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REGIONAL CAPTIVE PROPAGATION PROGRAMS AS PART OF CONSERVATION STRATEGIES FOR THREATENED WILDLIFE

Thomas J. Foose, Ph.D.

An "extinction" crisis is confronting the wildlife of our planet, especiallly tetrapod vertebrates (mammals, birds, reptiles, amphibians) with as many as one-third (6,000) of the 23,000 tetraped species threatened over the next century. Moreover, as wild populations are reduced in number and fragmented in distribution, other kinds of "extinction" threats appear in addition to the primary causes of the crisis, i.e., habitat degradation and unsustainable exploitation. These other threats are the so-called stochastic problems that are peculiar to small populations. As the name indicates, stochastic problems are random and hence difficult to predict. However, there are management measures that can remedy these problems.

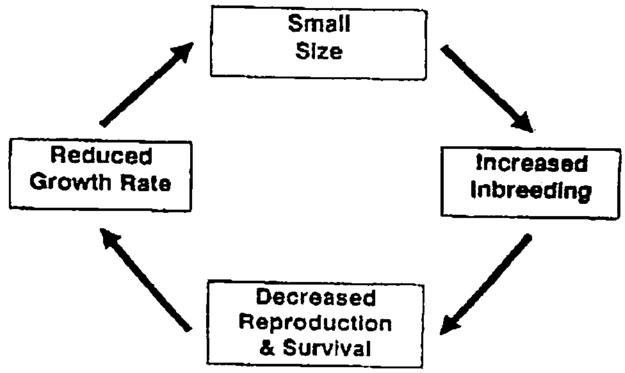
Stochastic problems can be environmental, demographic or genetic in nature:

Environmentally, small populations can be devastated by catastrophes or decimated by less drastic fluctuations in environmental conditions that can impair survival and fertility of individuals. Catastrophes (floods, fires, oil spills, disease epidemics, political upheavals) are increasingly recognized as severe threats to small populations. For larger and more widely distributed populations, these environmental viscissitudes are less significant. However, when a species or subspecies is reduced to a single small population, the results can be catastrophic, i.e., the floods that devastared the sole population of Sangai in the Keibul Lamjao National Park in the early 1950s.

Demographically, even in the absence of deleterious vagaries in the environment, small populations can develop intrinsic problems such as biased sex ratios, unstable age distributions, or random failures in survival and fertility that can fatally disrupt propagation and persistence.

Genetically, small populations can also lose heritable diversity that is necessary for fitness (survival and fertility) under existing environmental conditions as well as adaptation to changed enviroments in the future.

The smaller a populations and the more restricted it is in distribution, the greater these stochastic risks will be. Moreover, the environmental, demographic, and genetic problems can interact synergistically to create an extinction vortex for small populations (Figure 1)

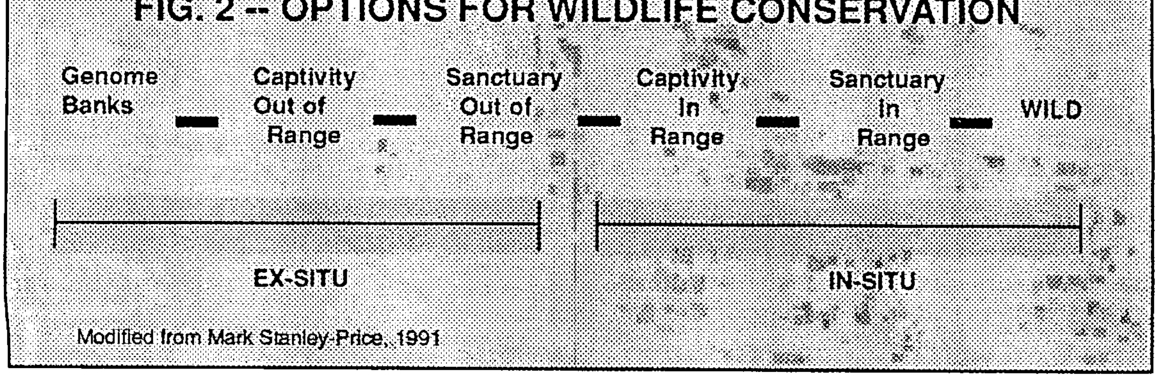


EXTINCTION VORTEX

To counteract these problems, conservation strategies must be based on maintaining or restoring viable populations. A viable population is one that is sufficiently large and well distributed to survive the stochastic as well as deterministic threats to survival. Intensive management is required to achieve viable populations. Over the last 10 years, the science of conservation biology and viable population theory has been and is still evolving to provide the tools for intensive management of threatened wildlife. A significant development in this regard has been improved systems for categorizing the degree of threat for wildlife species and populations, c.g. The Mace-Lande system now being adapted and adopted by the IUCN for Red Data Lists.

Managed propagation programs in zoos and affiliated captive facilities are one component of a spectrum of intensive management options available for threatened wildlife and hence are an integral part of holistic conservation strategies. (Figure 2, below).

FIG. 2 -- OPTIONS FOR WILDLIFE CONSERVATION



There are a number of advantages of captivity, including: protection from poachers, less environmental perturbations, more genetic management, secure expansion of the populations; easier opportunity for conservation-related research.

In general, captive populations and programs can serve 3 roles in holistic conservation strategies:

1) ***living ambassadors*** that can educate the public and even government at all levels and can generate funds and provide focus for *in situ* conservation;

2) ***scientific resources*** that can provide information and technologies beneficial to protection and management of populations is the wild;

3) ***genetic and demographic reservoirs*** that can be used to assist survival or recovery of taxa in trouble in the wild.

This last point is extremely important. Captive propagation programs must provide support, but not be a substitute for, viable populations in the wild.

There is growing need for captive propagation as part of conservation strategies for threatened wildlife, especially the larger vertebrates. These species are frequently the most difficult to conserve viably in natural habitats. Zoos can and should assume a major responsibility for conservation of tetrapods.

Formally coordinated and scientifically managed captive propagation programs are now developing worldwide at both the Regional and Global level (Figure 3). Twelve Regions of the zoo world have such programs in some stage of evolution Regional programs are in progress for over 300 taxa. The first established and hence most advanced are in North America (the Species Survival Plan or SSP), Europe (the European Endangered Species Programm or EEP) and Australasia (The Australasian Speices Management Program or ASMP).

Figure 3 - Regional Programmes

It is critical that other Regional Programs, like the Indian Endangered Species Programme develop as rapidly as possible because space and resources in zoos is so limited in relation to the need for captive breeding by many species and subspecies.

Organised captive programs formulate masterplans for management and propagation of the taxa selected for captivity. The basic objectives of captive propagation programs are:

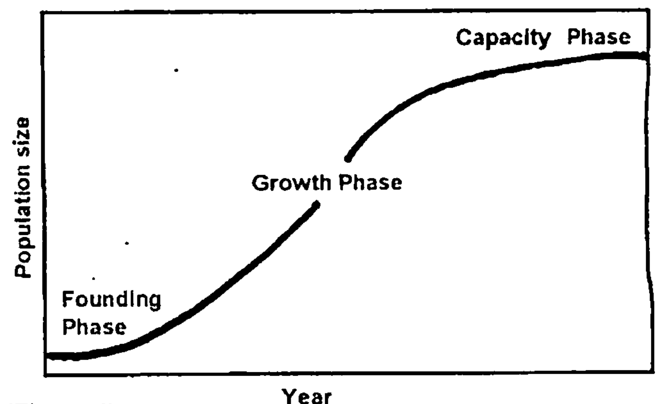
1) Husbandry success
2) Demographic security
3) Genetic diversity

Husbandry success is a pre-requisite to population management -- to achieve demographic security and genetic diversity in the captive population so that it can be used for support of wild populations. Increasing, regional captive propagation programs are systematically confronting husbandry issues and using the network the program provides to disseminate good standards and advances to all participating institutions.

In terms of population management, SSP programs try to minimize genetic change and maximize demographic security while the taxon is in captivity. Since loss of genetic diversity and risks to demographic security are functions of population size, an important part of every program is establishment of a target population size large enough to achieve acceptable genetic and demographic objectives. In terms of the genetic and demographic problems, more is always better for target populations, However, captive habitat is limited so the target populations must be compromises between maxima (large enough for viability) and minima (that don't exclude other taxa from programs).

The target populations are based in part on specific objectives for the amount of genetic diversity to be maintained for a specified period of time. A common objective is to preserve 90% of the gene diversity (expected heterozygosity) for 100 years. Combining these objectives with biological characteristics of the population such a generation time and the genetically effective size (N_e) permits a target size to be calculated. Computer software known as CAPACITY (by Jon Ballou, U.S. National Zoological Park) is available for target population calculations.

It is often a useful fiction to visualize the history and development of captive populations as depicted in this graph. (Figure 4) The population is expanded from a base of founders to a target size. Ideally, this expansion should be as rapid as



(Figure 4)

possible for both demographic securtiy and genetic diversity although some details of genetic management may require less than maximal growth in some instances. Once at target size, the population should be stabilized demographically.

The number of founders, i.e. animals from the source population (in this case the wild) that establish the derived population (in this case the captive) is important since this is the sample of the wild gene pool that the captive program can then try to preserve. The number of founders can affect the target size required. To a point, the more founders, the better as this graph illustrates, although there may be a point of diminishing returns at about 20-30 effective founders.

However, the number of founders does depend in part on the kind of diversity from the wild gene pool that is of concern. This graph relates to average heterozygosity, in a loosed sense the more common alleles. If rare alleles (which may be important for future adaptation) are of concern, the number of founders required may be much larger.

Whatever the number of founders, it is useful to visualize the attempt to preserve genetic diversity in captive or other intensively managed small populations in terms of the relative representation of founder lineages over time. Ideally, this representation should be equal. However, uneven production of offspring and hence transmission of genes through the pedigree cause disparity in representation of lineages and reduction of diversity. The reduction is the result of both actual loss of alleles and in the unevenness of their distribution.

As a consequence, larger representations are established for each linage that reflects the proprtion of that founder's genome that is still in the captive population. Reproduction is then managed to move the representation of each founder linage from its current to the target level.

In actual practice, this adjustment of founder lineages is achieved by selecting animals for reproduction in terms of genetic importance. Mean kinship has emerged along with measures of genome uniqueness as the primary criteria. Mean kinship is a measure of the degree of relationship between this individual and all other animals in the living descendant (i.e. non-founder) population . The values range from 0 (the animal has no relatives in the living descendant population) and 1 (the animal is completely related to every animal in the living descendant population). Hence, the lower the mean kinship of an individual, the more important this animal is for breeding to preserve the genetic diversity of the founders.

Demographic management is also essential for captive programs to avoid population explosions and extinctions, i.e., booms and bias. The basic questions and considerations about demography for captive population managers includes

- What is the current size and structure (ages and sexes) of the population

- How will the size and structure probably change if there is no demographic management?

- How do managers want the size and structure to change (including no change).

- How can/must managers manipulate the population through control of reproduction and survival to produce desired changes

Regulation of the reproduction and survivorship, i.e. the basic life table, is the way to manage the population demographically.

All of this genetic and demographic analysis and management require basic studbook data be compiled for the population. Again, standard software (e.g. SPARKS from ISIS) is available and essential for this purpose.

SPARKS Single Population Analysis and Records Keeping System

The bottom line is that masterplans for captive propagation programs provide institution-by-institution and animal-by-animal recommendations for propagation and management. In paticular, the masterplan recommends which animals are to be bred (or not bred) with each and therefore which animals need to be transferred among institutions.

In summary, intensive genetic and demographic management programs must respond to a number of questions:

- What are genetic and demographic objectives

- How many founders are needed

- How large a population (target) must be maintained

- What kinds of genetic and demographic management are required

While the art and science of managing small populations, especially in captivity, continues to evolve, moderate consensus currently about what to do is as follows:

- Adopt acceptable goals for demographic security and genetic diversity.
- Establish target population large enough to achieve goals.
- Aquire an adequate number of founders (20 - 30 Effective founders measured as Founder Genome Equivalents F.G.E.s)
- Produce 7-12 progeny from each founder; breed founders as long as possible.
- Expand population as rapidly as possible from initial to target size.
- Distribute population over multiple facilities; regulate interchange.
- Extend generation time once at target population.
- Manage family sizes to regulate demographically and optimize genetically.
- Reproduce animals with low mean kinship and high genome consequences;

Organizational aspects are as critical as biological considerations to the success of captive propagation programs. Experience in many regions has demonstrated that each program must have a coordinator who has the expertise and experience to provide leadership to formulate and implement the programs. Highly participatory management committees, or as they are sometimes known propagation groups, consisting of representative of institutions with the species are also essential for successful programs.

Finally, it must be re-emphasized that captive populations and programs must be developed as part of holistic conservation strategies whose paramount goal is the survival and recovery of viable populations in the wild. Achieving viable numbers and distributions, will require development of metapopulations, in systems of smaller populations managed interactively. Viable populations will also require intensive management . Moreover, captive-type management will need to be increasingly applied to small populations in the wild.

Developing holistic conservation strategies is greatly faciliated by Population and Habitat Viability Analysis (PHVA). PHVA is an intensive analysis of a particular taxon or one of its populations. PHVA's use computer models: to explore extinction processes that operate on small and often fragmented populations of threatened taxa and to examine the probable consequences for the viability of the population under various management actions or inactions. The models incorporate information on distributional, demographic, and genetic characteristics of the population and on conditions in the environment to simulate probable fates (especially probability of extinction and loss of genetic variation) under these circumstances. PHVAs use models to evaluate a range of scenarios for the populations under a variety of management (or non-management) regimes. As a result to the different scenarios modelled, it is possible to recommend management actions that maximize the probability of survival or recovery of the populations. These actions may include establishment, enlargement, or more management of populations in protected areas, poaching control; reintroduction or translocation; sustainable use programs; education efforts and captive breeding.

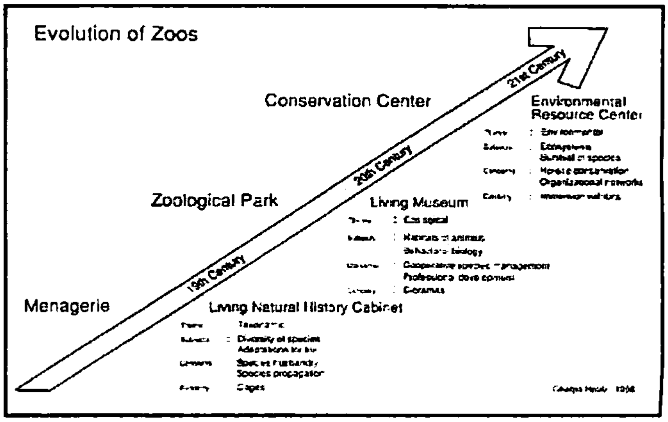


FIGURE 6 - EVOLUTION OF ZOOS

In conclusion, more and more zoos are evolving into conservation centres to fulfill their potential and responsibilities to help conserve the wildlife heritage of our planet (Figure 6). But, much more needs to be done. The zoos of India are a major componenet of the global captive community. The more rapidly regional captive propagation programs can develop, the greater will be the benefit to conservation.

Dr. T. J. Foose is presently Programm Officer for the International Black Rhino Foundation.

Editors' Note: Dr. Foose's presentation actually included Global as well as Regional Captive Breeding Programmes, which are teamwork processes to bring about maximize efficient and effective utilization of captive resources. It seemed best tocarry this over in a subsequent issue as Part II of this excellent presentation.

MOCK MASTERPLANNING SESSION FOR A REGIONAL CAPTIVE BREEDING PROGRAMME IN INDIA FOR *RHINOCEROS UNICORNIS*

Thomas J. Foose, Programme Officer, International Black Rhino Foundation

Developing on the background and foundation provided by the general presentation of global and regional captive propagation programs, a mock (model) workshop was conducted as a class exercise to consider how such ex situ efforts could be further organised in India. The species selected was the Indian rhino *(Rhinoceros unicornis)*. The workshop was led by this writer assisted by S. Walker but was conducted interactively with all participants.

A first step in developing a regional breeding programme is compilation of a working studbook. This compilation is facilitated by the use of the SPARKS studbook software provided by the International Species Inventory System (ISIS). There is an International Studbook for *Rhinoceros unicornis* which has been entered into SPARKS. In the past, there have been some delays in communication of data from regions to the International Studbook. Hence, many Regions of the Zoo World have developed Regional Studbooks to provide more timely data for use in developing Regional Captive Propagation Programs. Z.O.O. has assisted in the initiation of such regional compilation for India. Figure 1 provides an overview of the number and distribution of Indian rhino in Indian zoos. Currently, there are 36 (25.10.1) rhino in Indian zoos with another 7 (2.5) in a semi-captive situation at Dudhwa National Park, site of the first rhino reintroduction project in India.

A second step in development of a Regional Plan is the establishment of objectives for the programme. An extremely important objective is the number of founders (individuals from the wild) to initiate the programme and the target population to be developed. The size of target population is determined by the demographic and genetic goals for the regional population in the context of the global programme for this species. The GCAP recommendations for Asia is 78, of which at least 50 might be in Indian zoos. Toward this target objective, the mock workshop suggested that the 9 zoos already with the species outside Assam each maintain 4 (2.2) and that one or two more zoos outside Assam add the species and each maintain 4 (2.2).

It was noted that 24 (17.7) of the captive rhino in India are wild born. Nine (4.5) of them have produced living descendants and hence are actual, as opposed to potential founders. At least 3 (2.1) more founders now dead have living descendants. Thus there are 12 (6.6) actual founders and another 11.1 potential founders in the Indian captive population. The sex ratio of the entire populaton and the founder base is skewed toward males. It was suggested that it would be beneficial to recruit a few additional founders. This could be done without trapping by utilising female rhino calves which have been rescued from wild during monsoon as mates for extant wild-origin captive males.

Ultimately, a Masterplan for a Regional Captive Propagation Program provides institution-by-institution and animal-by-animal recommendations on which animals should (and should not) be mated with each other to achieve the demographic and genetic objectives. SPARKS software permits genetic and demographic analysis that can be used for this purpose. Desired matings may frequently entail relocation of individuals among zoos.

Table 1 provides additional detail on the genetic and demographic characteristics of this population that were used to formulate recommendations for matings and moves in this population. The highest priority identified was the need to provide appropriate mates for the four zoos which currently have only male rhino (Table 2). It was also observed that the breeder male at Kanpur has died leaving 4 sons who are, therefore, related to the surviving female.

The initial recommendations for relocation of animals is based purely on biological objectives for the regional (and global) population. These recommendations must then be reconciled with institutional interests and needs that may be in conflict with the population objectives. Resolving these conflicts so that the program can be implemented entails much political negotiaion. Indeed there was a discussion that people problems often consume more time and effort than biological problems do. As an exercise, various members of the class assumed the roles of directors of zoos with Indian rhino but not attending the course to enact simulated negotiations to reconcile populational versus institutional interests.

Finally, there was discussion of the point that organisational consideration are as important as biological factors in developing a Regional Captive Breeding Programme. Experience in other Regions has emphasized the importance of an active coordinator that can provide leadership in formulating and implementing the program. Moreover, it is also crucial to form an active and participatory committee representing the zoos with the rhino. There was a consensus among the class that it would be most useful if this matter could be emphasized at future meetings of the Central Zoo Authority and the Indian Zoo Directors' Association so that effective coordinators and commitees can be organised for the Indian rhino as well as for the Lion-tailed macaque and the Indian lion. There will be major meetings of the global communities concerned with these species in India in 1993 and programmes for these three species can serve as models for many other regional captive breeding programmes in India.

TABLE 1

Rhinoceros unicornis in Captivity -- Current and Target Population

Region	Current Population	Target Population
Asia	45	78
(India)	(35)	(50)
North America	40	76
World	120	230

TABLE 2 -- INDIAN RHINOCEROSUS IN CAPTIVITY IN INDIAN ZOOS

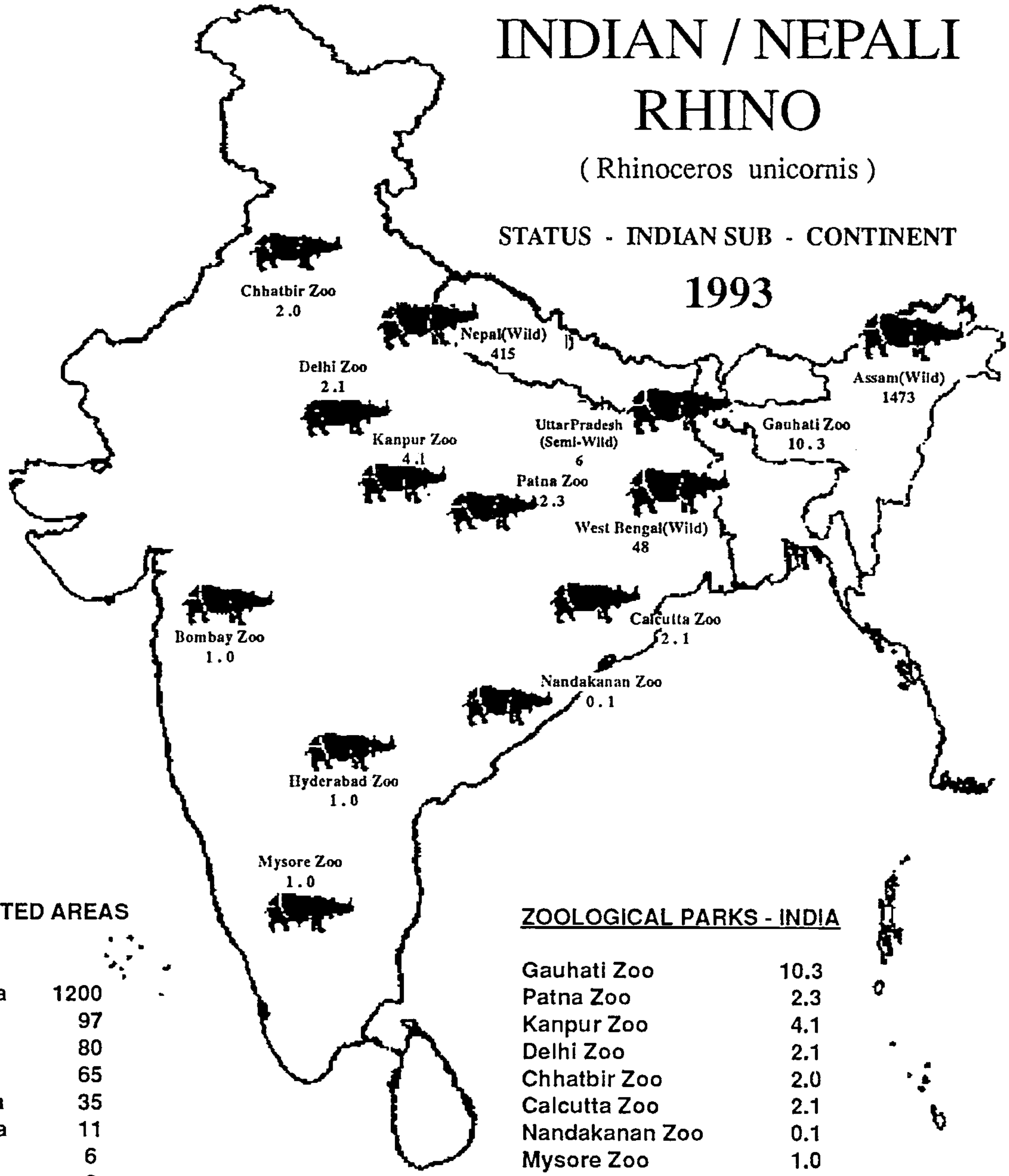
	(Below 10 yrs Juvenile		Between 10-40 Adult		Over 40 Aged		Total captive		Wild born		Captive born	
	m	f	m	f	m	f	m	f	m	f	m	f
Gauhati	7	1	3	2	0	0	10	3	8	2	2	1
Patna	0	2	2	1	0	0	2	3	2	1	0	2
Kanpur	3	0	1	1	0	0	4	1	0	1	4	0
Delhi	1	0	1	1	0	0	2	1	1	1	1	0
Chhatbir	1	0	1	0	0	0	2	0	2	0	0	0
Calcutta	1	0	1	1	0	0	2	1	1	1	1	0
Nandankanan	0	0	0	1	0	0	0	1	0	1	0	0
Mysore	0	0	1	0	0	0	1	0	1	0	0	0
Bombay	0	0	1	0	0	0	1	0	1	0	0	0
Hyderabad	0	0	1	0	0	0	1	0	0	0	1	0
	13	3	12	7	0	0	25	10	16	7	9	3

INDIAN / NEPALI RHINO

(Rhinoceros unicornis)

STATUS - INDIAN SUB - CONTINENT

1993



PROTECTED AREAS

India

Kaziranga	1200
Orang	97
Manas	80
Pobitara	65
Jaldapara	35
Gurumara	11
Dudhwa	6
Laokhowa	6
Other	25

Nepal

Chitwan	400
Bardia	15
Total	1940

ZOOLOGICAL PARKS - INDIA

Gauhati Zoo	10.3
Patna Zoo	2.3
Kanpur Zoo	4.1
Delhi Zoo	2.1
Chhatbir Zoo	2.0
Calcutta Zoo	2.1
Nandakanan Zoo	0.1
Mysore Zoo	1.0
Bombay Zoo	1.0
Hyderabad Zoo	1.0
Total male/female	25.10
Total Rhino Indian zoos	35
Total World Zoos	120