent mortality of males between ages 4 and 5
   10.00 (EV = 3.00 SD) percent annual mortality of adult males (5<=age<=11)
    EVs may have been adjusted to closest values
        possible for binomial distribution.
    EV in mortality will be correlated among age-sex classes
       but independent from EV in reproduction.

  Frequency of type 1 catastrophes: 10.000 percent
    with 0.900 multiplicative effect on reproduction
     and 1.000 multiplicative effect on survival

  Frequency of type 2 catastrophes: 0.050 percent
    with 0.500 multiplicative effect on reproduction
     and 0.500 multiplicative effect on survival

  Frequency of type 3 catastrophes: 0.020 percent
    with 0.990 multiplicative effect on reproduction
     and 0.500 multiplicative effect on survival

  Frequency of type 4 catastrophes: 0.001 percent
    with 0.750 multiplicative effect on reproduction
     and 0.750 multiplicative effect on survival
```

Initial size of Population 1:
(set to reflect stable age distribution)

Age	1	2	3	4	5	6	7	8	9	10	11	Total	
	7	7	6	5	5	4	4	3	4	2	3	50	Ma
	7	7	6	5	5	4	4	3	4	2	3	50	Fe

Carrying capacity = 200 (EV = 15.00 SD)

Deterministic population growth rate (based on females, with assumptions of no limitation of mates and no inbreeding depression):

r = -0.003 lambda = 0.997 R0 = 0.980
Generation time for: females = 6.31 males = 7.59

Stable age distribution:

Age class	females	males
0	0.112	0.112
1	0.056	0.056
2	0.051	0.051
3	0.046	0.046
4	0.041	0.041
5	0.037	0.037
6	0.034	0.034
7	0.030	0.030
8	0.027	0.027
9	0.025	0.025
10	0.022	0.022
11	0.020	0.020

Ratio of adult (>= 5) males to adult (>= 3) females: 0.692

Population1

Year 10
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 10, P[S] = 1.000
Population size = 98.50 (9.73 SE, 30.76 SD)
Expected heterozygosity = 0.983 (0.002 SE, 0.005 SD)
Observed heterozygosity = 0.999 (0.001 SE, 0.002 SD)
Number of extant alleles = 84.00 (5.60 SE, 17.71 SD)

Year 20
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 10, P[S] = 1.000
Population size = 92.20 (13.17 SE, 41.66 SD)
Expected heterozygosity = 0.969 (0.003 SE, 0.010 SD)
Observed heterozygosity = 0.980 (0.005 SE, 0.015 SD)
Number of extant alleles = 52.50 (4.93 SE, 15.59 SD)

Year 30
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 10, P[S] = 1.000
Population size = 98.90 (12.14 SE, 38.39 SD)
Expected heterozygosity = 0.954 (0.006 SE, 0.018 SD)

```
     Number of extant alleles =   24.09 (   1.44 SE,   13.66 SD)

Year 50
     N[Extinct] =        19, P[E] = 0.190
     N[Surviving] =      81, P[S] = 0.810
     Population size =             103.42 (   9.44 SE,   84.93 SD)
     Expected heterozygosity =    0.875 (  0.012 SE,   0.107 SD)
     Observed heterozygosity =    0.921 (  0.010 SE,   0.089 SD)
     Number of extant alleles =   20.11 (   1.31 SE,   11.77 SD)

Year 60
     N[Extinct] =        23, P[E] = 0.230
     N[Surviving] =      77, P[S] = 0.770
     Population size =             97.03 (   9.17 SE,   80.42 SD)
     Expected heterozygosity =    0.862 (  0.011 SE,   0.098 SD)
     Observed heterozygosity =    0.890 (  0.010 SE,   0.087 SD)
     Number of extant alleles =   17.64 (   1.15 SE,   10.05 SD)

Year 70
     N[Extinct] =        30, P[E] = 0.300
     N[Surviving] =      70, P[S] = 0.700
     Population size =             94.04 (   9.09 SE,   76.03 SD)
     Expected heterozygosity =    0.836 (  0.018 SE,   0.150 SD)
     Observed heterozygosity =    0.872 (  0.018 SE,   0.150 SD)
     Number of extant alleles =   15.49 (   1.07 SE,    8.93 SD)

Year 80
     N[Extinct] =        35, P[E] = 0.350
     N[Surviving] =      65, P[S] = 0.650
     Population size =             86.26 (   8.28 SE,   66.74 SD)
     Expected heterozygosity =    0.822 (  0.017 SE,   0.133 SD)
     Observed heterozygosity =    0.855 (  0.016 SE,   0.126 SD)
     Number of extant alleles =   13.63 (   0.96 SE,    7.70 SD)

Year 90
     N[Extinct] =        37, P[E] = 0.370
     N[Surviving] =      63, P[S] = 0.630
     Population size =             96.71 (  10.79 SE,   85.61 SD)
     Expected heterozygosity =    0.800 (  0.020 SE,   0.162 SD)
     Observed heterozygosity =    0.840 (  0.020 SE,   0.158 SD)
     Number of extant alleles =   11.75 (   0.86 SE,    6.82 SD)

Year 100
     N[Extinct] =        43, P[E] = 0.430
     N[Surviving] =      57, P[S] = 0.570
     Population size =             85.68 (  10.86 SE,   81.96 SD)
     Expected heterozygosity =    0.804 (  0.018 SE,   0.133 SD)
     Observed heterozygosity =    0.823 (  0.020 SE,   0.149 SD)
     Number of extant alleles =   11.12 (   0.76 SE,    5.72 SD)

In 100 simulations of 100 years of Population1:
  43 went extinct and 57 survived.

This gives a probability of extinction of 0.4300 (0.0495 SE),
```

or a probability of success of 0.5700 (0.0495 SE).

43 simulations went extinct at least once.
Of those going extinct,
mean time to first extinction was 58.44 years (3.56 SE, 23.34 SD).

No recolonizations.

Mean final population for successful cases was 85.68 (10.86 SE, 81.96 SD)

Age 1	2	3	4	Adults	Total	
7.58	6.77	5.56	4.46	13.88	38.25	Males
8.37	7.49			31.58	47.44	Females

Without harvest/supplementation, prior to carrying capacity truncation,
mean growth rate (r) was -0.0231 (0.0025 SE, 0.2221 SD)

Final expected heterozygosity was 0.8041 (0.0176 SE, 0.1329 SD)
Final observed heterozygosity was 0.8234 (0.0198 SE, 0.1495 SD)
Final number of alleles was 11.12 (0.76 SE, 5.72 SD)
****

VORTEX -- simulation of genetic and demographic stochasticity

SANGAI.012
Tue Oct 20 00:00:40 1992

1 population(s) simulated for 100 years, 100 runs

No inbreeding depression

First age of reproduction for females: 3 for males: 5
Age of senescence (death): 11
Sex ratio at birth (proportion males): 0.5000

Population 1:

Polygynous mating; 90.00 percent of adult males in the breeding pool.

Reproduction is assumed to be density independent.

20.00 (EV = 10.00 SD) percent of adult females produce litters of size
80.00 percent of adult females produce litters of size 1

30.00 (EV = 10.00 SD) percent mortality of females between ages 0 and 1
10.00 (EV = 5.00 SD) percent mortality of females between ages 1 and 2
10.00 (EV = 2.00 SD) percent mortality of females between ages 2 and 3
10.00 (EV = 2.00 SD) percent annual mortality of adult females (3<=age<
30.00 (EV = 10.00 SD) percent mortality of males between ages 0 and 1
15.00 (EV = 5.00 SD) percent mortality of males between ages 1 and 2
15.00 (EV = 3.00 SD) percent mortality of males between ages 2 and 3

```
     Observed heterozygosity =    0.971 (  0.005 SE,    0.017 SD)
     Number of extant alleles =   39.10 (   4.22 SE,    13.35 SD)

Year 40
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =     10, P[S] = 1.000
     Population size =          106.10 (  11.96 SE,    37.83 SD)
     Expected heterozygosity =    0.940 (  0.008 SE,    0.024 SD)
     Observed heterozygosity =    0.959 (  0.007 SE,    0.023 SD)
     Number of extant alleles =   32.40 (   3.25 SE,    10.29 SD)

Year 50
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =     10, P[S] = 1.000
     Population size =           97.60 (  12.05 SE,    38.11 SD)
     Expected heterozygosity =    0.926 (  0.012 SE,    0.037 SD)
     Observed heterozygosity =    0.934 (  0.015 SE,    0.048 SD)
     Number of extant alleles =   26.30 (   2.48 SE,     7.83 SD)

Year 60
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =     10, P[S] = 1.000
     Population size =           87.40 (  12.72 SE,    40.22 SD)
     Expected heterozygosity =    0.909 (  0.011 SE,    0.034 SD)
     Observed heterozygosity =    0.920 (  0.011 SE,    0.036 SD)
     Number of extant alleles =   21.10 (   2.18 SE,     6.89 SD)

Year 70
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =     10, P[S] = 1.000
     Population size =           89.50 (  16.67 SE,    52.73 SD)
     Expected heterozygosity =    0.886 (  0.015 SE,    0.047 SD)
     Observed heterozygosity =    0.911 (  0.018 SE,    0.058 SD)
     Number of extant alleles =   18.20 (   2.27 SE,     7.19 SD)

Year 80
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =     10, P[S] = 1.000
     Population size =           87.60 (  14.18 SE,    44.84 SD)
     Expected heterozygosity =    0.876 (  0.019 SE,    0.061 SD)
     Observed heterozygosity =    0.907 (  0.026 SE,    0.082 SD)
     Number of extant alleles =   16.00 (   2.08 SE,     6.57 SD)

Year 90
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =     10, P[S] = 1.000
     Population size =           71.30 (  10.79 SE,    34.11 SD)
     Expected heterozygosity =    0.867 (  0.016 SE,    0.051 SD)
     Observed heterozygosity =    0.868 (  0.026 SE,    0.081 SD)
     Number of extant alleles =   13.60 (   1.46 SE,     4.62 SD)

Year 100
     N[Extinct] =        0, P[E] = 0.000
     N[Surviving] =     10, P[S] = 1.000
     Population size =           64.40 (   9.54 SE,    30.16 SD)
```

```
     Expected heterozygosity =    0.831 (  0.028 SE,   0.088 SD)
     Observed heterozygosity =    0.843 (  0.035 SE,   0.110 SD)
     Number of extant alleles =   11.70 (   1.33 SE,    4.22 SD)


In 10 simulations of 100 years of Population1:
  0 went extinct and 10 survived.

This gives a probability of extinction of 0.0000 (0.0000 SE),
  or a probability of success of          1.0000 (0.0000 SE).

Mean final population for successful cases was 64.40 (9.54 SE, 30.16 SD)

   Age 1       2       3       4    Adults    Total
    4.60    4.80    4.70    1.60    16.50     32.20  Males
    3.60    4.90                    23.70     32.20  Females

Without harvest/supplementation, prior to carrying capacity truncation,
  mean growth rate (r) was -0.0051 (0.0025 SE, 0.0789 SD)

Final expected heterozygosity was      0.8313 ( 0.0279 SE,  0.0883 SD)
Final observed heterozygosity was      0.8425 ( 0.0349 SE,  0.1105 SD)
Final number of alleles was             11.70 (   1.33 SE,    4.22 SD)
************************************************************************
```

VORTEX -- simulation of genetic and demographic stochasticity

SANGAI.012
Tue Oct 13 02:42:49 1992

1 population(s) simulated for 100 years, 100 runs

No inbreeding depression

First age of reproduction for females: 3 for males: 5
Age of senescence (death): 11
Sex ratio at birth (proportion males): 0.5000

Population 1:

Polygynous mating; 90.00 percent of adult males in the breeding pool.

Reproduction is assumed to be density independent.

20.00 (EV = 10.00 SD) percent of adult females produce litters of size 0
80.00 percent of adult females produce litters of size 1

30.00 (EV = 10.00 SD) percent mortality of females between ages 0 and 1
10.00 (EV = 5.00 SD) percent mortality of females between ages 1 and 2
10.00 (EV = 2.00 SD) percent mortality of females between ages 2 and 3
10.00 (EV = 2.00 SD) percent annual mortality of adult females (3<=age<=11)
30.00 (EV = 10.00 SD) percent mortality of males between ages 0 and 1
15.00 (EV = 5.00 SD) percent mortality of males between ages 1 and 2
15.00 (EV = 3.00 SD) percent mortality of males between ages 2 and 3
15.00 (EV = 3.00 SD) percent mortality of males between ages 3 and 4
15.00 (EV = 2.00 SD) percent mortality of males between ages 4 and 5
15.00 (EV = 3.00 SD) percent annual mortality of adult males (5<=age<=11)
EVs may have been adjusted to closest values
possible for binomial distribution.
EV in reproduction and mortality will be correlated.

Frequency of type 1 catastrophes: 10.000 percent
with 0.800 multiplicative effect on reproduction
and 0.700 multiplicative effect on survival

Frequency of type 2 catastrophes: 5.000 percent
with 0.500 multiplicative effect on reproduction
and 0.600 multiplicative effect on survival

Initial size of Population 1:
(set to reflect stable age distribution)

Age 1	2	3	4	5	6	7	8	9	10	11	Total	
9	8	6	5	5	3	3	2	2	1	1	45	M
9	9	7	6	5	4	4	3	3	3	2	55	F

Carrying capacity = 300 (EV = 15.00 SD)

```
SANGAI.012    ***OutputFilename***
N     ***PlotterFiles?***
100     ***Simulations***
100     ***Years***
10     ***ReportingInterval***
1     ***Populations***
N     ***InbreedingDepression?***
Y     ***EVcorrelation?***
2     ***TypesOfCatastrophes***
P     ***MonogamousOrPolygynous***
3     ***FemaleBreedingAge***
5     ***MaleBreedingAge***
11     ***MaximumAge***
0.500000     ***SexRatio***
1     ***MaximumLitterSize***
N     ***DensityDependentBreeding?***
20.000000     ***Population1:PercentLitterSize0***
80.000000     ***Population1:PercentLitterSize1***
10.000000     ***EV--Reproduction***
30.000000     ***FemaleMortalityAtAge0***
10.000000     ***EV--FemaleMortality***
10.000000     ***FemaleMortalityAtAge1***
5.000000     ***EV--FemaleMortality***
10.000000     ***FemaleMortalityAtAge2***
2.000000     ***EV--FemaleMortality***
10.000000     ***AdultFemaleMortality***
2.000000     ***EV--AdultFemaleMortality***
30.000000     ***MaleMortalityAtAge0***
10.000000     ***EV--MaleMortality***
15.000000     ***MaleMortalityAtAge1***
5.000000     ***EV--MaleMortality***
15.000000     ***MaleMortalityAtAge2***
3.000000     ***EV--MaleMortality***
15.000000     ***MaleMortalityAtAge3***
3.000000     ***EV--MaleMortality***
15.000000     ***MaleMortalityAtAge4***
2.000000     ***EV--MaleMortality***
15.000000     ***AdultMaleMortality***
3.00000     ***EV--AdultMaleMortality***
10.000000     ***ProbabilityOfCatastrophe1***
0.800     ***Severity--Reproduction***
0.700000     ***Severity--Survival***
5.0000     ***ProbabilityOfCatastrophe2***
0.5000     ***Severity--Reproduction***
0.600000     ***Severity--Survival***
N     ***AllMalesBreeders?***
Y     ***Answer--A--Known?***
90.000000     ***PercentMalesInBreedingPool***
Y     ***StartAtStableAgeDistribution?***
100     ***InitialPopulationSize***
300     ***K***
15.000000     ***EV--K***
N     ***TrendInK?***
N     ***Harvest?***
N     ***Supplement?***
```

```
Deterministic population growth rate (based on females, with assumptions of
    no limitation of mates and no inbreeding depression):

     r =  -0.005     lambda = 0.995      R0 =      0.972
   Generation time for:  females = 6.01    males = 7.19

Stable age distribution:  Age class     females     males
                               0         0.110      0.110
                               1         0.074      0.074
                               2         0.063      0.060
                               3         0.055      0.049
                               4         0.047      0.040
                               5         0.040      0.032
                               6         0.035      0.026
                               7         0.030      0.021
                               8         0.026      0.017
                               9         0.022      0.014
                              10         0.019      0.011
                              11         0.016      0.009

Ratio of adult (>= 5) males to adult (>= 3) females: 0.453


Population1

Year 10
     N[Extinct] =       0, P[E] = 0.000
     N[Surviving] =   100, P[S] = 1.000
     Population size =           109.56 (   6.03 SE,   60.29 SD)
     Expected heterozygosity =    0.977 (  0.001 SE,   0.010 SD)
     Observed heterozygosity =    0.995 (  0.001 SE,   0.008 SD)
     Number of extant alleles =   74.09 (   2.67 SE,   26.70 SD)

Year 20
     N[Extinct] =       1, P[E] = 0.010
     N[Surviving] =    99, P[S] = 0.990
     Population size =           106.53 (   7.81 SE,   77.66 SD)
     Expected heterozygosity =    0.952 (  0.004 SE,   0.036 SD)
     Observed heterozygosity =    0.972 (  0.004 SE,   0.036 SD)
     Number of extant alleles =   45.33 (   2.28 SE,   22.66 SD)

Year 30
     N[Extinct] =       7, P[E] = 0.070
     N[Surviving] =    93, P[S] = 0.930
     Population size =            96.80 (   7.86 SE,   75.83 SD)
     Expected heterozygosity =    0.929 (  0.006 SE,   0.055 SD)
     Observed heterozygosity =    0.961 (  0.004 SE,   0.040 SD)
     Number of extant alleles =   31.98 (   1.72 SE,   16.59 SD)

Year 40
     N[Extinct] =      10, P[E] = 0.100
     N[Surviving] =    90, P[S] = 0.900
     Population size =            87.78 (   7.03 SE,   66.68 SD)
     Expected heterozygosity =    0.902 (  0.008 SE,   0.076 SD)
     Observed heterozygosity =    0.946 (  0.006 SE,   0.055 SD)
```

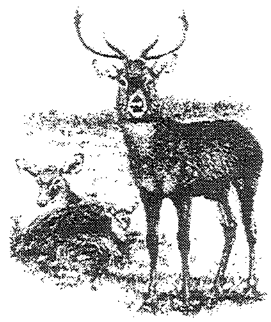
```
SANGAI.022     ***OutputFilename***
N     ***PlotterFiles?***
10     ***Simulations***
100     ***Years***
10     ***ReportingInterval***
1     ***Populations***
N     ***InbreedingDepression?***
N     ***EVcorrelation?***
4     ***TypesOfCatastrophes***
P     ***MonogamousOrPolygynous***
3     ***FemaleBreedingAge***
5     ***MaleBreedingAge***
11     ***MaximumAge***
0.500000     ***SexRatio***
1     ***MaximumLitterSize***
N     ***DensityDependentBreeding?***
20.000000     ***Population1:PercentLitterSize0***
80.000000     ***Population1:PercentLitterSize1***
10.000000     ***EV--Reproduction***
50.000000     ***FemaleMortalityAtAge0***
10.000000     ***EV--FemaleMortality***
10.000000     ***FemaleMortalityAtAge1***
5.000000     ***EV--FemaleMortality***
10.000000     ***FemaleMortalityAtAge2***
2.000000     ***EV--FemaleMortality***
10.000000     ***AdultFemaleMortality***
0.500000     ***EV--AdultFemaleMortality***
50.000000     ***MaleMortalityAtAge0***
10.000000     ***EV--MaleMortality***
10.000000     ***MaleMortalityAtAge1***
5.000000     ***EV--MaleMortality***
10.000000     ***MaleMortalityAtAge2***
2.000000     ***EV--MaleMortality***
10.000000     ***MaleMortalityAtAge3***
2.000000     ***EV--MaleMortality***
10.000000     ***MaleMortalityAtAge4***
2.000000     ***EV--MaleMortality***
10.000000     ***AdultMaleMortality***
3.000000     ***EV--AdultMaleMortality***
10.000000     ***ProbabilityOfCatastrophe1***
0.900000     ***Severity--Reproduction***
1.000000     ***Severity--Survival***
0.050000     ***ProbabilityOfCatastrophe2***
0.500000     ***Severity--Reproduction***
0.500000     ***Severity--Survival***
0.020000     ***ProbabilityOfCatastrophe3***
0.990000     ***Severity--Reproduction***
0.500000     ***Severity--Survival***
0.001000     ***ProbabilityOfCatastrophe4***
0.750000     ***Severity--Reproduction***
0.750000     ***Severity--Survival***
N     ***AllMalesBreeders?***
Y     ***Answer--A--Known?***
90.000000     ***PercentMalesInBreedingPool***
Y     ***StartAtStableAgeDistribution?***

100     ***InitialPopulationSize***
200     ***K***
15.000000     ***EV--K***
N     ***TrendInK?***
N     ***Harvest?***
N     ***Supplement?***
N     ***AnotherSimulation?***
```

MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)
Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992
Mysore

Section 3

HABITAT EVALUATION

HABITAT EVALUATION

The Working Group identified the following limiting factors leading to habitat degradation

1. Land encroachment and human settlement inside the park;
2. Illegal grazing by domestic cattle;
3. Illegal fishing in park area;
4. Unauthorised entry of local people for collection of non-wood forest products;
5. Uncontrolled fire in dry months;
6. Deforestation in the hill slopes;
7. Industrial activity in the wetland area;
8. Inadequate enforcing machinery for implementation and regulatory measures.

In view of the above mentioned factors, the Working Group created an Action Plan which may be considered by the implementing authorities:

Action Plan

1. The enclave (Khorda village) of the National Park consisting of 50 families may be relocated

2. All encroachment from within the boundary of the National Park should be removed

3. An attempt should be made to demarcate the boundary of the National Park by suitable means

4. Stall feeding of cattle, reduction of cattle and development of fodder plots out of the park area should be taken up to curb grazing, e.g. "Interface forestry."

5. Since the water area of the National Park is well below 10% of the total lake area, fishing should be totally prohibited in the National Park

6. The road touching the western boundary and the Canal cutting across the National Park should be re-aligned to direct all human movement outside the Park. The adjacent forest area west of the road may be included in the National Park.

7. Some selected controlled burning of grassland in early or late October should be done for promoting healthy growth of palatable grass and acting as firelines to prevent general burning of the area during dry months

8. Afforestation of denuded hill slopes should be taken up in phased manner using desirable indigenous species.

9. There should be adequate number of staff provided with modern firearms, radio telemetry set-up, night vision equipment, etc. together with reasonable mobility for enforcement of regulatory measures in order to protect the habitat and its inhabitants.

10. An integrated local and apex body may be set up for taking suitable measures to preserve the natural wetland ecosystem of the area.

11. Habitat improvement programmes should be undertaken for eradiction of un-desirable species and replacement by desirable species

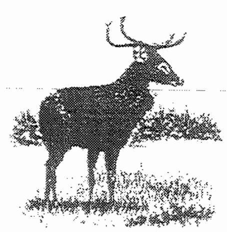
12. Eco-devlopment programmes are to be undertaken to provide alternatives to fringe population to to reduce pressure on the habitat. N.G.O.'s. with local base should also be involved in the process.

13. Education and awareness programme to be launched on a mass scale to educate the local people so that they may desist from indulging in destruction of habitat.

14. Selection of an alternative habitat for introduction of this species in the wild should be done to ensure the survival of the species in the country in the event of a catastrophic event decimating all or part of the single population in Manipur.

Additional comments from invitees who could not attend:

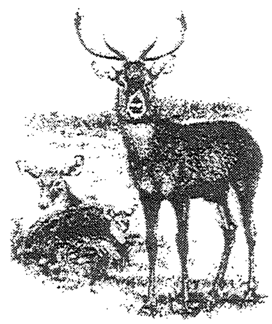
Vinod Rishi, Addl. Director (WL), Govt. of India commented on the Draft that although the major thrust of the proposed action plan is control of biotic and antropogenic factors, the importance given these factors is not reflected in the assumptions of the Modelling Group. That is, that the probability of deterioration of park protection from social instability would be 0.05 as indicated in paragraph 1 on assumptions made for input data, on the basis of which a report of the Wild Population Modelling Working Group has been prepared. Two environmental catastrophic stochastic factors were considered: multiplicative factors relating to reproduction and survival of the species, and also social instability. The latter appears to be the only factor relating to the biotic interaction affecting Park protection. The degree of importance given to elimination of human activities and rehabilitation of human settlements is not consistent with the probability level allocated to of deterioration of Park protection from this factor Therefore it requires a review by the Working Group.



MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)
Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992
Mysore

Section 4

DISEASE AND MORTALITY

DISEASE AND MORTALITY -- IN SITU

Disease and mortality among wild Sangai is a potential decimating factor of the population. Considering the ecological and other anthropogenic factors influencing the disease incidence and mortality pattern, the following conditions need attention:

1. Haemorrhagic septicemia is likely to be an important disease that can affect Sangai, followed by foot and mouth disease, black quarter and anthrax among the infectious diseases. In the absence of reports on mortality due to disease, however, it is not possible to be more specific.

2. Prevailing agroclimatic conditions and intermixing of domestic livestock in the sanctuary, increase the liklihood of pasteurellosis precipitating into an epidemic form. There are reports of FMD among the domestic livestock, which could affect the population growth rate of Sangai.

3. Enhanced parasitic load in Sangai is possible because of the obvious intermixing with the domestic stock; this may contribute to reduced resistance and predispose the animals to other diseases.

4. Pesticides used for fishing in the phumdis could adversely affect the health of Sangai and should be investigated immediately. Periodical analysis of water samples will help in evaluating the situation.

5. Enhanced awareness and thorough understanding of diseases of domestic animals in the surrounding area, supported by appropriate laboratory back-up and confirmation of the disease problem is absolutely necessary.

6. Carcases or remains of Sangai encountered in the field should be subjected to detailed necropsy examination to identify the cause of death.

7. Considering the fact that a qualified veterinary pathologist may not be readily available to investigate the carcass in time, there is an urgent need to train a non-veterinarian such as a laboratory technician, veterinary technician or compounder to learn the protocol of collecting, preserving and shipping diagnostic material to the nearest diagnostic laboratory. For this purpose the park management should possess a standard post-mortem kit, preservatives, containers and packing materials. Even if a veterinarian is available, specimens for laboratory diagnosis should be collected and dispatched to the laboratory.

8. Sangai being a cervid and having access only to a limited area for grazing, chances of developing mineral deficiency is very high. In addition, there is a possibility of minerals being leached away due to heavy rainfall and waterlogging.

Increased burden of parasitism as mentioned earlier, will add further to the deterioration of the health status of Sangai. At present only salt licks are provided which contain almost exclusively sodium and chloride. Hence any quality mineral supplements containing all the minerals, especially calcium and phosphorous, may be added along with the salts provided. Addition of mineral supplements are recommended because the standard salt licks cannot provide all minerals in the required quantity.

DISEASE/MORTALITY (CAPTIVE)

Overview: Review of all available reports (over past 30 years for Sangai indicate that the major cause of mortality is traumatic injury (41.5%). Injuries generally are related to inter-male aggression (28.5%) although many injuries also presumably were associated with self-destructive behaviour (12.9%). Other causes of mortality included infant mortality (10.4%), infectious diseases and deaths from unknown causes (20.2%). Of the infectious diseases, only tuberculosis (TB) has been definitely diagnosed: 3 cases at the National Zoo (1962-1991); 3 cases at the Kanpur Zoo (1976 - 1990); and 12 cases at the Calcutta Zoo (1956-1988). Pneumonia also has been described as a clinical syndrome, although the specific etiological agents were unknown. The causes of neonatal mortality are unknown but are likely to be related to natal-illness or failure of passive transfer of maternal immunoglobulins.

Recommendations:

Health Care

I. Neonatal care: At 48-72 hours of age, a complete physical examination should be performed and morphometric measurements obtained. In addition to the physical exam, the following should be performed:

a) standardized body measurement (i.e., crown-rump, shoulders-hoof, chest circumference, etc.)
b) body weight
c) vaccinations and medical treatment
   1. tetanus antitoxin
   2. vitamin E/multiple vitamin
   3 long acting antibiotics
d) treat umbilicus with tincture of iodine
e) eartagging

In cases of premature or weak fawns, consideration should be given to handrearing and/or supplementing offspring with colostrum or milk replacer. If failure of passive transfer is suspected, colostrum should be available and provided orally within 12 - 24 hours after birth. Sodium sulfite turbidity testing can be performed if failure of passive transfer is suspected.

II. Herd Health Management

Regular health screening including physical examination is essential to minimize animal health problems. Routine vaccination and screening for endo and ecto parasites should be performed. Vaccination first should be instituted at 4 months of age to include vaccines for rinderpest, HS, and clostridium.

After initial vaccination animals should be re-vaccinated at approximately 12 month intervals to include tetanus toxoid, clostridium, rabies and rinderpest. For re-vaccinations, animals should be sedated to permit routine physical examinations, blood sampling and hoof trimming as required. Routine serum chemistry and complete blood counts also should be performed for the purpose of developing a clinical database. Serum from each individual also should be banked to assist in epidemiological investigation should disease outbreaks occur.

Fecal samples should be collected and screened for parasites at three month intervals and animals should then be treated with specific antihelmintic as required.

Clinically ill animals should be segregated from the herd in areas where they can be adequately treated. Isolation of sick individuals will help prevent disease transmission to healthy animals. Each clinical case should be thoroughly investigated in an effort to formulate a definitive diagnosis. Complete necropsy examinations of all dead animals should be performed todetermine a specific cause of death. Post-morten sampler should be submitted for clinical, histopathological, microbiological, serological and toxicological tests as required. Collaborations with veterinary and/or medical institutes should be encouraged.

Animal movements should be carefully performed, taking into account the availability of capture and restraint equipment. Shipments of animals should only be performed when ambient temperatures are not excessive. For re-introductions, animals first must be thoroughly screened using all available diagnostic tests and reintroduction candidates should be quarantined for at least four weeks before release, preferably in a holding area near the release site.

III Record keeping

A uniform system for recording and maintaining animal health records and anaesthetic reports should be developed. A centralised data base then should be compiled to include descriptions of clinical cases and anesthesia reports disseminated to all veterinarians working with Sangai.

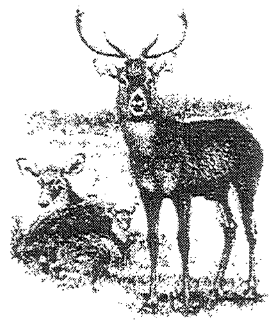
Fecal samples should be collected and screened for parasites at three month intervals and animals should then be treated with specific antihelmintic as required.

MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)

Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992
Mysore

Section 5

CAPTIVE MANAGEMENT

CAPTIVE CARRYING CAPACITY

he total captive population of Sangai in India was assessed with an eye to distributing animals in such a way as to promote maximum growth of the population There are fifteen zoos in India which are presently holding Sangai, i.e. Delhi - 12.17; Calcutta - 10.7, Kanpur - 5.5, Hyderabad - 4.5, Ahmedabad 4.3, Madras 3.2, Assam 2.3, Mysore 2.2, Manipur 2.0, Bhilai 2.1, Chhatbir 1.2, Lucknow 1.1, Jaipur 1.0, Nandankanan 0.1, Trivandrum 1.0. There is a total of 99 (50.49) animals in fifteen zoos.

All the animals that are now in the collections of various zoos have come from only two (2) wild caught pairs which were given to Calcutta Zoo (1.1) in 1956 and Delhi Zoo (1.1) in 1962. There is also a male Sangai (1.0) in Manipur which is said to be the offspring of a female of wild origin and a male of Delhi origin.*

The offspring of the Delhi pair have gone to eight different zoos in the country, viz. Ahmedabad, Hyderabad, Lucknow, Kanpur, Imphas, Jaipur, Chhatbir, Mysore Similarly, the offspring from the Calcutta pair have gone to five other zoos, viz. Mysore, Assam, Trivandrum, Nandankanan, Bhilai

An interesting feature is that Mysore Zoo acquired a pair from Delhi and 1.2 from Calcutta in 1974. In the same year of their acquisition the male from Delhi died. The female of Delhi and the other females cannot be identified.

i.	Delhi origin	29.34
ii.	Calcutta origin	14. 9
iii.	Uncertain mixture (Mysore)	6. 7

With this data as background material, the Working group examined the size of captive groups of Sangai in various zoos. The collections vary from lone animals to large groups of 27 animals in a single collection.

Carrying capacity of existing zoos : The size of enclosures is again widely varied from a few square metres to over 2 ha. Eleven zoos have fairly large enclosures varying from 2000 square metres to 10,000 square metres.

Considering the size of enclosures excepting Delhi and Kanpur, all the other nine (9) zoos could manage larger herds, e.g., Manipur, Mysore, Hyderabad, Madras, Chhatbir and Trivandrum. Pairing of animals in zoos which have singles should be done immediately: e.g., Trivandrum 1.0; Jaipur 1.0, Nandankanan 0.1.

Finally, in addition to the zoos that are presently keeping Sangai in their collection, the following zoos should consider initiating captive breeding programmes for this species: Van Vihar Park, Bhopal; Sanjay Gandhi Zoo, Patna; Indira Gandhi Zoo, Vizak, Venkateswariah Zoo, Tirupati and Coimbatore Zoo, Coimbatore.

Considering the existing (100) animals, the original two founder zoos, i.e. Delhi, Calcutta and perhaps Kanpur could retain groups of 5.5 animals and all the other zoos, 2.2 animals. The surplus should go to Manipur to make up their breeding group.

Of the surplus in future, including that from the additional zoos which have been recommended to found breeding programmes a substantial portion should go to the Manipur programme to become the property of the Government of Manipur as well as their offspring.

Considering the difficulty zoos have had with fighting between males in mixed groups, it may be desirable to start bachelor herds. Also separate enclosures can be provided so that a 1.1 ratio is maintained. This is ideal for increasing the size of the population quickly but animals will have to be moved frequently.

* The Manipur male is no more living.

Comments

It is probably not worthwhile to give too much importance to the "Mysore mixture" as there is a great liklihood that none of those animals which are possibly mixed survived long enough to breed.

CAPTIVE MANAGEMENT

Recommendations:

1. **Housing:** Taking into consideration the variation in the present sizes of enclosures in different zoos, most of the existing facilities are adequate and hence are optimum. Sizing of the enclosure need not be specified, however the outdoor enclosure should be fairly large. It is essential that the facilities for seperation of the males should be provided. A minimum area of 10 X 15 ft. may be provided per adult animal in the night cages. A marshy area in the enclosure seems to add to the well-being of the animals as does enriched vegetation.

2. **Feed.** Diifferent zoos follow different food regimins and all of them are almost equally successful in rearing Sangai. . As such it is felt that the present practice of food supply is adequate. It is recommended that 2 - 3% of the body weight of basic feed may be given besides roughage ad libitum. Care should be taken to provide the pregnant females with one and a half times their normal ration while the lactating mothers should be given two times the normal diet.

3. **Sanitation.** As left-over feed and water results in the formation of aflatoxins which are injurious to the animals, all the left-over food and water should be removed and fresh food and water should be kept. Regular disinfection of the feeding trays and water troughs in and around the enclosures should be ensured.

4. **Prophylactic measures.** The present prophylactic measures are considered to be adequate and the same may be continued without fail Regular worm egg counts should be made to assess if prophylactic measures are working.

5. **Group composition**. Most of the zoos presently keep Sangai in large groups. There is a very high mortality due to aggression between male which affects females as well. In addition, the dominant male is likely to be the only contributor to the gene pool. Aggression injuries are easily controlled by seperation of males (stag in hard antler). Adult males should be kept seperate, allowing only one male per season access to a specific number of females. It is ideal to have groups of 1.2 adults in different enclosures. This would also assist in determining parentage and allows for stag rotation, as well as curtailing the problem of aggression.

6. **Breeding and rearing.** Under present husbandry conditions there are considerable infant mortalities. Also, some of the females are not contributing to the progeny. In order to create a larger population for an active captive breeding programme the causes of infant mortalities should be aggressively pursued. Weights should be taken and a full post-mortem conducted on infant deaths. Post mortem results should be sent to the Studbook Keeper for collation and analysis to ascertain reasons for infant mortality.

Acquiring technical expertise in handrearing and artificial insemination will increase options for genetic and demographic management. Problems of infant mortalities and female infertility may also be overcome.

7. Record keeping : At present most of our facilities do not identify individual animals. For a better management, it is imperative to have individual animals identified and the records maintained. For this purpose it is suggested to tag all the young ones. Young deer should be tagged within 24 hours of birth. Tags should be made available to all the zoo. The adult animals can be tagged as and when caught for treatment and sedated, etc. Each year the Studbook Keeper or central body should be informed of all births, deaths and stock movements. Post Mortem reports would help considerably in the long-range husbandry of the species.

8. Keeper training: There is an urgent need to improve basic training in Sangai-keeping for keepers of the zoos holding *Cervus eldi eldi*. The experience gained in this field by the Delhi and Calcutta zoo personnel may be availed.

Additional comments :

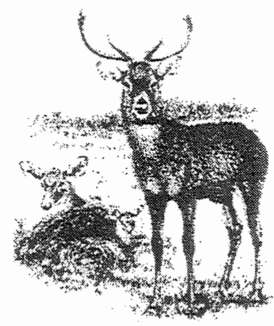
Anne Wright, World Wide Fund for Nature, an invitee who could not attend suggested the following:
1. A special Sangai Mobile Unit - Zoo Clinic with a travelling veterinarian and an advisor on feeding management.
2. Populations in existing zoos should be improved in situ in lieu of sending to Manipur Zoo under present conditions.
3. Second or third re-introduced populations could be placed out of Manipur to give additional security from political and social stochasticity.
4. Training for zoo attendants as opposed to higher echelon staff could be arranged through British Council in zoos abroad with a high success rate with ungulate populations.

MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)

Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992

Mysore

Section 6

Human Impact and Education

EDUCATION

N.g.o.'s or club people belonging to the surrounding area will make the best educators: they know the local people as well as being committed and having time to devote to these works. As governmental agencies sometimes have difficulties working with village and tribal people, n.g.o.'s and clubs can be utilitsed to raise the consciousness of indigenous people. A smooth relationship with the people living around the park is crucial and this should be developed by the ngo's and clubs before attempting to teach them.

It is also important to provide employment opportunities for the people as many of them suffered a heavy loss when the Park was created. If the practical problems are solved they will be in a better position to realise the importance of the Park. Opportunities could be created in the field of education itself, as guides and propagandists.

Some Eco-development funds may be available for environmental education by the wildlife oriented ngo's. The Government of Manipur should allocate more funds for educational programmes in the Forest Department as well as n.g.o.'s. The Forest Department and Education Department should add specialised information on both fauna and flora of Keibul Lamjao to be included in the school curriculum. The role of media in disseminating information and creating awareness was highlighted.

Recommendations:

1. Cooperate with clubs and non-governmental organisations to conduct educational programmes.

2. The education should be both formal and informal (school programmes and extension programmes).

3. Institute some social welfare programmes (medical camp, adult education programme) to gain the confidence of the locals and establish good faith.

4. Cooperate with programme officers of Eco-development programe for tribal people's welfare providing material for educational material to be funded by the Ecodevelopment programme.

5. Court the business and industrialist community so that a sense of responsbility and involvement on their part is developed. Subsequently, they could be tapped for funds.

6. Meetings and Seminars, both formal and informal for both scientists and laymen should be arranged to enhance awareness and increase knowledge of the need of environmental education. In this regard it may be useful to conduct a seminar about the Problems of Keibul Lamjao for the business community, politicians and administrative level officers to give them a sense of participation and record their ideas for protecting the area.

7. Official special events (Wildlife Week, Animal Welfare Fortnightly, Forestry Day) should be utilised fully. Quiz programmes, elocution competitions and some other programmes should be conducted to the primary to college level students to get their attention on wildlife

8. Visitors centre and Interpretation Centre staffed by local people and forest guards should be set up both inside and outside the Park focusing on the uniqueness of Manipur wildlife.and the Keibul Lamjao National Park.

9. Training in Education and Interpretation should be given to the Forests Guards and Rangers as well as school teachers in Imphal and surrounding area.

HUMAN IMPACT

In the absence of officials and ngo's from Manipur, published information such as Prof. H. Tombi Singh entitled "Impact of Human Activities on the Keibul Lamjao National Park," E. P. Gee's Report (BNHS 57 (3) 597-617, 1960), and Ranjit Sinh's Report on Sangi (BNHS 72 (2) 243-255, 1975) were utilised to assess the human impact on the Park. All the literature give weight to effect of human activities on the precarious position of the Sangai in the Keibal Lamjao National Park. Prof. Tombi Singh had nicely assessed the latest position in his paper.

Recommendations:

1. Cattle grazing, fishing, poaching of animals, collection of fodder and food plants and the use of pesticides and fertilisers in and around the National Park should be curtailed.

2. Attempts should be made to resettle human habitations from the National Park to other suitable areas so that the encroached area can be retrieved.

3. The area around the Logtak Lake should be reforested, especially with polyculture for the catchment area of the lake, utilising only indigenous species of flora.

4. A coordinator at a senior level from the University or among retired scientists may be identified on a full-time basis to bring network various researchers in different disciplines. Interaction between all local and state governmental agencies and non-governmental voluntary agencies who have interest in eco-restoration is also recommended.

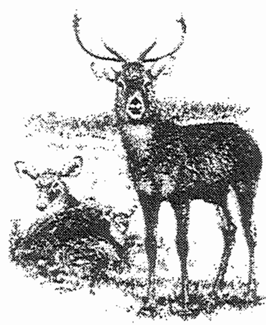
5. Staff maintained to enforce the provisions of law, maintenance of law and order and manage the National Park, should be enhanced at different hierarchical levels.

MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)

Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992

Mysore

Section 7

POST P.H.V.A. REVIEW

SANGAI — POST P.H.V.A. REVIEW

Introduction : *C.B.S.G. analytical processes (e.g. P.H.V.A.'s, C.A.M.P.'s, etc.) are so named because emphasis is on process and product rather than result. It is acknowledged that action cannot or will not be carried out in the same time frame and with the same consistency in the great diversity of the world's political, social, economic, environmental and biological cultures. Resolution of complex species problems will be more responsive to a step-wise but systematic and scientific approach. If momentum and progress can be sustained, it is enough to insure resolution in an appropriate manner and with long-term positive consequences.*

The Sangai Post P.H.V.A. Review was significant in that it was held in collaboration with the C.Z.A. followed the first ever Southern Regional Species Coordinators meeting conducted by the Central Zoo Authority. It preceeded the Lion-tailed macaque PHVA and allowed persons from far away who had attended the Sangai workshop to attend and provide continuity. It provided a venue for approving the final Draft of the Sangai PHVA and continuing discussion on a different level with the participation of the Central Zoo Authority. Because of these factors and the activities which resulted from this meeting, it is being included in this Report on P.H.V.A. for Manipur Brow-antlered Deer.

Post P.H.V.A. Review
10 October 1993, Madras Zoo
Chaired by S. C. Sharma and Dr. U. S. Seal.

Attended by Sangai Zoo Directors and other interested persons

The second draft of the Sangai PHVA Workshop Report was briefly reviewed and accepted by those present. It is to be published as the final draft of the report from the PHVA.

A discussion was held on the details of actions that need to be undertaken with the captive and wild populations during the next year and following to secure the recovery of this critically endangered species. The results of this discussion and analysis are summarized in the remainder of this report.

1. Program Goals
A. Prevent extinction of the species
B. Protect the remaining gene pool of the species
C. Establish an evolutionarily viable population of the species in wild habitat.
D. Exhibit and Public Education.

II. Problems
A. Genetic in Captive and Wild Populations
B. Disease in Captive Population
C. Captive Space and Management
D. Limited Habitat and Single Small Wild Population
E. Poaching

III. Options

A. New Wild Populations
1. New habitats and protected areas
2. Translocation
3. Reintroduction

B. Captive Population Management
1. Exchange of animals
2. Exchange of genetic materials -- semen or embryos

C. New Genetic Material to Captive Population from Wild -- animals, semen or embryos

IV. Genetics

Statement of Problem:

The wild population has been through a bottleneck of about 20 and now numbers about 80 animals. It is subject to poaching which has perhaps kept the population from expanding to the full capacity of the protected area which may be about 120 animals. This population may have lost 7-10% of its heterozygosity by drift over the past 30 years (4-5 generations).

The captive population was derived from 4 founder animals (2.2) collected in 1959 (1.1 for Calcutta) and in 1961 (1.1 for Delhi) when the wild population was about 50 animals and now numbers about 95-100 animals. It has been maintained in 2 lineages (Delhi and Calcutta lines) with no confirmed genetic exchange between the lineages. Analyses indicate that both lineages may have lost about 50% of their original diversity so that no more than about 2 founder equivalents are represented in the total captive population.

Comments: The captive populations probably contain less than 3% of genetic diversity that is not present in the wild population. Addition of genetic material from the captive population to the wild population would not be of significant benefit to the wild.

The captive population, as now composed, would not be the preferred genetic choice for establishing new populations of the Sangai.

Founders from the current wild population would provide the broadest genetic base for establishing new wild populations. The precise protocols for selecting new habitats, animals to be used as founders, and the reintroduction procedures need to be developed in detail. There is available a substantial literature on habitat and translocation of cervids that will be useful for developing these protocols.

Cervids are very flexible in their use of habitats and resilient to change. The definition of suitable habitat can be much broader than the type that they now occupy or even the types they have occupied in the recent past. We know from experience all over the world, that if protected and with a wide range of food resources, that cervid populations can expand very rapidly with doubling times of 3-4 years. Primary importance needs to be given to the establishment of several other populations to expand the gene pool and to protect against catastropic events.

If the captive population is intended provide representation of the wild population gene pool as a protection against its extinction, then genetic supplementation of the captive population needs to be done. This could be by removal of wild caught animals to the captive population or by collection of semen and embryos to place in the captive population.

The current captive population still represents a significant insurance against extinction of the species. It will do so until additional wild populations are established. The current captive population should be maintained and managed.

Exchanges of animals or genetic materials between the 2 captive Sangai lineages need to be undertaken as quickly as possible (before the next breeding season). This needs to be done with movement of males in both directions to breed with females of the other lineage. Alternatively these genetic transfers might be accomplished by artificial insemination. This technology is well established with this species.

Tuberculosis has been identified and studied in the Calcutta collection. A report is available. It is suggested that TB might occur in other captive collections as well. TB is a major problem in cervids in Canada and the USA. There has been much work done recently on diagnosis and management with several major reports available. This information may be useful.

The occurrence of TB is another argument for NOT using any of the captive animals for supplementation of the current wild population. The use of captive animals as part of program to establish another wild population should not be considered until it is certain that the animals used are free of TB.

It is possible to establish a TB-free herd of Sangai, as has been done with Arabian oryx in Saudi Arabia, but a great deal of effort and resources are required. This problem requires further analysis with the involvement of appropriate experts.

In summary, immediate action needs to be taken to select protected areas in Manipur or elsewhere in the Northeast for additional populations of the Sangai. Protocols need to be developed for the establishment of those populations by translocation of wild caught animals and the program started. Exchange of genetic material between the captive lineages needs to be started. New genetic materials needs to be introduced into the captive population. The problem of tuberculosis in the captive herds needs to be addressed with state of the art knowledge and protocols established to prevent its continued spread and remove it from the captive herds.

MANIPUR BROW-ANTLERED DEER
(Cervus eldi eldi)
Sangai

Population & Habitat Viability Assessment

11 - 13 October 1992
Mysore

Section 8

CURRENT IN SITU AND EX SITU POSITION

GROUND CENSUS REPORT OF SANGAI HELD 9 - 10 MARCH 94 AT KEIBUL LAMJAO NATIONAL PARK.

S. Singsit, Chief Wildlife Warden, Government of Manipur.

INTRODUCTION

The Sangai (*Cervus eldi eldi,* Maclelland 1842) is one of the rarest mammals of the world. Its distribution is restricted to the Keibul Lamjao National Park of Manipur. This cervid which is listed in the Red Data Book needs legal protection. The first aerial census of Sangai at Keibul Lamjao shows only 14 sangai in the year 1975. During subsequent census conducted at Keibul Lamjao there has been a steady increase in the number of animals touching the highest figure of 95 in 1986 (ground census). But the aerial census conducted during 1987 shows only 35 Sangai perhaps due to poor ground visibility. Again, from 1988 onwards the Sangai population increased gradually showing 75 animals in 1990 (aerial census). No census was carried out during 1991 due to non-availability of Helicopter.

During 1992 both the ground and aerial census were carried out. The ground census counted 104 animals while the aerial census counted only 62 animals. The difference in the figure of ground census and aerial census is mainly due to difference in the timing and season of counting. The most favourable season and time for counting Sangai is the middle part of March in the early morning (6.30 a.m. to 9 a.m.). During this season the old grasses were dried up and new shoots just sprouted. So, the visibility of the Sangai is perfect during this time. By nature Sangai graze in the early morning and late in the evening. During the middle of the day when the neat of the sun increases they used to take rest in time of the day. The aerial census was conducted on 16.4.92 at 11 a.m. to 12 noon including the time taken from Imphal airport to Keibul and back. The ground census conducted during 1993 (15.4.93 and 16.4.93) has counted 98 animals. The decrease in the animals is perhaps due to poor visibility due to rank growth of grasses and reeds.

GROUND CENSUS OF SANGAI, 1994 : - The area of the National Park excluding Laphupat area (which is mainly water area) was divided into 20 (twenty) blocks which distinct boundaries of cleared strips. For every block one bamboo Machan (about 20 ft. ht) were installed for the purpose of counting. Majdoors were engaged along the boundary as well as the strip lines to protect any unwanted infiltrators and crossing of animals respectively during the census period small patches in the blocks were burnt under control for clear visibility of animals prior to census.

For conducting the census successfully the Panchayat Committee and Secretary of the local Clubs were requested to render all their possible help in the census. All the enumerators were given some basic idea about the method of counting, identification of the animals, method of filling the counting from etc. one day ahead of the date of census. The enumerators consisted of Chief Wildlife Warden, Prof. H. Tombi Singh, Life Science Department of Manipur University, Dy. Conservator of Forests (Wildlife), Asstt, Conservator of Forests (Wildlife), field staffs and members of the local clubs. In a machan/block there are two or more enumerators, one from the Forest Department and one or more from the Clubs/N.G.O.s were engaged. The census was conducted during two consecutive days i.e. on 9.3.94 and 10.3.94 in the early hours of the day. Total count was carried out on the first day while the sampling count was carried out on the second day.

METHOD OF COUNTING

(A) Total count: Since there were clear boundary demarcation of each block, the possibility of double counting from one jurisdiction to another was reduced to a great extent. By nature if not disturbed, Sangai used to graze in a particular area without making and quick movement here and there. So, the possibility of double counting in a particular block is ruled out. The Machan could not be seen from another machan. Moreover Majdoors were engaged along the strips to check any crossing of animals from one block to another. The operation started from 6 AM and ended at 9 AM. (compilation of the Data is shown in the Annexure - I)

(B) Sampling count :- Out of the 20 blocks, 5 blocks were picked up randomly. The same procedure as that the total count were carried out in the sample blocks. The mean of the five blocks were taken indicating stag, Hind & fawn separately. Thus, the total no. of animals of the sampling count is obtained by multiplying the mean by 20 (Data enclosed in Annexure - II). Comparing the two methods, the total count revealed less no. of animals. Hence, it is taken as the total no. of animals in the park i.e. stag-56, Hind-65 and Fawn-16.

ANNEXURE - I
Total Count

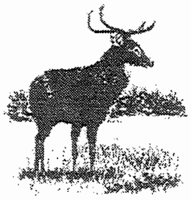
Machan No./ Block No.	Location	Animal sighted during 6 A.M. to 9 A.M			
		Stag	Hind	Fawn	Total
1.	Haorak phumlak	2	3	1	6
2.	Phumdi Asangbi	2	2	1	5
3.	Misangsoi	1	3	1	5
4.	Toya Pangbi	5	7	1	13
5.	Natal Kha	1	2	1	4
6.	Kaching Achouba	5	2	2	9
7.	Hambru houbi	7	3	0	10
8.	Khordak Ichil	3	2	2	7
9.	Major pal	7	3	1	11
10.	Thamna houbi	2	3	1	6
11.	Laphurit houbi	2	4	0	6
12.	Pabot Kha	1	6	0	7
13.	Mayaidak	3	4	0	7
14.	Shagram Kha	2	2	1	5
15.	Khodangkhong Office Maning	1	4	0	5
16.	Pabotchingao Nongpok	2	5	1	8
17.	Khordak Maning	2	2	1	5
18.	Pabot Chingnukok Awang	2	3	1	6
19.	Pabot Chingjao	5	3	0	8
20.	Pabot Chingnukok	1	2	1	4
		56	65	16	137

ANNEXURE - II :
Sampling count

Sl.No.	Machan No.	Name of location	Animals sighted during 6 A.M. to 9 A. M.			Total	Remarks
			Stag	Hind	Fawn	Total	Remarks
1	2	3	4	5	6	7	8
1.	1	Haorok phumlak	4	2	4	10	Final figures
2.	2	Phumdi Asengbi	1	3	1	5	Stag Hind Fawn
3.	12	Pabot Kha	3	5	1	9	3X20 3X20 1X20
4.	13	Mayaidak	4	4	1	9	=60 60 20
5.	19	Pabotchingjao	6	5	2	13	=140
			18	19	9	46	
Mean =			3.6	3.6	1.8	9.2	

ANNEXURE - III
POPULATION OF SANGAI (BROW ANTLERED DEER)

Sl.No. & Year	Type of Census	No.of animals Male	Female	Fawn	Total animals.	Remarks
1. 1975	Aerial	-	-	-	14	Details of male, female and fawn are not available.
2. 1977	-do-	6	8	4	18	Ground visibility was perfect for census.
3. 1978	-do-	9	10	4	23	-do-
4. 1979	-do-	9	13	8	30	-do-
5. 1980						
6. 1981		-	-	-	-	NO CENSUS
7. 1982						
8. 1983						
9. 1984	Ground	20	25	6	51	No helicopter available.
10.1985	Ground	2	33	5	60	No helicopter available.
11. 1986	-do-	44	45	6	95	-do-
12. 1987	Aerial	11	17	7	35	Poor ground visibility -- population under-estimated.
13. 1988	-do-	20	25	7	52	
14. 1989	-do-	23	29	12	64	Visibility was perfect
15. 1990 (5.4.90)	-do-	29	35	12	76	
16. 1991	-	-	-	-	-	No census
17. 1992 (20 to 22.3.92)	Ground	37	51	16	104	No Airforce helicopter available.
18. 1992 (16.4.92)	Aerial	21	32	9	62	Population is underestimated due to poor visibility
19. 1993 (15 to 16.4.93)	Ground	38	48	12	98	
20. 1994 (9 to 10.3.94)	Ground	56	65	16	137	



FAMILY TREE OF SANGAI
IN INDIAN ZOOLOGICAL GARDENS

W I L D

- **Calcutta** 1.1 1956 *5.4.13 -- 1994*
  - **Trivandrum** 2.2 1963 *1.1 -- 1994*
    - **Trichur** 1.1 1964 *0.0 -- 1994*
  - **Jaldapara** 1.1 1964 * *0.0 -- 1994*
  - **Bhilai** 1.1 1986 *2.1 -- 1994*
  - **Nandankanan** 1.0 -- 1992 0.1 -- 1994
- **Imphal Zoo** 0.1 - circa 1975
- **National Zoo** 1.1 1962 *10.27 -- 1994*
  - **Ahmedabad** 1.1 1974 *0.3 -- 1994*
  - **Hyderabad** 1.1 1974 *2.5 -- 1994*
  - **Lucknow** 1.1 1976 *1.1 -- 1994*
  - **Kanpur** 1.1 1976 *4.4 -- 1994*
  - **Keibul Lamjao** 2.2 1976 * *nil*
  - **Imphal** 1.1 1978 *0.0 -- 1994*
  - **Kanpur/Lucknow** 1979 1.1
  - **Jaipur** 1.1 1982 *1.0 1994*
  - **Nandankanan** 1.1 1984 *0.1 1994*
  - **Chhatbir** 1.1 1990 *2.3 1994*
  - **Lucknow** 1.1 -- 1988 *1.1 -- 1994*
  - **Trivandrum** 0.1 -- 1994 *1.1 -- 1994*
- **Mysore** (from Calcutta and National Zoo) 1.1 1973 1.2 1974 *2.1 1994*
  - **Madras** 1.1 1963 *2.2.1 -- 1994*
  - **Assam** 1.2 1985 *3.5 -- 1994*
  - **Trivandrum** 1.1 1985 *1.1 1994*

* Introduction and restocking attempts

Key : The first figure is what was given from the founder line to the named zoo and in which year. The second figure is the present stock postion as on this year.

Data for Stock position as on March 1994 courtesy of Central Zoo Authority, Government of India

PRESENT LOCATION OF BROW ANTLERED DEER (SANGAI) IN INDIAN ZOOS (Till March 1994)

S.No.	Sex	DATE OF BIRTH/TRANSFER	SIRE	DAM	PREVIOUS LOCATION	LOCAL ID	NAME	NAME
** ANDHRA PRADESH								
* Zoological Park HYDERABAD								
1	F	12/11/87	UNK	UNK		UNK	UNK	UNK
2	M	06/12/87	UNK	UNK		UNK	UNK	UNK
3	F	10/12/87	UNK	UNK		UNK	UNK	UNK
4	F	26/12/88	UNK	UNK		UNK	UNK	UNK
5	F	09/01/89	UNK	UNK		UNK	UNK	UNK
6	F	01/10/90	UNK	UNK		UNK	UNK	UNK
7	M	08/01/92	UNK	UNK		UNK	UNK	UNK
** ASSAM								
* Zoological Park GUWAHATI								
8	F	21/01/85	UNK	UNK	MYSORE	UNK	MENAKA	MENAKA
9	M	21/01/85	UNK	UNK	MYSORE	UNK	GANESH	GANESH
10	F	23/11/89	GANESH	MENAKA		UNK	KANTI	KANTI
11	F	13/01/91	GANESH	MENAKA		UNK	RADHA	RADHA
12	M	28/11/92	GANESH	MENAKA		UNK	BHISMA	BHISMA
13	M	15/12/92	GANESH	MENAKA		UNK	KRISHNA-TT	KRISHNA-
14	F	23/12/93	GANESH	MENAKA		UNK	BONTI	BONTI
15	F	01/01/94	GANESH	MENAKA		UNK	JONTI	JONTI
** DELHI								
* Zoological Park DELHI								
16	M	29/10/77	UNK	UNK		UNK	UNK	UNK
17	M	21/10/86	UNK	UNK		UNK	UNK	UNK
18	F	08/10/88	UNK	UNK		UNK	UNK	UNK
19	F	17/10/88	UNK	UNK		UNK	UNK	UNK

COMPILED BY CENTRAL ZOO AUTHORITY, GOVT. OF INDIA.

20	F	14/10/89	UNK	UNK	UNK	UNK	UNK
21	F	15/10/89	UNK	UNK	UNK	UNK	UNK
22	M	21/10/90	UNK	UNK	UNK	UNK	UNK
23	F	25/10/90	UNK	UNK	UNK	UNK	UNK
24	F	26/10/90	UNK	UNK	UNK	UNK	UNK
25	F	29/10/90	UNK	UNK	UNK	UNK	UNK
26	M	16/01/91	UNK	UNK	UNK	UNK	UNK
27	F	14/10/91	UNK	UNK	UNK	UNK	UNK
28	M	17/10/91	UNK	UNK	UNK	UNK	UNK
29	F	19/10/91	UNK	UNK	UNK	UNK	UNK
30	F	23/10/91	UNK	UNK	UNK	UNK	UNK
31	F	23/10/91	UNK	UNK	UNK	UNK	UNK
32	F	01/01/92	UNK	UNK	UNK	UNK	UNK
33	M	15/09/92	UNK	UNK	UNK	UNK	UNK
34	M	20/10/92	UNK	UNK	UNK	UNK	UNK
35	M	21/10/92	UNK	UNK	UNK	UNK	UNK
36	M	27/10/92	UNK	UNK	UNK	UNK	UNK
37	F	01/11/92	UNK	UNK	UNK	UNK	UNK
38	F	01/11/92	UNK	UNK	UNK	UNK	UNK
39	F	01/11/92	UNK	UNK	UNK	UNK	UNK
40	F	11/11/92	UNK	UNK	UNK	UNK	UNK
41	F	11/12/92	UNK	UNK	UNK	UNK	UNK
42	F	21/12/92	UNK	UNK	UNK	UNK	UNK
43	F	28/10/93	UNK	UNK	UNK	UNK	UNK
44	M	28/10/93	UNK	UNK	UNK	UNK	UNK
45	F	05/11/93	UNK	UNK	UNK	UNK	UNK
46	F	05/11/93	UNK	UNK	UNK	UNK	UNK
47	F	09/11/93	UNK	UNK	UNK	UNK	UNK
48	F	09/11/93	UNK	UNK	UNK	UNK	UNK
49	F	21/11/93	UNK	UNK	UNK	UNK	UNK
50	F	21/11/93	UNK	UNK	UNK	UNK	UNK

51 F	07/12/93	UNK	UNK		UNK	UNK	UNK
52 F	07/12/93	UNK	UNK		UNK	UNK	UNK

** GUJARAT

Zoological Park AHMEDABAD

53 F	01/10/91	UNK	UNK		T91/1	UNK	UNK
54 F	01/10/91	UNK	UNK		T91/2	UNK	UNK
55 F	27/10/93	10362	UNK		T93/3	UNK	UNK

** KARNATAKA

* Zoological Park MYSORE

56 M	10/01/80	UNK	UNK		UNK	UNK	UNK
57 F	05/12/80	UNK	UNK		UNK	UNK	UNK
58 M	22/01/91	UNK	UNK		UNK	UNK	UNK

** KERALA

* Zoological Park TRIVANDRUM

59 M	/ /	UNK	UNK		UNK	UNK	UNK
60 F	/ /	UNK	UNK		UNK	UNK	UNK

** MADHYA PRADESH

* Zoological Park BHILAI

61 M	13/10/86	UNK	UNK		UNK	UNK	UNK
62 F	20/10/89	UNK	UNK		UNK	UNK	UNK
63 M	10/11/93	UNK	UNK		UNK	UNK	UNK

** ORISSA

* Zoological Park NANDANKANAN

64 F	22/10/88	UNK	UNK		UNK	UNK	UNK

** PUNJAB

* Zoological Park CHATBIR

65 M	25/03/91	UNK	UNK	DELHI	UNK	SONU	SONU
66 F	26/01/92	SONU	ROZY		UNK	GOGY	GOGY
67 F	15/03/93	SONU	ROZY		UNK	RAZNY	RAZNY
68 M	19/03/93	SONU	ROZY		UNK	MOUZY	MOUZY
69 F	23/10/93	SONU	ROZY		UNK	BHURY	BHURY

RAJASTHAN

Zoological Park JAIPUR

70	M	01/08/82	UNK	UNK	DELHI	UNK	UNK	UNK

TAMILNADU

Zoological Park MADRAS

71	F	03/09/87	SHEKHAR	UNK		UNK	SUJATHA	SUJATHA
72	M	29/12/87	UNK	UNK		UNK	DHAMA	DHAMA
73	M	15/10/90	UNK	UNK		UNK	ARJUNA	ARJUNA
74	F	01/12/91	UNK	UNK		UNK	BHAMA	BHAMA
75	U	11/10/93	UNK	UNK		UNK	UNK	UNK

UTTAR PRADESH

Zoological Park KANPUR

76	M	28/10/86	UNK	DEVI		UNK	PRAKASH	PRAKASH
77	M	09/11/87	UNK	BINDOO		UNK	SOORAJ	SOORAJ
78	F	08/11/89	RAMAN	BINDOO		UNK	SARITA	SARITA
79	M	01/10/91	RAMAN	BINDOO		UNK	RAJU	RAJU
80	F	16/10/91	RAMAN	KAMALA		UNK	RADHA	RADHA
81	F	01/11/92	RAMAN	SARITA		UNK		
82	F	06/11/92	RAMAN	SARITA		UNK		
83	M	17/11/93	PRAKASH	SARITA		UNK		

Zoological Park LUCKNOW

84	M	14/09/85	UNK	UNK	DELHI	UNK		
85	F	16/10/85	UNK	UNK	DELHI	UNK		

WEST BENGAL

Zoological Park CALCUTTA

86	U	10/11/86	UNK	UNK		UNK	UNK	UNK
87	U	12/11/87	UNK	UNK		UNK	UNK	UNK
88	U	12/11/87	UNK	UNK		UNK	UNK	UNK
89	U	15/12/87	UNK	UNK		UNK	UNK	UNK
90	U	15/12/87	UNK	UNK		UNK	UNK	UNK
91	U	15/12/87	UNK	UNK		UNK	UNK	UNK
92	U	13/10/88	UNK	UNK		UNK	UNK	UNK
93	U	28/10/88	UNK	UNK		UNK	UNK	UNK
94	U	05/11/88	UNK	UNK		UNK	UNK	UNK
95	U	10/12/88	UNK	UNK		UNK	UNK	UNK
96	U	11/12/88	UNK	UNK		UNK	UNK	UNK
97	U	23/10/89	UNK	UNK		UNK	UNK	UNK

98	M	11/02/90	UNK	UNK	TAG1	UNK	UNK
99	F	26/10/90	UNK	UNK	TAG2	UNK	UNK
100	M	15/10/91	UNK	UNK	TAG5	UNK	UNK
101	M	27/10/91	UNK	UNK	TAG6	UNK	UNK
102	F	12/11/91	UNK	UNK	TAG7	UNK	UNK
103	M	10/12/92	UNK	UNK	UNK	UNK	UNK
104	U	10/11/93	UNK	UNK	UNK	UNK	UNK
105	F	10/11/93	UNK	UNK	UNK	UNK	UNK
106	M	10/11/93	UNK	UNK	UNK	UNK	UNK
107	F	06/12/93	UNK	UNK	UNK	UNK	UNK

Captive Breeding Specialist Group

Species Survival Commission
IUCN -- The World Conservation Union
U. S. Seal, CBSG Chairman

POPULATION and HABITAT VIABILITY ANALYSIS WORKSHOPS

Objectives and Process

The PHVA workshop provides population viability assessments for each population of a species or subspecies as decided in arranging the workshop. The assessment for each species will undertake an in depth analysis of information on the life history, population dynamics, ecology, and population history of the individual populations. Information on the demography, genetics, and environmental factors pertinent to assessing the status of each population and its risk of extinction under current management scenarios and perceived threats will be assembled in preparation for the PHVA and for the individual populations before and during the workshop.

An important feature of the workshops is the elicitation of information from the experts that is not readily available in published form yet which may of decisive importance in understanding the behavior of the species in the wild. This information will provide the basis for constructing simulation models of each population which will in a single model evaluate the deterministic and stochastic effects and interactions of genetic, demographic, environmental, and catastrophic factors on the population dynamics and extinction risks. The process of formulating information to put into the models requires that assumptions and the data available to support the assumptions be made explicit. This process tends lead to consensus building on the biology of the species, as currently known, and usually leads to a basic simulation model for the species that can serve as for continuing discussion of management alternatives and adaptive management of the species or population as new information is obtained. It in effect provides a means for conducting management programs as scientific exercises with continuing evaluation of new information in a sufficiently timely manner to be of benefit to adjusting management practices.

These workshop exercises are able assist the formulation of management scenarios for the respective species and evaluate their possible effects on reducing the risks of extinction. It is also possible through sensitivity analyses to search for factors whose manipulation may have the greatest effect on the survival and growth of the population(s). One can in effect rapidly explore a wide range of values for the parameters in the model(s) to gain a picture of how the species might respond to changes in management. This approach may also be used to assist in evaluating the information contribution of proposed and ongoing research studies to the conservation management of the species.

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PHVA Workshop Preparation

Information and Expertise

Short reviews and summaries of new information on topics of importance for conservation management and recovery of the individual populations are also prepared during the workshop. Of particular interest are topics addressing:

(1) factors likely to have operated in the decline of the species or its failure to recover with management and whether they are still important,

(2) the need for molecular taxonomic, genetic heterozygosity, site specific adaptations, and the effects of seed banks on the rate of loss of heterozygosity,

(3) the role of disease, predation, and competition in the dynamics of the wild population, in potential reintroductions or translocations, and in the location and management of captive populations,

(4) the possible role of inbreeding in the dynamics and management of the captive and wild population(s),

(5) the potential uses of reproductive technology for the conservation of the species whether through genome banking or transfer of genetic material between subpopulations,

(6) techniques for monitoring the status of the population during the management manipulations to allow their evaluation and modification as new information is developed,

(7) the possible need for metapopulation management for long term survival of the species,

(8) formulation of quantitative genetic and demographic population goals for recovery of the species and what level of management will be needed to achieve and maintain those goals,

(9) cost estimates for each of the activities suggested for furthering conservation management of the species.

PHVA Workshop Preparation

Preparation and Documentation Needs

Information to be included in briefing book:

1. Bibliography - preferably complete as possible and either on disk or in clean copy that we can scan into a computer file.

2. Taxonomic description and most recent article(s) with information on systematic status including status as a species, possible subspecies, and any geographically isolated populations.

3. Molecular genetic articles and manuscripts including systematics, heterozygosity evaluation, parentage studies, and population structure.

4. Description of distribution with numbers (even crude estimates) with dates of information, maps (1:250,000 or better if needed) with latitude and longitude coordinates.

5. Protection status and protected areas with their population estimates. Location on maps. Description of present and projected threats and rates of change. For example, growth rate (demographic analysis) of local human populations and numerical estimates their use of resources (development plans) from the habitat.

6. Field studies - both published and unpublished agency and organization reports (with dates of the field work). Habitat requirements, habitat status, projected changes in habitat. Information on reproduction, mortality (from all causes), census, and distribution particularly valuable. Is the species subject to controlled or uncontrolled exploitation? Collecting?

7. Life history information - particularly that useful for the modelling. Includes: size - stage information, stage transitions, age of first reproduction, mean seed production and germination rates, occurrence and survival of seed banks, life expectancy, stage mortalities, adult mortality, dispersal, and seasonality of reproduction.

8. Published or draft Recovery Plans (National or regional) for the wild population(s). Special studies on habitat, reasons for decline, environmental fluctuations that affect reproduction and mortality, and possible catastrophic events.

9. Management masterplans for the captive population and any genome banks.

11. Color pictures (slides okay) of species in wild - suitable for use as cover of briefing book and final PVA document.

PHVA Workshop Preparation

Plans for the Meeting:

1. Dates and location. Who will organize the meeting place and take care of local arrangements? Should provide living quarters and food for the 3 days in a location that minimizes outside distractions. Plan for meeting and working rooms to be available for the evening as well as the day. Three full days and evenings are needed for the workshop with arrival the day before and departure on the 4th day.

2. Average number of participants about 30 usually with a core group of about 15 responsible for making presentations. Observers (up to 20) welcome if facilities available but their arrangements should be their own responsibility. Essential that all with an interest in the species be informed of the meeting. Participants to include: (1) all of the biologists with information on the species in the wild should be invited and expected to present their data, (2) policy level managers in the agencies with management responsibility, (3) NGOs that have participated in conservation efforts, (4) education and PR people for local programs, (5) botanical garden or herbarium biologists with knowledge of the species, (6) experts in plant population biology and needed areas of biological expertise and (7) local scientists with an interest in the species.

3. Preparation of briefing document.

4. Funding (cost analysis available) - primarily for travel and per diem during the meeting, preparation of briefing document and the PVA report, and some personnel costs. CBSG costs are for preparation of the documents, completion of the modelling and report after the meeting, travel of 3-4 people, and their per diem. We estimate that each PHVA Workshop costs CBSG $10,000 to $15,000 depending upon the amount of work required in preparation and after the workshop to complete the report.

5. Preparation of agenda and securing of commitments to participate, supply information, and make presentations needs to have one person responsible and to keep in close contact with CBSG office on preparations.

6. Meeting facilities need to include meeting room for group, break away areas, blackboard, slide projector, overhead projector, electrical outlets for 3+ computers, printer (parallel port IBM compatible), and photocopying to produce about 200-500 copies per day. Have food brought in for lunches. Allow for working groups to meet at night.

SSC MISSION

To preserve biological diversity by developing and executing programs to save, restore and wisely manage species and their habitats.

PHVA WORKSHOPS

Guidelines

Every idea or plan or belief about the Species can be examined and discussed

Everyone participates & no one dominates

Set aside (temporarily) all special agendas except saving the Species

Assume good intent

Yes and ...

Stick to our schedule ... begin and end promptly

Primary work will be conducted in sub-groups

Facilitator can call 'timeout'

Agreements on recommendations by consensus

Plan to complete and review draft report by end of meeting

Adjust our process and schedule as needed to achieve our goals

POPULATION AND HABITAT VIABILTY ASSESSMENT

_ CBSG/SSC/IUCN thanks the 'Host Agency' for the invitation to participate in this Workshop on the conservation of the 'SPECIES'.

- SSC MISSION: To preserve biological diversity by developing and executing programs to save, restore and wisely manage species and their habitats.

- Captive Breeding Specialist Group (CBSG) works as a part of the IUCN Species Survival Commission (SSC) to assist rescue of species.

- CBSG has conducted **Population and Habitat Viability Assessment** (PHVA) workshops for >50 species in 22 countries at the request of host countries.

- **Values of the Workshops** are in:

  * bringing together all groups responsible for the saving and management of the species to build a consensus on actions needed for the recovery of the species;

  * bringing together experts whose knowledge may assist rescue of the species;

  * assembling current information on status of the species and the threats to its survival;

  * providing an objective assessment of the risk of extinction of the species based upon current information;

  * using simulation models to test alternative management actions for rescue of the species and its recovery;

  * producing an objective report which can be used as a basis for the policy and implementation actions that are needed to save the species.

- These Workshops have helped chart a course for saving of many species; we hope that this Workshop will be a help to our colleagues in their work to save the 'Species'.

PHVA DATA NEEDS

MAP OF POPULATION(S) DISTRIBUTION AND FRAGMENTATION

CENSUS AND CHANGES DURING PAST 10-50 YEARS

AVERAGE AGE OF FIRST REPRODUCTION (FEMALE & MALE)

OLDEST AGE (SENESCENCE)

MONOGAMOUS OR POLYGYNOUS

INBREEDING

CATASTROPHES & THREATS

ALL MALES IN BREEDING POOL?

MAXIMUM YOUNG PRODUCED PER YEAR

PROPORTION OF ADULT FEMALES REPRODUCING PER YEAR

PROPORTION OF YOUNG (LITTER/CLUTCH SIZES)

MORTALITY: 0 - 1
JUVENILES
ADULT

FREQUENCY & SEVERITY OF CATASTROPHES

STARTING POPULATION SIZE (AGE DISTRIBUTION IF KNOWN)

CARRYING CAPACITY AND PROJECTED CHANGES

HARVESTS

SUPPLEMENTATION

ANNUAL RATES AND STANDARD DEVIATIONS IF POSSIBLE

PHVA Workshop Preparation

VORTEX

Simulation model of stochastic population change
Written by Robert Lacy
Chicago Zoological Park
Brookfield, IL 60513

Version 5.1, 13 April 1991

Stochastic simulation of population extinction

Life table analyses yield average long-term projections of population growth (or decline), but do not reveal the fluctuations in population size that would result from variability in demographic processes. When a population is small and isolated from other populations of conspecifics, these random fluctuations can lead to extinction even of populations that have, on average, positive population growth. The VORTEX program (earlier versions called SIMPOP and VORTICES) is a Monte Carlo simulation of demographic events in the history of a population. Some of the algorithms in VORTEX were taken from a simulation program, SPGPC, written in BASIC by James Grier of North Dakota State University (Grier 1980a, 1980b, Grier and Barclay 1988). Fluctuations in population size can result from any or all of several levels of stochastic (random) effects. Demographic variation results from the probabilistic nature of birth and death processes. Thus, even if the probability of an animal reproducing or dying is always constant, we expect that the actual proportion reproducing or dying within any time interval to vary according to a binomial distribution with mean equal to the probability of the event (p) and variance given by $Vp = p * (1 - p) / N$. Demographic variation is thus intrinsic to the population and occurs in the simulation because birth and death events are determined by a random process (with appropriate probabilities).

Environmental variation (EV) is the variation in the probabilities of reproduction and mortality that occur because of changes in the environment on an annual basis (or other timescales). Thus, EV impacts all individuals in the population simultaneously -- changing the probabilities (means of the above binomial distributions) of birth and death. The sources of EV are thus extrinsic to the population itself, due to weather, predator and prey populations, parasite loads, etc.

VORTEX models population processes as discrete, sequential events, with probabilistic outcomes determined by a pseudo-random number generator. VORTEX simulates birth and death processes and the transmission of genes through the generations by generating random numbers to determine whether each animal lives or dies, whether each adult female produces broods of size 0, or 1, or 2, or 3, or 4, or 5 during each year, and which of the two alleles at a genetic locus are transmitted from each parent to each offspring. Mortality and reproduction probabilities are sex-specific. Fecundity is assumed to be independent of age (after an animal reaches reproductive age). Mortality rates are specified for each pre-reproductive age class and for reproductive-age animals. The mating system can be specified to be either monogamous or polygynous. In either case, the user can specify that only a subset of the adult male population is in the breeding pool (the remainder being excluded perhaps by social factors). Those males in the breeding pool all have equal probability of siring offspring.

Each simulation is started with a specified number of males and females of each pre-reproductive age class, and a specified number of male and females of breeding age. Each animal in the initial population is assigned two unique alleles at some hypothetical genetic locus, and the user specifies the severity of inbreeding depression (expressed in the model as a loss of viability in inbred animals). The computer program simulates and tracks the fate of each population, and outputs summary statistics on the probability of population extinction over specified time intervals, the mean time to extinction of those simulated populations that went extinct, the mean size of populations not yet extinct, and the levels of genetic variation remaining in any extant populations.

Extinction of a population (or meta-population) is defined in VORTEX as the absence of either sex. (In some earlier versions of VORTEX, extinction was defined as the absence of both sexes.) Recolonization occurs when a formerly extinct population once again has both sexes. Thus, a population would go "extinct" if all females died, and would be recolonized if a female subsequently migrated into that population of males. Populations lacking both sexes are not considered to be recolonized until at least one male and at least one female have moved in.

A population carrying capacity is imposed by a probabilistic truncation of each age class if the population size after breeding exceeds the specified carrying capacity. The program allows the user to model trends in the carrying capacity, as linear increases or decreases across a specified numbers of years.

The user also has the option of modelling density dependence in reproductive rates. I.e., one can simulate a population that responds to low density with increased (or decreased) breeding, or that decreases breeding as the population approaches the carrying capacity of the habitat. To model density-dependent reproduction, the user must enter the parameters (A, B, C, D, and E) of the following polynomial equation describing the proportion of adult females breeding as a function of population size:

$$\text{Proportion breeding} = A + BN + CNN + DNNN + ENNNN,$$

in which N is total population size. Note that the parameter A is the proportion of adult females breeding at minimal population sizes. A positive value for B will cause increasing reproduction with increasing population sizes at the low end of the range. Parameters C, D, and E dominate the shape of the density dependence function at increasingly higher population sizes. Any of the values can be set to zero (e.g., to model density dependence as a quadratic equation, set $D = E = 0$). To determine the appropriate values for A through E, a user would estimate the parameters that provide the best fit of the polynomial function to an observed (or hypothetical) data set. Most good statistical packages have the capability of doing this. Although the polynomial equation above may not match a desired density dependence function (e.g., Logistic, Beverton-Holt, or Ricker functions), almost any density dependence function can be closely approximated by a 4th-order polynomial. After specifying the proportion of adult females breeding, in the form of the polynomial, the user is prompted to input the percent of successfully breeding females that produce litter sizes of 1, 2, etc. It is important to note that with density dependence, percents of females producing each size litter are expressed as percents of those females breeding, and the user does not explicitly enter a percent of females producing no offspring in an average year. (That value is given by the polynomial.)

In the absence of density dependence, the user must specify the percent of females failing to breed, and the percents producing each litter size are percents of all breeding age females (as in earlier versions of VORTEX). Read the prompts on the screen carefully as you enter data, and the distinction should become clear. VORTEX models environmental variation simplistically (that is both the advantage and disadvantage of simulation modelling), by selecting at the beginning of each year the population age-specific birth rates, age-specific death rates, and carrying capacity from distributions with means and standard deviations specified by the user. EV in birth and death rates is simulated by sampling binomial distributions, with the standard deviations specifying the annual fluctuations in probabilities of reproduction and mortality. EV in carrying capacity is modelled by sampling a normal distribution. EV in reproduction and EV in mortality can be specified to be acting independently or jointly (correlated in so far as is possible for discrete binomial distributions).

Unfortunately, rarely do we have sufficient field data to estimate the fluctuations in birth and death rates, and in carrying capacity, for a wild population. (The population would have to be monitored for long enough to separate, statistically, sampling error, demographic variation in the number of breeders and deaths, and annual variation in the probabilities of these events.) Lacking any data on annual variation, a user can try various values, or simply set EV = 0 to model the fate of the population in the absence of any environmental variation.

VORTEX can model catastrophes, the extreme of environmental variation, as events that occur with some specified probability and reduce survival and reproduction for one year. A catastrophe is determined to occur if a randomly generated number between 0 and 1 is less than the probability of occurrence (i.e., a binomial process is simulated). If a catastrophe occurs, the probability of breeding is multiplied by a severity factor specified by the user. Similarly, the probability of surviving each age class is multiplied by a severity factor specified by the user.

VORTEX also allows the user to supplement or harvest the population for any number of years in each simulation. The numbers of immigrants and removals are specified by age and sex. VORTEX outputs the observed rate of population growth (mean of N[t]/N[t-1]) separately for the years of supplementation/harvest and for the years without such management, and allows for reporting of extinction probabilities and population sizes at whatever time interval is desired (e.g., summary statistics can be output at 5-year intervals in a 100-year simulation).

VORTEX can track multiple sub-populations, with user-specified migration among the units. (This version of the program has previously been called VORTICES.) The migration rates are entered for each pair of sub-populations as the proportion of animals in a sub-population that migrate to another sub- population (equivalently, the probability that an animal in one migrates to the other) each year. VORTEX outputs summary statistics on each subpopulation, and also on the meta-population. Because of migration (and, possibly, supplementation), there is the potential for population recolonization after local extinction. VORTEX tracks the time to first extinction, the time to recolonization, and the time to re-extinction.

Overall, VORTEX simulates many of the complex levels of stochasticity that can affect a population. Because it is a detailed model of population dynamics, it is not practical to examine all possible factors and all interactions that may affect a population. It is therefore incumbent upon the user to specify those parameters that can be estimated reasonably, to leave out of the model those that are believed not to have a substantial impact on the population of interest, and to explore a range of possible values for parameters that are potentially important but very imprecisely known. VORTEX is, however, a simplified model of the dynamics of populations. One of its artificialities is the lack of density dependence of death rates except when the population exceeds the carrying capacity. Another is that inbreeding depression is modelled as an effect on juvenile mortality only; inbreeding is optimistically assumed not to effect adult survival or reproduction.

VORTEX accepts input either from the keyboard or from a data file. Whenever VORTEX is run with keyboard entry of data, it creates a file called VORTEX.BAT that contains the input data, ready for resubmission as a batch file. Thus, the simulation can be instantly rerun by using VORTEX.BAT as the input file. By editing VORTEX.BAT, a few changes could easily be made to the input parameters before rerunning VORTEX. Note that the file VORTEX.BAT is over-written each time that VORTEX is run. Therefore, you should rename the batch file if you wish to save it for later use. By using data file input, multiple simulations can be run while the computer is unattended. (Depending on the computer used, the simulations can be relatively quick -- a few minutes for 100 runs -- or very slow.) Output can be directed to the screen or to a file for later printing. I would recommend that VORTEX only be used on a 80386 (or faster) computer with a math co-processor. It should run on slower machines, but it might be hopelessly slow.

The program can make use of any extended memory available on the computer (note: only extended, not expanded, memory above 1MB will be used), and the extra memory will be necessary to run analyses with the Heterosis inbreeding depression option on populations of greater than about 450 animals. To use VORTEX with expanded memory, first run the program TUNE, which will customize the program EX286 (a Dos Extender) for your computer. If TUNE hangs up DOS, simply re-boot and run it again (as often as is necessary). This behavior of TUNE is normal and will not affect your computer. After TUNEing the Dos Extender, run EX286, and then finally run VORTEX. TUNE needs to be run only once on your computer, EX286 needs to be run (if VORTEX is to be used with extended memory) after each re-booting of the computer. Note that EX286 might take extended memory away from other programs (in fact it is better to disable any resident programs that use extended memory before running EX286); and it will release that memory only after a re-boot. If you have another extended memory manager on your system (e.g., HIMEM.SYS), you will have to disable it before using EX286.

VORTEX uses lots of files and lots of buffers. Therefore, you may need to modify the CONFIG.SYS file to include the lines

```
FILES=25
BUFFERS=25
```

in order to get the program to run.

VORTEX is not copy protected. Use it, distribute it, revise it, expand upon it. I would appreciate hearing of uses to which it is put, and of course I don't mind acknowledgement for my efforts. James Grier should also be acknowledged (for developing the program that was the base for VORTEX) any time that VORTEX is cited.

A final caution: VORTEX is continually under revision. I cannot guarantee that it has no bugs that could lead to erroneous results. It certainly does not model all aspects of population stochasticity, and some of its components are simply and crudely represented. It can be a very useful tool for exploring the effects of random variability on population persistence, but it should be used with due caution and an understanding of its limitations.

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SAMPLE

Mississippi Sandhill Crane

Population Viability Analysis Data Form

Species: *Grus canadensis*

Species distribution:
Jackson County MS, with possible migrants in Baldwin County MS.(Valentine 1981)

Study taxon: *G. canadensis pulla*

Study population location:
Wild population confined to Jackson County MS, from the Pascagoula River west to about the Harrison County line. The northern limit runs on an east-west line (Lat. 30 35') about 6.4 km north of Vancleave. The southern limit is Simmons Bayou and Graveline Bay, nearly to the Gulf of Mexico.(Valentine 1981)

Metapopulation:
No separate population

Specialized requirements:
Savannas, or other openings at edges of swamps, forests, or plantations. Fresh water is necessary in the maintenance of preferred habitats and for drinking. (Smith & Valentine 1987)

Age of first reproduction for each sex:
a) **Earliest:** 3 yr. (Valentine & Logan 1988).
b) **Mean:** 3 yr for males, 4 yr for females - Florida Sandhills (Mississippi Sandhill Crane Recovery Plan-(MSCRP)

Clutch size (N, mean, SD, range):
1.7 (MSCRP

	Captive PWRC 1986-90	Wild - 1990	
Number fertile:	74%	61%	
Number hatch:	73%	64% - before '82	36% - '82 and after
Number fledged:	72%	46% - Florida sandhills	

Captive information - See attached PWRC production records for more information - J.Nicolich pers. comm.

Wild information, Table 6 - Florida information - MSCRP

Laying season:
First of April Earliest-early March Latest-late May

Laying frequency (interclutch interval):
About two days between eggs. (J.Nicolich pers. comm.)

Are multiple clutches possible?
Yes, if first clutch is lost, 13 of 119 clutches laid were reported as renestings (MSCRP)

Duration of incubation:
30 days including the day of laying, but not including the day of hatching. (Valentine 1982)

Hatchling sex ratio:
1:1 Male to females - Sandhills generally (MSCRP)

Egg weights:
Average weight 147.9 g (Walkinshaw 1981)

Hatchling weights (male and female):
Average weight 113.0 g (J.Nicolich, Pers. comm.)

Age(s) at fledging:
About 75 days - Sandhills generally (MSCRP)

Adult sex ratio:

Adult body weight of males and females:
Captive - Females 4.19 kg, Males 4.19 kg (J.Nicolich, pers. comm.)

Reproductive life-span (male & female, Range):
Unknown, Oldest Mississippi sandhill crane in captivity is 21 yrs.
Other species, male Siberian - sperm in late 70's, pair of White-naped breeding in their late 60's (ICF data)

Life time reproduction (mean, male & female):
Relatively low, at the present time there are only 2.3 juveniles to 100 adults. (MSCRP)

Social structure in terms of breeding:
Monogamous pair bond will change if mate is ill, dies, or if pair is unsuccessful.
Young birds may re-pair several times before staying with a mate.

Proportion of adult males and females breeding each year:

64% - Florida Sandhill Crane (MSCRP)

Dispersal distance (mean, sexes)

Migrations (months, destinations)

The Mississippi sandhill crane probably doesn't migrate, but most birds fly to small cornfields or pastures to feed during the winter. The maximum flight distance to the feeding area is about 16 km. (Valentine 1981)

Territoriality (home range, season):

Greatest distance between nesting areas was 25 km and the shortest distance 2.5 km. (Valentine 1982).

Nesting territories average 180 (±71) ha (MSCRP)

Age of dispersal:

About 290 days after hatching - Sandhills generally (MSCRP)

Maximum longevity:

Unknown

Captivity = 21 yrs.

* 2 White-naped at least in their 60's. Siberian died at ~ 80 years.

Population census-most recent. Date of last census. Reliability estimate.:

80-90, 1989

In addition 29 young of the year were released in 1989 and not included in the census number. 26 of these birds survived to 1990.

Projected population (5,10,50 years).:

Preliminary models suggests a goal of 130-170 cranes in a 10 year period of time. (MSCRP)

Past population census (5,10,20 years-dates, reliability estimates):

See attached wild census

Population sex and age structure (young, juvenile, & adults)-time of year.:

Winter counts 2.3 juveniles per 100 adults (MSCRP)

Fecundity rates (by sex and age class):

Mortality rates and distribution (by sex and age) (neonatal, juvenile, adult):

Population density estimate. Area of population. Attach marked map.:

Source of mortality % (natural, poaching, harvest, accidental, seasonal?).: (MSCRP)

predators	poaching	pollutants
cranes	vehicles	tumors
flooding	fire\arson	parasites
droughts	powerlines	diseases

Habitat capacity estimate (Has capacity changed in past 20,50 years?):

From 1942-1981 using 6,475 ha: Savanna declined 74% to 14%. (Smith & Valentine 1987) Using 180 ha (MSCRP) as nesting territories, 1942 could have 26 territories and 1981 could have 5 territories.

Present habitat protection status.:

By 1990 19,000 acres of Jackson County, MS have been placed under the control of the USFWS in the form of the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR).

Projected habitat protection status (5,10,50 years).:

A goal of 22,000 acres, possibly more depending on what is required for a self-sustaining population. Unknown time frame. (MSCRP)

Environmental variance affecting reproduction and mortality (rainfall, prey, disease, snow cover?).:

Habitat loss, Fire, dense tree growth, flooding, hurricanes, droughts, disease, pollution, predation, and parasites.

Is pedigree information available?:

Captive Mississippi Sandhill Cranes through PWRC.

Attach Life Table if available.

Date form completed:

Sept. 8, 1992

Correspondent/investigator:

Name: Sheri Snowbank

Address: U.S. Forest Service
Gunflint Ranger Station
Grand Marais, MN 55604

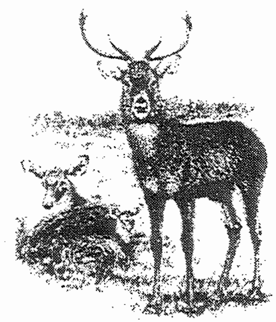
Telephone: 218-387-2885

Fax: 218-387-2488

MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)
Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992
Mysore

Section 9

HISTORY AND BACKGROUND OF KEIBUL LAMJAO NATIONAL PARK

BACKGROUND OF SANGAI AND KEIBUL LAMJAO NATIONAL PARK

From Draft Management Plan of Keibul Lamjao National Park (1993 - 1999)
Volume II of Briefing Book for Sangai P.H.V.A.
By V. Ramakanth, D.C.F. , Manipur

The Sangai (*Cervus eldi eldi*, Maclelland 1842) is one of four sub-species of Eld's deer. Sangai only is peculiar to Manipur, India. The Thamin deer *(Cervus eldi thamin)* has a population of about 2,200 individuals in Kyatthin Wildlife Sanctuary in Mayanmar, but the species is rare else where in that country and virtually extinct outside (Salter and Sayer). Of the other two sub-species, *Cervus eldi siamensis* (known as La-mang) is distributed in Vietnam, Laos and Cambodia and their population figure is unknown. *Cervus eldi hianansus* is restricted to Hianam Island and its population in the wild range from 200-300 (Wirth 1992).

Sangai has one of the lowest populations among the Cervids of the planet. In fact in the year 1951 the local administration had mistakenly declared the Sangai to be extinct. In the year 1975, it was discovered instead that the deer had been reduced to a pitifully small number of 14 individuals.

This deer is quite distinct from the rest of the Cervids of the world in having antlers that appear like inverted bows on the head. The brow-tine runs forward and almost parallel to the head and curls upwards and from the tip of the brow-tine to the point of the beam the antler sweeps in one continuous graceful curve. Of all the sub-species, Sangai has the largest ears which only adds to its beauty.

The habitat of this species is also equally unique. The three fourths of habitat of the deer consists of mats of vegetation (phumdi) floating on the water surface of the biggest natural fresh water lake in North-eastern India, the "Loktak". Forty square kms of this natural habitat the phumdi along with small hillocks and a thin strip of land has been given the legal status of a National Park (1977) and is named "Keibul Lamjao National Park". Since then efforts are being made by the Forest Department of Manipur to reduce the risk of extinction of Sangai. The fact that Sangai has reached a population figure of 76 gives testimony to the efforts at recovery.

It needs no elaboration that Sangai is still critically endangered and the fact that the wild population is restricted to one small area further complicates the matter. Small populations of less than 500 individuals are very much at risk of potential disasters (stochastic events) such as disease outbreak, natural catatrophes as well as increased inbreeding with every generation. The fact that the tiny population increased from only 14 individuals to 76 individuals in the last decades that does not guarantee the survival of the species in the future.

The peculiar habitat of Sangai along with certain unfortunate development affecting the habitat poses additional threats to this endemic deer. The Loktak hydro electric project has broken the cyclical settling and re-floating of phumdi in the National Park. The ecological consequences of keeping the water level almost constant in the Loktak Lake is yet to be fully realised. The invasion of weeds that have very high reproductive capacity like *Macarantha* spp. may adversely affect the species composition of the vegetation of the park.

It has been realised that is not sufficient to provide protection to Sangai, but that the animal population and the habitat be managed. The forest Department has been undertaking many steps in this direction. Many habitat improvement programmes like the eradication of undersirable species of plants, growing of palatale species of plants, immunisation of domestic cattle around the National Park as a preventive measure for the spread of communicable disease etc. form an integral part of the Annual Work-Programmes.

HISTORY OF SANGAI

Sangai is recorded to be found in the "swamps and bogs in the south of the Manipur valley and nowhere else in the state (Higgins 1934) and even during pre-historic times confined to the Vale of Manipur (Sinhji 1965). It is indisputable that Sangai is a part and parcel of the folk lore of Manipur and an integral part of the cultural heritage of Manipur. The Luwangs, one of the seven clans among the Meiteis (the valley dwellers) used to believe that one of their ancestors had turned into a Sangai with the blessings of Lord Sanamhi, a house hold diety. As Sangai is part of many legends and also myths, the habitat of Sangai also remained a mystery for more than a century. Neither Lt. Eld who spotted and recorded the deer in 1841 nor many other naturalists of repute including J. C. Higgins could decipher the exact nature of the complex habitat of this deer for over a century. Lt.Eld, (1841) in whose name the deer has come to be called describes the area inhabited by the deer s follows. "Its favourite haunts are the low grasses and swamps round the edge of Loktak Lake". A.H.D. Barron (1911) mentions swamps. Lt.Col.Alban Wilson (1924) refers to the area as a sea of grasses. Lt.Col. C. H. S. Stockley (1928) describes it as 'grassy swamps'.

J.C. Higgins (1934) wrote of this deer being found in the swamps and bogs in the south of the Manipur Valley and nowhere else in the state. It was E.P. Gee in 1959 who records for the rest of the world the nature of the habitat of Sangai as follows. "The first thing I found was the ten-square mile "swamp" in which the deer live, is not an ordinary swamp. It is a floating one, consisting of thick mat of humus and dead vegetation which actually floats on the water of the lake. About one fifth of this mat is above and four fifth are below the surface of the water. And on the mat grows reeds and grasses up to fifteen feet in height. This mat of humus is called Phumdi and its thickness varies from a few inches to about five feet. And these mats of vegetation sustain Sangai, Kharsa (Hog-deer, Axis procinus), wild boar and a host of other wild animals.

Prior to 1891, Sangai was given royal partronage and was protected by a royal decree. Any man who proved to have killed one Sangai had his hands chopped off. After 1891, Sangai used to be hunted under a permit issued by Manipur State Durbar. It was only in the year 1931 that Captain C.L.W.Harvey, the then President of estwhile Manipur Durbar having observed large scale poisoning and poaching of Wildlife in the state promulgated the first game Rules of Manipur State. However, Wildlife Preservation works received a serious setback Second World War as Civil administration broke down. This led to large scale hunting and trapping of animals by the poachers. It was only after independence that some consolidated efforts were put in for the conservation of the wildlife of the State.

In 1951 E.P. Gee, then Honorary Secretary of Eastern Zone of the Indian Board for Wildlife was informed by the local administration that Sangai was extinct. As per the directive of the International Union for conservation of Nature and Natural Resources a through investigation had to be carried out to establish finally the validity of the claim that Sangai was extinct. In October 1953 Sangai was found surviving in a small pocket of the National Park. In the year 1953 the whole of the Loktak Lake area was closed to shooting and declared a sanctuary by the Government of Manipur in order to protect Sangai, Later on it was decided that the whole of the Loktak area need not be closed and 52 sq.kms. of Southern portion of the Loktak was only made into a sanctuary. In 1959 this Keibul Lamjao Sanctuary was surveyed and officially reported as being about 10 & 3/4 square miles (27.8 sq.kms.) (Gee 1960). And cases of poaching of the deer were not infrequent.

In 1959 E.P. Gee carried out a ground census and estimated about 100 Sangai to be surviving at Keibul Lamjao and in the very year pointed out the urgent need for the legal protection for the Brow-antlered deer.

A flood in the year 1966 took a heavy toll of Sangai. The entire habitat of Sangai used to be put to public auction-sale for extraction of reeds and other grasses annually, a practice that continued even in the 1970's. The area remained as a protected Forest (not even a Reserved Forests) until the legal status of a National Park was confirmed. The Indian Wildlife (Protection) Act.1972 was introduced in the State and came into being from the 15th May, 1973. Under section 64 of the said Act, Manipur Wildlife (Protection) Rules, 1974 became operative with effect from 27th June, 1974 within the entire State.

In the year 1975 a first ever aerial census of Sangai was carried out by Dr. M. K. Ranjit Singh, then Deputy Secretary Department of Forests, Ministry of Agriculture, Government of India and he counted 14 (forteen) heads of Sangai. In view of protecting Sangai along with the associated plants and animals in its natural habitat, a National Park was created towards the end of March,1977 covering an area of 40 sq.kms. after giving adquate compensation for acquiring of patta lands inside the National Park. In the year 1976-77 a total sum of Rs.2.35 lakhs and in the year 1977-78 a sum of Rs.8460/- was given to acquire 66.49 acres of patta land on the Western part of Keibul Lamjao National Park and between the year 1977-78 and 1989-90, a sum of total of Rs.18,21,448/- has been deposited with the Dy. Commissioner (Imphal) for acquiring 98.67 acres of patta land on the eastern side of the park (i.e. 68.95 acres from Komlakhong village and 34.72 acres from Laphupat village).

The Keibul Lamjao is the first National Park of Manipur and the only floating National Park in the World.

PHYSICAL SETTING

Manipur is a State in North-eastern fringes of India. Situated between the parallels 23 ° 83'N-25 ° 68'N and the meridians 93 ° 63'E-94 ° 78'E and has a total surface area of 22356 Sq.kms.

The state has 854 kms. of border of which 352 kms. is the international border with Myanmar on the east. The remaining 502 kms. border seperates Manipur from Assam in the west, Nagaland on the North and Mizoram on the South. Physiographically the land is divisible into an oval shaped central valley and the surrounding mountains. The valley sprawling over 2,639 Sq. kms. is flat and with NNW - SSE orientation has a gentle slope towards the south measuring 798 mts.a.s.l. at the extreme north and 746 mts. at a.s.l. at the southern end.

The Imphal River of Manipur River meanders through the Manipur valley in a NW-SE direction, its important tributaries being the Kongba. the Irill, the Thoubal, the Heirok, the Sekmai, the Khuga and Chakpi. All these tributaries combine with the Imphal river to flow out again Southwards through a narrow gorge into Chindwin River in Myanmar. The valley is also dotted with lakes, the Pumlen pat, the Ikop pat, the Loushi pat, the Sana pat, the Waithou pat, the Poirou pat, Leitambi pat etc. the Loktak lake being the largest freshwater lake in the North-eastern India (93°-55' and 93°-55' East and latitude 24o-25' and 24o-42'N) of the total area of the valley, about 550 Sq.kms. from a unique wetland ecosystem in the World comprising of rivers, fresh water lakes and associated marshes fresh water ponds (under 8 ha.), Swamps, seasonally flooded grass-lands savanna and plam savanna. The floating mats of vegetation on the Loktak Lake is an integral part of this wetland ecosystem sustain the endemic deer-Sangai.

CLIMATE :

Keibul Lamjao comes under the Biogeographical Province of the Burma Monsoon Forests 4.09.04. The state is included in the 'Eastern Highland Province' of the five province classification of the Himalayas. From ecological and biogeographical stand point, Manipur is included in the Eastern Himalayas Region of the Himalays (Spate 1957, Puri 1960 FRI 1971, Mani 1974). Besides the influence by its location around the latitudes just north of Tropic, the climate of the state is governed by the relief of land and the rain bearing winds viz, South-West Monsoon and the Mediterranean winds in water.

The mean maximum temperature varies from 21.7°C (January) to 29.2°C (August)and mean minimum temperature from 3.6°C (January) to 21.4°C (July and August). Humidity as recorded at 0830 hours is minimum during March (60%) and maximum during July (82.6%). Mean annual rainfall is 118.4 cm, the minimum monthly rainfall occurs in December (0.5cm) and maximum during June (23.6cm).

THE PHUMDI FORMATION IN THE LOKTAK LAKE

In the year 1978, Shri H. S. Panwar, in his survey Report records that the phumdis play an important role in Loktak ecosystem. The soil particles from the catchment areas along with burnt and unburnt vegetable matters of Jhum cultivation enter into and accumulate in the lake. In course of time the debris get bonded with the roots of different grasses. The high percentage of vegetable matter in this accumulated mixture gives it low specific gravity causing it to float in a loose formation. This floating mass continues to accumulate more soil particles and humus and thus the growth activities of reedy grasses and tender bushed is accelerated. Thus formed phumdi remains floating on the water, the level of which used to vary with seasons, prior to the construction of the Ithai barrage which is expected to raise the level of water in the Park area to 769.12 mts on a perpetual basis.

VEGETATION OF THE WETLANDS

So far 167 species of plants belonging to 49 families have been identified from the wetlands of the Manipur Valley including eight species of Peteridophytes and one species of Bryophyte, the family Asteranceae being biggest among the families of flowering plants being represented by 26 species (Singh and Shamananda 1988). The following is the list of 41 species of plants from Keibul Lamjao National Park as available in the records of the Forest Department. The floating mats of vegetation (phumdi) of the National park also support some of the rare and endangered plant species such as *Oryza rufipogon*, a variety of wild rice indigenous to Manipur. A fungus infection in the plant body of *Zizania latifolia* makes it a delicacy both for local population and the deer communites. On the small hillocks scattered inside the National Park and in the outer fringes of the water species like *Cycas pectinatee* could still be seen as well as numerous others.

E.P. Gee in his report on the status of the Brow-antlered Deer in 1959-60 lists the composition of different grasses and reeds on the phumdi as follows:

1. Tou	*Phyagmites karka*	45%	of the	Sanctuary
2. Singput :		25%	"	"
3. Khimum	*Saceharum munja*	15%	"	"
4. Ising Kambong	*Zizania latifolia*	5%	"	"
5. Pulei	*Alpinia allughus*	5%	"	"
6. Singnang	*Saccharum Procerum*	2%	"	"
7. Miscellanious		3%	"	"

However, the percentage composition of certain species, especially that of Zizania latifolia and phragmites karka and Saccharum munja show remarkable changes from vegetative type seen earlier in the park.

The Loktak lake is infested with various species of floating, submerged and emergent plants Fourteen species of floating plants, 15 species of submerged vegetation five rooted as well as floating species of plants inhabiting the lake have been idetified (Det 1961a, Bhatia and Sankas 1979). The water hyacinth *(Eichornia crassipes* Mart) used to dominate the lake prior to the biological control measures adopted at the lake.

THE FAUNA OF THE NATIONAL PARK

The Hog Deer *(Cervus porcinus)* is the co-habitant of the National Park whose member far exceeds that of Sangai. The Wild Boar, *(Sus scrofa)*, Common Otter *(Lutra lutra)*, the Large Indian Civet *(Viverra zibetha)* and the small Indian Civet. *(Viverricula indica)* are the other mammals reported from the Park.

The following resident and migratory birds are either found or reported to have been seen in the area; Grey-lag goose, Comb duck, White-winged wood duck (no longer seen these days), Pink headed duck (last seen in 1932), Cotton teal, Common whistling teal, Large whistling teal Sheldrake, Rudy sheldrake or Brahmani duck (no longer seen these days), Mallard (last seen 1924), Grey duck, Burmese grey duck, Crested teal, Gadwall (no longer seen these days), Baikal or cludking teal, Blue winged teal, Shoveller, Red crested pochard (rare winter visitor), Pochard or Sunbird (no longer seen), White eyed pochard (no longer seen), Tufted pochard, Wood cock, Wood snipe, Eastern solitary snipe, Common fan tailed snipe, Swinhoe's snipe, Jack snipe, painted snipe, Eastern golden plover, Lapwing or green plover, Spurwinged plover, Burmese red-wattled lapwing, Grey-headed lapwing, Eastern grey-plover Indian stone plover, Great stone plover, Hooded crane (no longer seen these days), Sarus crane, Terns

Eastern curlews, Common Coot Indian purple coot, Chinese White breasted water hen, Indian darter, White ibis, Glossy ibis, Black necked stork. Eastern white stork, Eastern purple heron, Estern grey heron, Indian pond heron, Chinese pond heron, Indian little Green heron,and Night heron.

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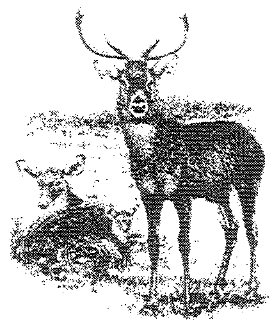
MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)

Sangai

Population & Habitat Viability Assessment Report



11 - 13 October 1992

Mysore

Section 10

P.H.V.A. & VORTEX

Captive Breeding Specialist Group

Species Survival Commission
IUCN – The World Conservation Union
U. S. Seal, CBSG Chairman

POPULATION and HABITAT VIABILITY ANALYSIS WORKSHOPS

Objectives and Process

The PHVA workshop provides population viability assessments for each population of a species or subspecies as decided in arranging the workshop. The assessment for each species will undertake an in depth analysis of information on the life history, population dynamics, ecology, and population history of the individual populations. Information on the demography, genetics, and environmental factors pertinent to assessing the status of each population and its risk of extinction under current management scenarios and perceived threats will be assembled in preparation for the PHVA and for the individual populations before and during the workshop.

An important feature of the workshops is the elicitation of information from the experts that is not readily available in published form yet which may of decisive importance in understanding the behavior of the species in the wild. This information will provide the basis for constructing simulation models of each population which will in a single model evaluate the deterministic and stochastic effects and interactions of genetic, demographic, environmental, and catastrophic factors on the population dynamics and extinction risks. The process of formulating information to put into the models requires that assumptions and the data available to support the assumptions be made explicit. This process tends lead to consensus building on the biology of the species, as currently known, and usually leads to a basic simulation model for the species that can serve as for continuing discussion of management alternatives and adaptive management of the species or population as new information is obtained. It in effect provides a means for conducting management programs as scientific exercises with continuing evaluation of new information in a sufficiently timely manner to be of benefit to adjusting management practices.

These workshop exercises are able assist the formulation of management scenarios for the respective species and evaluate their possible effects on reducing the risks of extinction. It is also possible through sensitivity analyses to search for factors whose manipulation may have the greatest effect on the survival and growth of the population(s). One can in effect rapidly explore a wide range of values for the parameters in the model(s) to gain a picture of how the species might respond to changes in management. This approach may also be used to assist in evaluating the information contribution of proposed and ongoing research studies to the conservation management of the species.

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PHVA Workshop Preparation

Information and Expertise

Short reviews and summaries of new information on topics of importance for conservation management and recovery of the individual populations are also prepared during the workshop. Of particular interest are topics addressing:

(1) factors likely to have operated in the decline of the species or its failure to recover with management and whether they are still important,

(2) the need for molecular taxonomic, genetic heterozygosity, site specific adaptations, and the effects of seed banks on the rate of loss of heterozygosity,

(3) the role of disease, predation, and competition in the dynamics of the wild population, in potential reintroductions or translocations, and in the location and management of captive populations,

(4) the possible role of inbreeding in the dynamics and management of the captive and wild population(s),

(5) the potential uses of reproductive technology for the conservation of the species whether through genome banking or transfer of genetic material between subpopulations,

(6) techniques for monitoring the status of the population during the management manipulations to allow their evaluation and modification as new information is developed,

(7) the possible need for metapopulation management for long term survival of the species,

(8) formulation of quantitative genetic and demographic population goals for recovery of the species and what level of management will be needed to achieve and maintain those goals,

(9) cost estimates for each of the activities suggested for furthering conservation management of the species.

SSC MISSION

To preserve biological diversity by developing and executing programs to save, restore and wisely manage species and their habitats.

PHVA WORKSHOPS

Guidelines

Every idea or plan or belief about the Species can be examined and discussed

Everyone participates & no one dominates

Set aside (temporarily) all special agendas except saving the Species

Assume good intent

Yes and ...

Stick to our schedule ... begin and end promptly

Primary work will be conducted in sub-groups

Facilitator can call 'timeout'

Agreements on recommendations by consensus

Plan to complete and review draft report by end of meeting

Adjust our process and schedule as needed to achieve our goals

POPULATION AND HABITAT VIABILTY ASSESSMENT

_ CBSG/SSC/IUCN thanks the 'Host Agency' for the invitation to participate in this Workshop on the conservation of the 'SPECIES'.

- SSC MISSION: To preserve biological diversity by developing and executing programs to save, restore and wisely manage species and their habitats.

- Captive Breeding Specialist Group (CBSG) works as a part of the IUCN Species Survival Commission (SSC) to assist rescue of species.

- CBSG has conducted **Population and Habitat Viability Assessment** (PHVA) workshops for >50 species in 22 countries at the request of host countries.

- **Values of the Workshops** are in:

  * bringing together all groups responsible for the saving and management of the species to build a consensus on actions needed for the recovery of the species;

  * bringing together experts whose knowledge may assist rescue of the species;

  * assembling current information on status of the species and the threats to its survival;

  * providing an objective assessment of the risk of extinction of the species based upon current information;

  * using simulation models to test alternative management actions for rescue of the species and its recovery;

  * producing an objective report which can be used as a basis for the policy and implementation actions that are needed to save the species.

- These Workshops have helped chart a course for saving of many species; we hope that this Workshop will be a help to our colleagues in their work to save the 'Species'.

PHVA DATA NEEDS

MAP OF POPULATION(S) DISTRIBUTION AND FRAGMENTATION

CENSUS AND CHANGES DURING PAST 10-50 YEARS

AVERAGE AGE OF FIRST REPRODUCTION (FEMALE & MALE)

OLDEST AGE (SENESCENCE)

MONOGAMOUS OR POLYGYNOUS

INBREEDING

CATASTROPHES & THREATS

ALL MALES IN BREEDING POOL?

MAXIMUM YOUNG PRODUCED PER YEAR

PROPORTION OF ADULT FEMALES REPRODUCING PER YEAR

PROPORTION OF YOUNG (LITTER/CLUTCH SIZES)

MORTALITY: 0 - 1
JUVENILES
ADULT

FREQUENCY & SEVERITY OF CATASTROPHES

STARTING POPULATION SIZE (AGE DISTRIBUTION IF KNOWN)

CARRYING CAPACITY AND PROJECTED CHANGES

HARVESTS

SUPPLEMENTATION

ANNUAL RATES AND STANDARD DEVIATIONS IF POSSIBLE specified to be either monogamous or polygynous. In either case, the user can specify that only a subset of the adult male population is in the breeding pool (the remainder being excluded perhaps by social factors). Those males in the breeding pool all have equal probability of siring offspring.

Each simulation is started with a specified number of males and females of each pre-reproductive age class, and a specified number of male and females of breeding age. Each animal in the initial population is assigned two unique alleles at some hypothetical genetic locus, and the user specifies the severity of inbreeding depression (expressed in the model as a loss of viability in inbred animals). The computer program simulates and tracks the fate of each population, and outputs summary statistics on the probability of population extinction over specified time intervals, the mean time to extinction of those simulated populations that went extinct, the mean size of populations not yet extinct, and the levels of genetic variation remaining in any extant populations.

Extinction of a population (or meta-population) is defined in VORTEX as the absence of either sex. (In some earlier versions of VORTEX, extinction was defined as the absence of both sexes.) Recolonization occurs when a formerly extinct population once again has both sexes. Thus, a population would go "extinct" if all females died, and would be recolonized if a female subsequently migrated into that population of males. Populations lacking both sexes are not considered to be recolonized until at least one male and at least one female have moved in.

A population carrying capacity is imposed by a probabilistic truncation of each age class if the population size after breeding exceeds the specified carrying capacity. The program allows the user to model trends in the carrying capacity, as linear increases or decreases across a specified numbers of years.

The user also has the option of modelling density dependence in reproductive rates. I.e., one can simulate a population that responds to low density with increased (or decreased) breeding, or that decreases breeding as the population approaches the carrying capacity of the habitat. To model density-dependent reproduction, the user must enter the parameters (A, B, C, D, and E) of the following polynomial equation describing the proportion of adult females breeding as a function of population size:

$$\text{Proportion breeding} = A + BN + CNN + DNNN + ENNNN,$$

in which N is total population size. Note that the parameter A is the proportion of adult females breeding at minimal population sizes. A positive value for B will cause increasing reproduction with increasing population sizes at the low end of the range. Parameters C, D, and E dominate the shape of the density dependence function at increasingly higher population sizes. Any of the values can be set to zero (e.g., to model density dependence as a quadratic equation, set D = E = 0). To determine the appropriate values for A through E, a separately for the years of supplementation/harvest and for the years without such management, and allows for reporting of extinction probabilities and population sizes at whatever time interval is desired (e.g., summary statistics can be output at 5-year intervals in a 100-year simulation).

VORTEX can track multiple sub-populations, with user-specified migration among the units. (This version of the program has previously been called VORTICES.) The migration rates are entered for each pair of sub-populations as the proportion of animals in a sub-population that migrate to another sub- population (equivalently, the probability that an animal in one migrates to the other) each year. VORTEX outputs summary statistics on each subpopulation, and also on the meta-population. Because of migration (and, possibly, supplementation), there is the potential for population recolonization after local extinction. VORTEX tracks the time to first extinction, the time to recolonization, and the time to re-extinction.

Overall, VORTEX simulates many of the complex levels of stochasticity that can affect a population. Because it is a detailed model of population dynamics, it is not practical to examine all possible factors and all interactions that may affect a population. It is therefore incumbent upon the user to specify those parameters that can be estimated reasonably, to leave out of the model those that are believed not to have a substantial impact on the population of interest, and to explore a range of possible values for parameters that are potentially important but very imprecisely known. VORTEX is, however, a simplified model of the dynamics of populations. One of its artificialities is the lack of density dependence of death rates except when the population exceeds the carrying capacity. Another is that inbreeding depression is modelled as an effect on juvenile mortality only; inbreeding is optimistically assumed not to effect adult survival or reproduction.

VORTEX accepts input either from the keyboard or from a data file. Whenever VORTEX is run with keyboard entry of data, it creates a file called VORTEX.BAT that contains the input data, ready for resubmission as a batch file. Thus, the simulation can be instantly rerun by using VORTEX.BAT as the input file. By editing VORTEX.BAT, a few changes could easily be made to the input parameters before rerunning VORTEX. Note that the file VORTEX.BAT is over-written each time that VORTEX is run. Therefore, you should rename the batch file if you wish to save it for later use. By using data file input, multiple simulations can be run while the computer is unattended. (Depending on the computer used, the simulations can be relatively quick -- a few minutes for 100 runs -- or very slow.) Output can be directed to the screen or to a file for later printing. I would recommend that VORTEX only be used on a 80386 (or faster) computer with a math co-processor. It should run on slower machines, but it might be hopelessly slow.

The program can make use of any extended memory available on the computer (note: only extended, not expanded, memory above 1MB will be used), and the extra memory will be necessary to run analyses with the Heterosis inbreeding depression option on populations of greater than about 450 animals. To use VORTEX with expanded memory, first run the program TUNE, which will customize the program EX286 (a Dos Extender) for your computer. If TUNE hangs up DOS, simply re-boot and run it again (as often as is necessary). This behavior of TUNE is normal and will not affect your computer. After TUNEing the Dos Extender, run EX286, and then finally run VORTEX. TUNE needs to be run only once on your computer, EX286 needs to be run (if VORTEX is to be used with extended memory) after each re-booting of the computer. Note that EX286 might take extended memory away from other programs (in fact it is better to disable any resident programs that use extended memory before running EX286); and it will release that memory only after a re-boot. If you have another extended memory manager on your system (e.g., HIMEM.SYS), you will have to disable it before using EX286.

VORTEX uses lots of files and lots of buffers. Therefore, you may need to modify the CONFIG.SYS file to include the lines

```
FILES=25
BUFFERS=25
```

in order to get the program to run.

VORTEX is not copy protected. Use it, distribute it, revise it, expand upon it. I would appreciate hearing of uses to which it is put, and of course I don't mind acknowledgement for my efforts. James Grier should also be acknowledged (for developing the program that was the base for VORTEX) any time that VORTEX is cited.

A final caution: VORTEX is continually under revision. I cannot guarantee that it has no bugs that could lead to erroneous results. It certainly does not model all aspects of population stochasticity, and some of its components are simply and crudely represented. It can be a very useful tool for exploring the effects of random variability on population persistence, but it should be used with due caution and an understanding of its limitations.

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SAMPLE

Mississippi Sandhill Crane

Population Viability Analysis Data Form

Species: *Grus canadensis*

Species distribution:
Jackson County MS, with possible migrants in Baldwin County MS.(Valentine 1981)

Study taxon: *G. canadensis pulla*

Study population location:
Wild population confined to Jackson County MS, from the Pascagoula River west to about the Harrison County line. The northern limit runs on an east-west line (Lat. 30 35') about 6.4 km north of Vancleave. The southern limit is Simmons Bayou and Graveline Bay, nearly to the Gulf of Mexico.(Valentine 1981)

Metapopulation:
No separate population

Specialized requirements:
Savannas, or other openings at edges of swamps, forests, or plantations. Fresh water is necessary in the maintenance of preferred habitats and for drinking. (Smith & Valentine 1987)

Age of first reproduction for each sex:
a) **Earliest:** 3 yr. (Valentine & Logan 1988).
b) **Mean:** 3 yr for males, 4 yr for females - Florida Sandhills (Mississippi Sandhill Crane Recovery Plan-(MSCRP)

Clutch size (N, mean, SD, range):
1.7 (MSCRP

	Captive PWRC 1986-90	Wild - 1990	
Number fertile:	74%	61%	
Number hatch:	73%	64% - before '82	36% - '82 and after
Number fledged:	72%	46% - Florida sandhills	

Captive information - See attached PWRC production records for more information - J.Nicolich pers. comm.

Wild information, Table 6 - Florida information - MSCRP

Proportion of adult males and females breeding each year:
64% - Florida Sandhill Crane (MSCRP)

Dispersal distance (mean, sexes)

Migrations (months, destinations)
The Mississippi sandhill crane probably doesn't migrate, but most birds fly to small cornfields or pastures to feed during the winter. The maximum flight distance to the feeding area is about 16 km. (Valentine 1981)

Territoriality (home range, season):
Greatest distance between nesting areas was 25 km and the shortest distance 2.5 km. (Valentine 1982).
Nesting territories average 180 (±71) ha (MSCRP)

Age of dispersal:
About 290 days after hatching - Sandhills generally (MSCRP)

Maximum longevity:
Unknown
Captivity = 21 yrs.
* 2 White-naped at least in their 60's. Siberian died at - 80 years.

Population census-most recent. Date of last census. Reliability estimate.:
80-90, 1989
In addition 29 young of the year were released in 1989 and not included in the census number. 26 of these birds survived to 1990.

Projected population (5,10,50 years).:
Preliminary models suggests a goal of 130-170 cranes in a 10 year period of time. (MSCRP)

Past population census (5,10,20 years-dates, reliability estimates):
See attached wild census

Population sex and age structure (young, juvenile, & adults)-time of year.:
Winter counts 2.3 juveniles per 100 adults (MSCRP)

Fecundity rates (by sex and age class):

Mortality rates and distribution (by sex and age) (neonatal, juvenile, adult):

Population density estimate. Area of population. Attach marked map.:

Laying season:

First of April Earliest-early March Latest-late May

Laying frequency (interclutch interval):

About two days between eggs. (J.Nicolich pers. comm.)

Are multiple clutches possible?

Yes, if first clutch is lost, 13 of 119 clutches laid were reported as renestings (MSCRP)

Duration of incubation:

30 days including the day of laying, but not including the day of hatching. (Valentine 1982)

Hatchling sex ratio:

1:1 Male to females - Sandhills generally (MSCRP)

Egg weights:

Average weight 147.9 g (Walkinshaw 1981)

Hatchling weights (male and female):

Average weight 113.0 g (J.Nicolich, Pers. comm.)

Age(s) at fledging:

About 75 days - Sandhills generally (MSCRP)

Adult sex ratio:

Adult body weight of males and females:

Captive - Females 4.19 kg, Males 4.19 kg (J.Nicolich, pers. comm.)

Reproductive life-span (male & female, Range):

Unknown, Oldest Mississippi sandhill crane in captivity is 21 yrs.
Other species, male Siberian - sperm in late 70's, pair of White-naped breeding in their late 60's (ICF data)

Life time reproduction (mean, male & female):

Relatively low, at the present time there are only 2.3 juveniles to 100 adults. (MSCRP)

Social structure in terms of breeding:

Monogamous pair bond will change if mate is ill, dies, or if pair is unsuccessful.
Young birds may re-pair several times before staying with a mate.

Source of mortality % (natural, poaching, harvest, accidental, seasonal?).: (MSCRP)

predators	poaching	pollutants
cranes	vehicles	tumors
flooding	fire\arson	parasites
droughts	powerlines	diseases

Habitat capacity estimate (Has capacity changed in past 20,50 years?):

From 1942-1981 using 6,475 ha: Savanna declined 74% to 14%. (Smith & Valentine 1987) Using 180 ha (MSCRP) as nesting territories, 1942 could have 26 territories and 1981 could have 5 territories.

Present habitat protection status.:

By 1990 19,000 acres of Jackson County, MS have been placed under the control of the USFWS in the form of the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR).

Projected habitat protection status (5,10,50 years).:

A goal of 22,000 acres, possibly more depending on what is required for a self-sustaining population. Unknown time frame. (MSCRP)

Environmental variance affecting reproduction and mortality (rainfall, prey, disease, snow cover?).:

Habitat loss, Fire, dense tree growth, flooding, hurricanes, droughts, disease, pollution, predation, and parasites.

Is pedigree information available?:

Captive Mississippi Sandhill Cranes through PWRC.

Attach Life Table if available.

Date form completed:

Sept. 8, 1992

Correspondent/investigator:

Name: Sheri Snowbank

Address: U.S. Forest Service
Gunflint Ranger Station
Grand Marais, MN 55604

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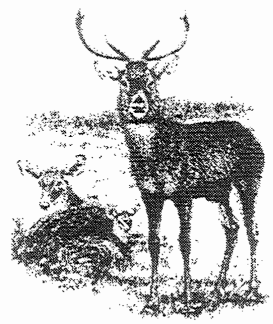
MANIPUR BROW-ANTLERED DEER

(Cervus eldi eldi)
Sangai

Population & Habitat Viability Assessment



11 - 13 October 1992
Mysore

Section 11

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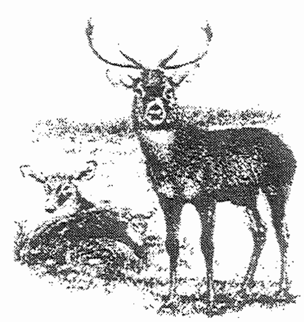

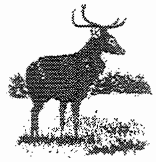

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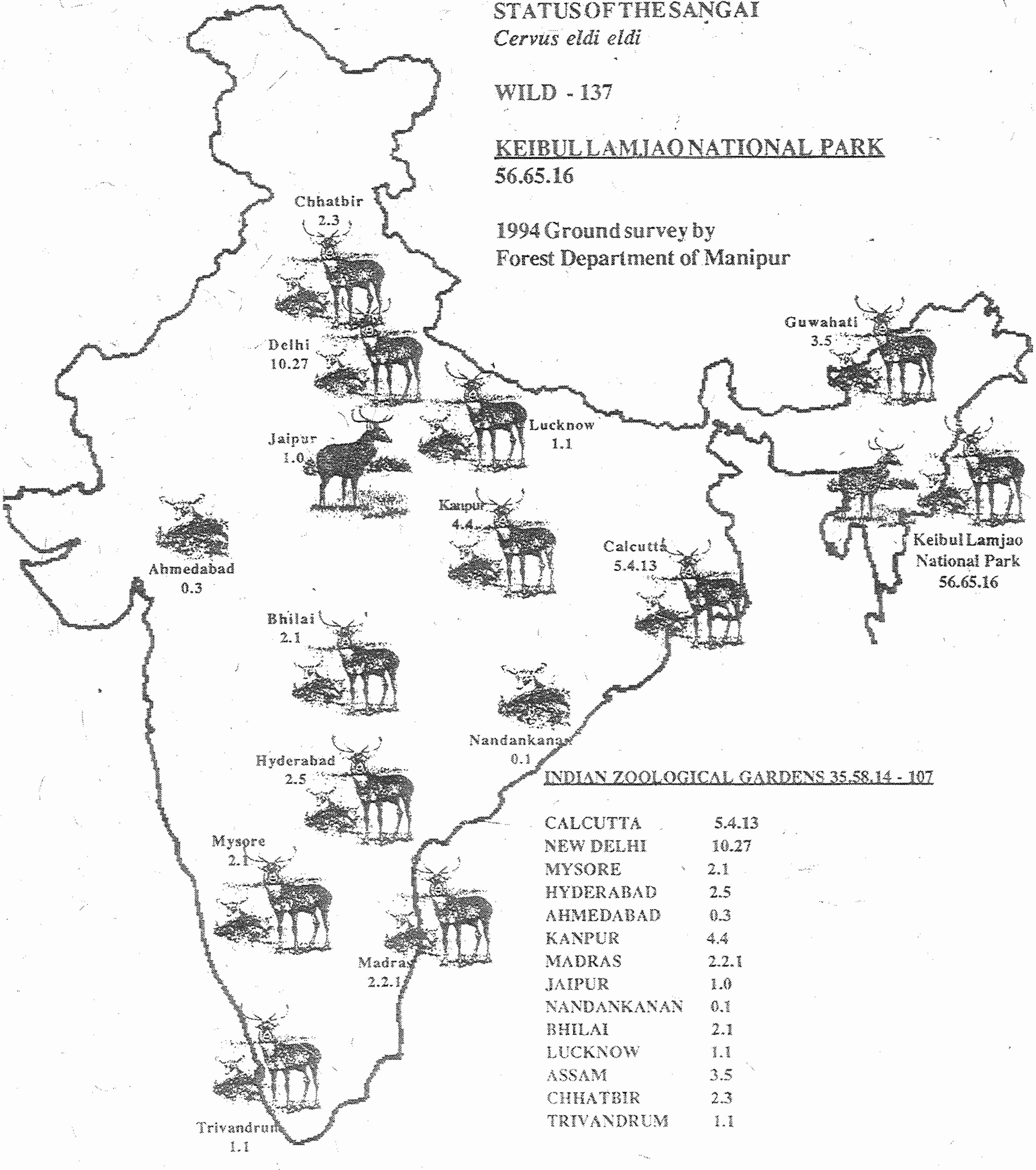
STATUS OF THE SANGAI
Cervus eldi eldi

WILD - 137

KEIBUL LAMJAO NATIONAL PARK
56.65.16

1994 Ground survey by
Forest Department of Manipur



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CALCUTTA	5.4.13
NEW DELHI	10.27
MYSORE	2.1
HYDERABAD	2.5
AHMEDABAD	0.3
KANPUR	4.4
MADRAS	2.2.1
JAIPUR	1.0
NANDANKANAN	0.1
BHILAI	2.1
LUCKNOW	1.1
ASSAM	3.5
CHHATBIR	2.3
TRIVANDRUM	1.1

The Manipur Brow-antlered Deer in 1994 -- *in-situ* and *ex-situ*