

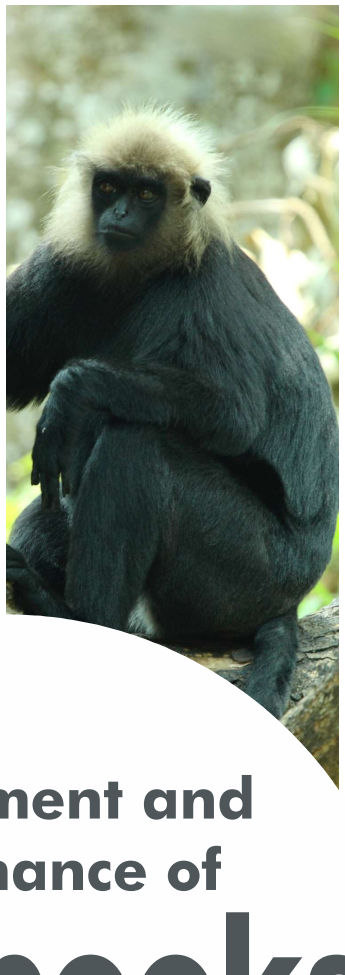


Development and Maintenance of Studbooks for Selected Endangered Species in Indian Zoos

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

केन्द्रीय चिड़ियाघर प्राधिकरण
Central Zoo Authority

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Development and Maintenance of Studbooks for Selected Endangered Species in Indian Zoos

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PROJECT TEAM

Dr. Parag Nigam
Scientist F & Principal Investigator

Dr. Anupam Srivastav
Project Consultant

Ms. Nilofer Begum
Junior Research Fellow

Ms. Neema Sangmo Lama
Research Assistant

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FOREWORD

Intensive efforts made to protect habitats and species globally using both *in-situ* and *ex-situ* approaches have achieved a measure of success. However, they are yet to achieve the sustained survival of all habitats/ species. Ensuring survival of species, whose extinction risk cannot be addressed by *in-situ* efforts alone entails their intensive management in *ex-situ* facilities.

Maintenance of populations that are genetically viable and demographically stable of species included under *ex-situ* conservation programs is critical to ensuring retention of evolutionary potential and adaptability to changing environmental conditions. Studbooks containing life-history details and pedigree records of individual specimens form the critical basis for understanding of the demographic structure and genetic status of the population and are critical for development of effective population management plans.

The Central Zoo Authority and Indian zoos have initiated a conservation breeding program for identified species in Indian zoos. As a part of this endeavour the Wildlife Institute of India was assigned the task of development and maintenance of studbook of 34 identified species. I have great pleasure in presenting the final report of the project titled "Development and maintenance of studbooks for selected endangered species in Indian zoos" awarded to the Wildlife Institute of India by the Central Zoo Authority.

The final report provides a brief account of the studbooks of 34 endangered wild animal species held in Indian zoos including genetic and demographic trends of these species in captivity that provide an insight into the long term viability of these captive populations.

I hope that the zoos housing the species would use the recommendations made in this regard for professional and scientific management of these species.

V. B. Mathur
Director, Wildlife Institute of India
September 2018

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Dr. D. N Singh, IFS, Member Secretary
Dr. Brij Kishor Gupta, Evaluation and Monitoring Officer
Dr. Devender Thakur, Scientific Officer
Mr. Ajay Kumar T. Evaluation and Monitoring Assistant
Mr. R.S. Rawat, Finance Officer
Ms. Natasha Sethi Vashisth, Technical Assistant
Mr. Vivek Goyal, Computer Personnel

Wildlife Institute of India
Dr. V.B. Mathur, Director
Dr. G. S. Rawat, Dean Faculty of Wildlife Sciences
Dr. P.K. Malik, Scientist-G & Head, Department of Wildlife Health Management
Dr. Bitapi C. Sinha, Scientist G & Research Coordinator
Mr. Virendra Sharma, Technical Assistant, Department of Wildlife Health Management

Zoo Directors, Biologists, Curators and Veterinarians

Alipore Zoological Garden, Kolkatta
Arignar Anna Zoological Park, Chennai
Assam State Zoo Cum Botanical Garden, Guwahati
Aurangabad Municipal Zoo, Aurangabad
Bannerghatta Biological Park, Bangalore
Bhagwan Birsa Biological Park, Ranchi
Biological Park, Itanagar
Chinkara Breeding Farm, Bhiwani
Dr. K. Shivarma Karanth Pilikula Biological Park, Mangalore
Dr. Shyamaprasad Mukherjee Zoological Garden, Surat
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Nehru Zoological Park, Hyderabad
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Padmaja Naidu Himalayan Zoological Park, Darjeeling
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Rajkot Municipal Zoo, Rajkot
Rescue Centre at Gorewada, Gorewada
Sajjangarh Biological Park, Udaipur
Sakkarbaug Zoo, Junajadh
Sanjay Gandhi Biological Park, Patna
Sanjay Gandhi National Park and Zoo, Borivilli
Sayaji Baug Zoo, Vadodra
Sepahijala Zoological Park, Agartala
South Khairbari Rescue Centre, Alipur Duar
Sri Chamarajendra Zoological Gardens, Mysore
Sri Venkateshwara Zoological Park, Tirupati
State Museum and Zoo, Thrissur
Sundarban Wild Animal Park, Jharkali
Tata Steel Zoological Park, Jamshedpur
Thiruvananthapuram Zoo, Thiruvananthapuram
Tiger & Lion Safari, Shimoga
Van Vihar National Park Zoo, Bhopal
Veermata Jijabai Bhosle Udyan & Zoo, Mumbai

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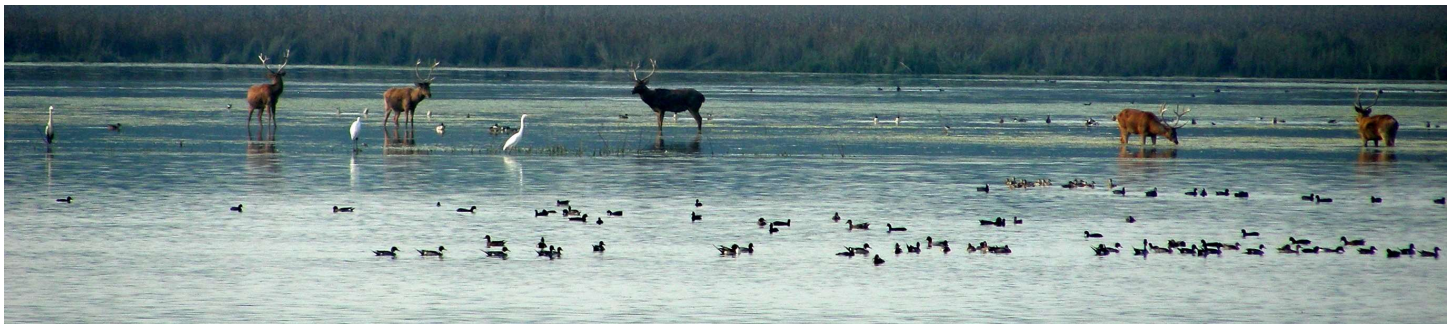
EXECUTIVE SUMMARY



Intensive efforts made to protect habitats and species globally have achieved a measure of success; however, they are yet to achieve the sustained survival of all habitats/ species. Ensuring the survival of species whose extinction risk cannot be addressed by *in-situ* efforts alone entails their intensive management in *ex-situ* facilities. A major goal identified for the operation of zoos both globally and nationally includes support for *in-situ* conservation efforts by maintaining *ex-situ* populations for insurance and reintroduction besides functioning as centres for conservation education. A critical component in this effort is the maintenance of sustainable *ex-situ* populations of species facing imminent extinction threats and not merely the breeding and maintenance of threatened species in captivity.

Maintenance of populations that are genetically viable and demographically stable of species included under *ex-situ* conservation programs is critical to ensuring retention of evolutionary potential and adaptability to changing environmental conditions. Establishment and operation of effective *ex-situ* conservation programs may therefore involve collection of as many unrelated founders as possible during the establishment phase. Subsequent management involves judicious use of this founder stock in a manner that minimizes relatedness in the population while maximizing reproductive output. Constraints of space and resources limit the ability of individual institutions to effectively achieve ex-situ conservation goals; however, pooling of populations from multiple institutions and subsequent management as a single unit can help in ensuring success.

Effective management of *ex-situ* populations involves an understanding of the demographic structure and genetic status of the population that form the basis for development of an effective population management plan. Studbooks containing life-history details and pedigree records of individual specimens at each location the species is maintained provide the basis for this. Analysis of studbook databases thus enables development of effective population management plans and breeding recommendations that ensure retention of maximum possible genetic diversity in the population.

Studbooks are primarily a compilation and source of genealogical and demographic data on those individuals of genus, species, sub-species or otherwise defined taxon that make up the whole or part of a captive population (Olney, 2001).

A studbook essentially contains all available information regarding a species in captivity. The major information includes:

- Information on the natural history and threats and stressors that the species faces to provide background information for developing appropriate husbandry practices.
- Records of all specimens/ individuals ever held in the geographic domain of the studbook. (The national studbooks contain all information made available on specimens held in Indian zoos and conservation breeding centres.)
- Known specimens present outside India, if relevant to the population.
- All direct ancestors of these specimens (regardless of location), tracing lineage to original wild-caught founders.
- All stillbirths, premature births and early deaths.

The Central Zoo Authority along-with the Indian zoos has initiated a conservation breeding program for identified species in Indian zoos. As a part of this endeavour the Wildlife Institute of India was assigned the task of development and maintenance of studbook of 34 identified species (table 1) in 2012 that are facing imminent extinction threats with the funding support of Central Zoo Authority.

Table 1: Species identified for development and maintenance of studbooks.

Group	Species
Canids	*Canis lupus chanco, Cuon alpinus, Canis lupus pallipes*
Felids	*Panthera uncia, Neofelis nebulosa, Panthera leo persica, Panthera tigris tigris*
Primates	*Macaca arctoides, Macaca silenus, Macaca leonina, Trachypithecus geei, Trachypithecus phayrei, Trachypithecus johnii, Hoolock hoolock*
Ungulates	*Equus hemionus khur, Capricornis thar, Pseudois nayuur, Rhinoceros unicornis, Moschiola indica, Bos gaurus gaurus, Tetracerus quadricornis, Gazella bennettii, Rucervus eldii eldii, Rucervus duvaucellii*
Small mammals	*Manis crassicaudata, Ailurus fulgens*
Pheasants	*Lopophurus impejanus, Polyplectron bicalcaratum, Tragopan melanocephalus, Catreus wallichi*
Vultures	*Gyps indicus, Gyps bengalensis, Gyps tenuirostris*
Columbidae	*Caloenas nicobarica*

METHODS

The work of developing and maintaining studbooks of identified species was carried out by using the following methods.

A review of literature to understand the taxonomy, natural history, distribution, threats and conservation actions was carried out from available sources.

The presence of species and the number of individuals present in individual zoos was ascertained on the basis of year-wise inventory of animals present on the Central Zoo Authority website and the species holdings present on the ZIMS platform of the species 360 website. Questionnaires for collection of pedigree records for species held at the zoos were mailed with a request to provide relevant records. Additionally efforts by way of visits to zoos were carried out to collect the pedigree records.

Data acquired by way of the above efforts was recorded in Single Population Analysis and Records Keeping Software (SPARKS) version 1.66 (ISIS 2004). The data was exported to PMx version 1.0 for further analysis for understanding the demographic and genetic status of populations of identified species that formed the basis for development of population management plans and breeding recommendations for the species.

Species for which data available was not amenable for recording in SPARKS due to lack of available records data was recorded in the form of an inventory. Based on this attempts were made at understanding the demographic and genetic structure of the populations.

Status of Species Identified for Development of Studbooks

The 34 species identified for development and maintenance of studbooks have been grouped based on their taxonomic affinities. The summary of findings for each group are summarized below.

CANIDS

Three species of canids have been identified for the development and maintenance of studbooks; they include Indian Wolf, Tibetan Wolf and Asiatic Wild Dog or Dhole. The Indian wolf and Tibetan Wolf are described in literature as subspecies of Gray wolves a species that is considered to be of least concern by the IUCN Red list; however, their geographical isolation and recent molecular genetics evidences are suggestive of their distinctiveness, necessitating ex-situ conservation efforts, dholes on the other hand because of declines across their range are considered as Endangered. All three species/ sub-species are facing imminent declines due to reduction in available habitats, retaliatory killings and disease threats. Status of the species in zoos of India based on information made available by holding zoos is provided in table 2.

Table 2: Status of canids identified for update/development of studbooks

Species	WPA 1972 Status	IUCN Red List Status	Status in Captivity in India (M/F/U/T)	Insts.
Indian Wolf *(Canis lupus pallipes)*	Schedule I	Status not available	39/33/16/88	12
Tibetan Wolf *(Canis lupus chanco)*	Schedule I	Status not available	2/7/4/13	2
Asiatic Wild Dog *(Cuon alpinus)*	Schedule II	Endangered	65/38/0/103	7

The three species/ sub-species have been in captivity for extended period of times; however the populations remain demographically unstable though Indian wolf and Dhole have adequate numbers to kick-start the populations. This is attributed to the small number of individuals that are reproductively active in these populations. The size of Tibetan wolf population has remained continuously small (N = 20) limiting its growth.

Inadequate record keeping with limited information available on dates of life-history events of individual specimens and their lineages limited accurate demographic and genetic analysis for all the three species/ sub-species. The populations of Indian wolf and Dhole contain limited genetic diversity that is non-representative of the free ranging populations while for Tibetan wolves no specimens could be traced to wild origin parents. Available data indicates a close relationship between individuals in the populations of Indian wolf and Dhole.

Recommendations

Based on the analysis carried out for the development of the studbooks the effective management of the three species/ sub-species of canids can be achieved by marking all individuals present in the populations using appropriate techniques to ensure individual animal identification and accurate record keeping. The lineages of existing specimens in these populations need to be ascertained using appropriate molecular genetics techniques. Identification of lineages should form the basis for development of breeding recommendations for the populations.

The limited reproductive output of the populations is suggestive of shortcomings in husbandry practices and availability of adequate enclosure space. It is suggested that a review of the existing housing and husbandry practices adopted for the upkeep of the species to identify potential shortcomings should form the basis for development of appropriate practices for maintaining the three species in captivity.

FELIDS

Four species of felids have been identified for the development and maintenance of studbooks; they include Bengal tiger, Asiatic lion, Snow leopard and Clouded leopard. All the four species are listed under the Schedule I of the Wildlife (Protection) Act while the IUCN RedList of Threatened Species lists Bengal tiger and Asiatic lions as Endangered and Snow leopard and Clouded leopard as Vulnerable due to decline in populations resulting from loss and fragmentation of habitats, decline in prey availability and poaching. Bengal tigers are habitat generalists inhabiting varied landscapes in the sub-continent that range from moist deciduous forest, evergreen and semi-evergreen forest, and mixed sub-tropical forests to mangroves. Asiatic lion, Snow leopard and Clouded leopard are habitat specialists inhabiting dry deciduous forest cover interspersed with moist mixed riverine valley forest patches, alpine and sub-alpine ecological zones and dense evergreen forest respectively. The continued decline in populations has necessitated *ex-situ* conservation of these felids. The status of the four species in Indian zoos based on information made available by holding zoos is provided in table 3.

Table 3: Status of felids identified for update/development of studbooks

Species	WPA 1972 Status	IUCN Red List Status	Status in Captivity in India (M/F/U/T)	Insts.
Bengal Tiger (*Panthera tigris tigris*)	Schedule I	Endangered	186/178/1/365	50
Asiatic Lion (*Panthera leo persica*)	Schedule I	Endangered	89/104/0/193	28
Snow Leopard (*Panthera uncia*)	Schedule I	Vulnerable	4/9/0/13	2
Clouded Leopard (*Neofelis nebulosa*)	Schedule I	Vulnerable	9/7/0/16	5

The four species have been maintained in Indian zoos for extended time periods. The populations of Bengal tiger and Asiatic lion in captivity have grown steadily since their entry in captivity and have attained demographic stability. The populations of Snow leopard and Clouded leopard have however remained consistently small (N < 20) and are thus susceptible to random events. The growth in population of Bengal tiger and Asiatic lion is attributed to the high birth rate and the contribution of a large number of founders used to establish the respective populations, while the limited reproductive output of the remaining populations constrains their growth.

The populations of Bengal tiger and Asiatic lion retain high levels of genetic diversity, though the founder genome is unequally represented with a select few lineages being over-represented in the population. On the other hand the population of Snow leopard though originating from a large founder base retains limited genetic diversity as the Indian captive population was established using closely related specimens acquired from zoos outside India and the current specimens are offspring of these individuals. The Clouded leopard population originates from a small founder base resulting in breeding between closely related individuals.

Recommendations

The analysis of pedigree databases carried out to understand the demographic and genetic status of the captive populations of the four species highlight the need for the following actions:

For the population of Bengal tiger and Asiatic lion attempts at equalizing the founder genome in the current population may be made by pairing individuals of unrepresented and under-represented lineages with the existing specimens of over-represented lineages. The same considerations may be used for equalizing the representation of the founder genome in the populations of Snow leopard and Clouded leopard.

Additional specimens of Snow leopard and Clouded leopard should be acquired and made available to zoos that have appropriate housing facilities for the species. The acquisitions may be through import of animals from zoos outside India or capture of wild origin specimens.

PRIMATES

A total of seven primate species have been identified for the development and update of studbooks (Table 4) these include one species of apes, three langurs and three macaque species. The species are threatened by habitat loss due to development of linear infrastructure, poaching and encroachment. Two species Nilgiri langur and Lion-tailed macaque are endemic to the Western ghats while the remaining inhabit varied forest types in North-eastern India. Golden langurs are restricted to forests in Manas National Park, Assam and adjoining areas in Bhutan while the range of others extends further eastward.

Hoolock gibbon inhabits mature forest; tropical evergreen forest, the wetter tropical semi-evergreen forests, sub-tropical monsoon evergreen broadleaf forests, and sub-tropical evergreen broadleaf hill or mountain forests. Golden langur inhabits subtropical and temperate broadleaf forests while Nilgiri langurs inhabit tropical moist deciduous, riverine, wet evergreen, and montane wet temperate forests and riparian forests at lower elevations besides montane shola forest patches. Phayre's leaf monkey inhabit primary and secondary evergreen and semi-evergreen forest, mixed moist deciduous forest, bamboo-dominated areas, light woodlands, and near tea plantations. Lion-tailed macaques are restricted to the evergreen forests of the Western Ghats, while Pig-tailed macaques inhabit tropical evergreen and semi-evergreen forest, tropical wet evergreen forest, tropical moist deciduous forest, coastal forest, swamp forest, low elevation pine forests (in Lao PDR and China) and montane forests. Stump tailed macaques are inhabitants of subtropical and tropical broadleaf evergreen forests.

Table 4: Status of Primates identified for update/development of studbooks

Species	WPA 1972 Status	IUCN Red List Status	Status in Captivity in India (M/F/U/T)	Insts.
Hylobatidae				
Hoolock Gibbon (*Hoolock hoolock*)	Schedule I	Endangered	25/16/7/48	9
Family Cercopithecidae				
Sub-family Colobinae				
Golden Langur (*Trachypithecus geei*)	Schedule I	Endangered	5/2/0/7	1
Nilgiri Langur (*Trachypethecus johnii*)	Schedule I	Vulnerable	11/11/3/25	5
Phayre's Leaf Monkey (*Trachypithecus phayrei*)	Schedule I	Endangered	7/15/9/31	2
Sub-family Cercopithecinae				
Lion Tailed Macaque (*Macaca silenus*)	Schedule I	Endangered	22/26/9/57	10
Pig Tailed Macaque (*Macaca nemestrina*)	Schedule I	Vulnerable	29/23/12/64	8
Stump Tailed Macaque (*Macaca arctoides*)	Schedule II	Vulnerable	19/25/1/45	9

Hoolock Gibbon

Their population has remained continuously small (N < 50) in captivity. The living population includes a large proportion of specimens of reproductive age; however only a small proportion is actually reproducing. It originates from 13 founders and retains 93% of their genetic diversity that is unequally represented in the population. The limited reproductive output of the population suggests of shortcomings in the housing and husbandry practices adopted for managing the species in captivity.

Recommendations

A review of the existing housing and husbandry practices adopted for managing the species in captivity needs to be undertaken based on the habitat requirements and behaviour of the species.

It is also essential to equalize family sizes and ensure an equal representation of founder animals to retain the maximum possible genetic diversity in the captive population.

The formation of breeding pairs as suggested in the breeding recommendations should be carried out with appropriate socialization prior to the mating season. As a prerequisite towards ensuring effective socialization, all new introductions should be in controlled conditions and under supervision.

Langurs

The population of the three species have consistently remained small (N << 50), with increase in number of specimens of Golden langur being primarily through acquisition of specimens from the wild and that for Nilgiri langur and Phayre's leaf monkey through captive births. The living population of Golden langur is extremely small, has only 6 individuals of reproductive age, and retains limited genetic diversity it is therefore unlikely to achieve conservation goals. Further, both the *in-situ* and *ex-situ* populations of the species due to its small distribution range and continued threats remains highly susceptible to extinction. The populations of Nilgiri langur and Phayre's leaf monkey with supplementation can however be managed to increase rapidly as the living populations have 20 and 24 specimens respectively of reproductive age, they further retain significant amounts of genetic diversity though from a small founder base. Records of only 32% of the specimens of Nilgiri langur could be traced back to founders, while for specimens of Golden langur and Phayre's leaf monkey records of 87.5% and 94.4% specimens could be traced back to founders.

Recommendations

The population of Golden langur due to its continued small size and limited reproductive output requires supplementation to kick-start the population. The housing and husbandry practices adopted need to be critically reviewed as the population has continued low reproductive output. Additional wild origin specimens may be acquired only after shortcomings in husbandry are identified and addressed. The populations of Nilgiri langur and Phayre's leaf monkey with supplementation using additional wild origin specimens can successfully achieve their conservation goals. This would require the creation of additional housing facilities to house the growing population. All specimens need to be marked for individual identification using appropriate techniques to enable maintenance of accurate records of individual life history events and parentages/ lineages.

Ungulates

Ungulates include the group of hoofed large mammals that play an important role in regulating ecosystem form and function and by acting as consumers of the primary productivity by plants and as prey for predators. They have evolved into a diverse group of animals that are responsible for creating spatial heterogeneity and modulating succession. They include one of the most diverse groups of mammals that have evolved to inhabit most of the earth.

Ten species of ungulates have been identified for the development and update of studbooks for management of their *ex-situ* populations. Details regarding their taxonomic position, threat perception and status in Indian zoos are summarized in table 5. These include 8 species belonging to the order Artiodactyla and 2 belonging to the order Perissodactyla.

Table 5: Status of Ungulates identified for update/development of studbooks

Species	WPA 1972 Status	IUCN Red List Status	Status in Captivity in India (M/F/U/T)	Insts.
Artiodactyla				
Family Bovidae				
Subfamily Caprinae				
Serow (*Capricornis thar*)	Schedule I	Near Threatened	4/5/0/9	6
Blue Sheep (*Pseudois nayaur nayaur*)	Schedule I	Least Concern	10/7/0/17	3
Subfamily Antilopinae				
Indian Gazelle (*Gazella gazella benneti*)	Schedule I	Least Concern	32/24/10/66	9
Sub-family Bovinae				
Gaur (*Bos gaurus*)	Schedule I	Vulnerable	80/67/5/152	17
Mouse Deer (*Moschiola indica*)	Schedule I	Least Concern	142/110/12/264	10
Four Horned Antelope (*Tetracerus quadricornis*)	Schedule I	Vulnerable	47/81/24/152	19
Family Cervidae				
Brow-antlered Deer (*Rucervus eldii eldii)*	Schedule I	Endangered	76/83/13/172	15
Swamp Deer (*Rucervus duvauceli*)	Schedule I	Vulnerable	71/131/53/255	16
Order Perissodactyla				
Family Equidae				
Indian Wild Ass (*Equus hemionus khur*)	Schedule I	Endangered	9/6/0/15	2
Family Rhinocerotidae				
One Horned Rhinoceros (*Rhinoceros unicornis*)	Schedule I	Vulnerable	20/15/0/35	9

Family Bovidae: Subfamily Caprinae and Antilopinae

The subfamily Caprinae includes two species viz. Serow and Blue Sheep, while the family Antilopinae includes Chinkara or Indian Gazelle. The threats that these species face in their natural habitat include competition from domestic livestock, land-use changes, poaching and disease. They inhabit varied landscapes that range from steep montane forests in the Himalayas for Serow to Himalayan grasslands on steep slopes in the altitude range of 2500 – 5500 m asl for blue sheep to arid and semi-arid grasslands and dry deciduous forests for Chinkara.

The captive populations of Serow and Blue sheep have remained small (N < 20) and are unlikely to achieve the goal of maintaining demographically stable and genetically viable populations due to the lack of breeding pairs that can initiate rapid growth through reproduction. The Chinkara population has a population size that is appropriate for initiating rapid population growth. The unavailability of records on dates of entry, exit and parentages of a large proportion of specimens in all the three populations has constrained detailed demographic and genetic analysis.

Recommendations

Based on the information available it is recommended that additional specimens for Serow and Blue sheep may be acquired, preferably from the wild to kick-start these populations. Supplementation of wild origin founders and development of appropriate pairing choices may be followed for achievement of conservation goals for the population of Chinkara. Species appropriate housing and husbandry practices need to be adopted for the three species based on a review of existing husbandry practices that considers the natural history and behaviour of each species. Marking of all individuals to ensure accurate records that minimally include dates of entry and exit, parentage records and reproductive events of all specimens entering captivity should be maintained.

Family Bovidae: Sub-family Bovinae

Three species of sub-family Bovinae have been identified for the development and maintenance of studbooks; they include Gaur or Indian bison, Mouse deer and Four-horned antelope. Habitat loss, land-use changes and poaching are threats shared by the three species, while Gaur is also susceptible to all livestock diseases that compete with it for resources. Gaur inhabits evergreen, semi-evergreen and moist-deciduous forests and dry deciduous forests, while Mouse deer inhabits dense forested areas in tropical evergreen rainforests and deciduous forests that have dense understory and Four-horned antelope inhabits dry deciduous mixed savanna forests with limited human disturbance.

The captive populations of the three species in Indian zoos are demographically stable with large populations and a large proportion of specimens of reproductive age that are capable of ensuring rapid growth. The populations of Gaur and Mouse deer originate from small founder bases and consequently retain sub-optimal levels of genetic diversity while the population of Four horned antelope originates from 25 founders and retains a large proportion of the genetic diversity brought in by them.

Recommendations

The populations of the 3 species in Indian zoos are demographically stable; however, interventions aimed at increasing the genetic diversity and a more equitable representation of the founder genome in the population are necessitated by the unequal representation of the founder genome in the current population.

A large proportion of the populations of all three species include specimens of unknown lineage. The lineages can be identified using appropriate molecular genetics techniques thereby enabling the development and implementation of more effective population management plans and pairing recommendations.

Family Cervidae

The family Cervidae includes two species, Sangai and Swamp deer or Barasingha that have been identified for development of studbooks. Both species are habitat specialists and are threatened by loss of habitat, poaching, competition with livestock and disease. Additionally Sangai exist as a single population in their unique phumdi habitat in the Keibul Lamjao National Park. Sanagai is restricted to a small area of the Keibul Lamjao National Park in Manipur inhabiting wetland areas characterized by floating mats of soil and vegetation (Phumdis), patches with floating rooted vegetation, open water areas, small hillocks and shallow water areas. Swamp deer utilize variety of habitat types including open forest where grasses are present, with maximum abundance occurring in marshy and sandy grasslands.

The current sizes of the populations indicate that they have been successfully reproducing in captivity and with appropriate interventions can act as insurance populations for the two species. Based on records available an understanding of the demographic status of the captive Sangai population could be developed; however, lack of information of ancestries of specimens' limits genetic analysis, for Swamp deer information is available primarily in the form of an inventory limiting both demographic and genetic analysis of the populations.

Both populations originate from extremely small founder bases and are likely to retain limited genetic diversity, additionally the homozygosity of both the captive and free ranging populations of Sangai as suggested by Angom et al. (2017) further constrain the availability of new founders that can augment the limited genetic diversity present in the population.

Recommendations

Effective management of the captive populations of Sangai and Swamp deer requires intensive efforts aimed at:

Record keeping and marking: The zoos must ensure individual animal identification and effective record keeping for developing population management plans.

Ascertaining taxonomy: The species Swamp deer has been confirmed to include three distinct sub-species that are also geographically separated. It is imperative that an assessment of this distinctness be carried out for maintaining sub-species level integrity of the captive specimens of Swamp deer using molecular tools.

Assessment of genetic status: Limited information on parentage limits development of population management plans for the two populations in captivity. The use of appropriate molecular genetics tools to assess the genetic status of the captive population and understand relationships between individuals would assist in development of a population management plan.

Order Perissodactyla: Family Equidae and Family Rhinocerotidae

The odd toed ungulates include 2 species that have been identified for the development and maintenance of studbooks, these include the Indian wild ass belonging to the family Equidae and One-horned rhinoceros belonging to the family Rhinocerotidae. Indian wild ass is threatened by land use changes, infrastructural development and competition with livestock and disease outbreaks. One-horned rhinoceros is threatened by poaching and invasive species that result in decline of habitat quality of the species. Indian wild ass inhabits arid and saline thorn scrub in the Little Rann of Kutch with a preference for croplands during monsoon and winter. One-horned rhinoceros inhabits riverine grasslands in the alluvial floodplains that are interspersed with swamp patches dominated by emergent vegetation.

The populations of both Indian wild ass and One-horned rhinoceros have continued small sizes (N < 50) with captive births inadequately addressing losses due to mortality. The small size of the living populations despite

the majority of specimens being of reproductive ages limits the likelihood of the populations achieving conservation goals. The low reproductive output of Indian wild ass is indicative of shortcomings in husbandry practices adopted for its captive management. The continued small size of both populations and their small founder base has resulted in limiting mating choices and breeding between closely related individuals as is indicated by the values of mean inbreeding and population mean kinship, additionally, the small founder base is unequally represented in the populations.

Recommendations

The practices adopted for husbandry of Indian wild ass and One-horned rhinoceros need to be reviewed to identify shortcomings. These should be appropriately addressed along-with creation of additional infrastructure for housing the additional animals entering the population. The pairing choices as included in the respective studbooks should be adopted to ensure an equal representation of the founder genome in the captive populations.

Small Mammals

The species identified for development of studbooks also include two small mammals that have placed together though they do not share taxonomic affinities. These include the Red panda and the Indian pangolin. Both species are threatened by poaching with habitat loss being an additional threat. The Red panda inhabits mixed deciduous and conifer forests in the eastern Himalayas while the Indian pangolin inhabits variety of habitat types that include open grasslands, scrub and rain forests, and in human dominated landscapes. The status of the two species in Indian zoos based on information made available by holding zoos is provided in table 6.

Table 6: Status of Small Mammals identified for update/development of studbooks

Species	WPA 1972 Status	IUCN Red List Status	Status in Captivity in India (M/F/U/T)	Insts.
Small Mammals				
Order Carnivora: Family Ailuridae				
Red Panda (*Ailurus fulgens*)	Schedule I	Endangered	8/13/3/24	3
Order Pholidota: Family Manidae				
Indian Pangolin (*Manis crassicaudata*)	Schedule I	Endangered	3/10/2/15	2

The populations of Red panda and Indian pangolin are characterized by their small size, and limited reproductive output of the latter in captivity. The small population size of Red panda has resulted in limiting mating choices and breeding between closely related individuals. The poor reproductive output and low survivorship of Indian pangolin remains a cause of concern and limits population growth.

Recommendations

Free ranging populations of both species are susceptible to extinction threats as factors responsible for decline of *in-situ* populations remain operational. Intensive *ex-situ* efforts are therefore necessary to ensure maintenance of insurance populations.

It is suggested that the husbandry practices of both species be critically evaluated to ascertain causes of the poor recruitment in the populations. The populations need to be supplemented with additional animals of breeding age to kick-start the populations to enable them to achieve conservation goals. Shortcomings identified should be addressed before acquisition of additional wild origin specimens.

AVES

A total of eight avian species have been identified for development and maintenance of studbooks these include three members of the family Accipitridae (White Rumped Vulture, Long Billed Vulture and Slender Billed Vulture), four members of Phasianidae (Cheer Pheasant, Grey Peacock Pheasant, Himalayan Monal and Western Tragopan) and one species form family Columbidae (Nicobar pigeon). The status of the species is presented below as table 7.

Drastic declines of vultures in India have been recorded in the recent past. These have been attributed to the use of veterinary drug Diclofenac in cattle, besides decline in availability of carrion, carcass poisoning and pesticide poisoning. The populations of pheasants have been declining as a consequence of habitat fragmentation and degradation, poaching and human encroachments; while Nicobar pigeon is threatened by habitat destruction and poaching.

The preferred habitat of the three vulture species ranges from evergreen to dry-deciduous to semi-arid areas, the White Rumped Vulture and Long Billed Vulture preferring areas close to carcass dumping sites while Slender Billed Vulture prefers open or forested areas away from human settlements. Cheer pheasant inhabits a wide altitudinal range in the Western Himalayas in areas having steep slopes with scattered trees and shrubs, especially where rocky cliffs and ravines are present. Himalayan Monal is a high altitude species inhabiting steep slopes and cliffs with a rocky terrain interspersed with grass and wood patches. Western tragopan inhabit open moist deciduous and coniferous temperate forests with dense undergrowth at elevations of 2,400–3,600 m asl; while Grey peacock pheasants inhabit hilly terrain in tropical and sub-tropical montane and lowland moist, broad-leaved evergreen and semi-evergreen forests with dense under storey, including bamboo. Nicobar pigeon inhabit small tropical islands with dense coastal forests in the Indo-Australian realm using smaller islands during the breeding season while the larger islands with presence of large number of fruiting trees are preferred during the non-breeding season.

Table 7: Status of Species identified for update/development of studbooks

Species	WPA 1972 Status	IUCN Red List Status	Status in Captivity in India (M/F/U/T)	Insts.
Family Accipitridae				
White Rumped Vulture (*Gyps bengalensis*)	Schedule I	Endangered	17/15/120/152	8
Long Billed Vulture (*Gyps indicus*)	Schedule I	Endangered	19/21/147/187	7
Slender Billed Vulture (*Gyps tenuirostris*)	Schedule I	Endangered	6/5/28/39	1
Family Phasianidae				
Cheer Pheasant (*Catreus wallichi*)	Schedule I	Vulnerable	14/26/5/45	3
Grey Peacock Pheasant (*Polypectron bicalcaratum*)	Schedule I	Least Concern	11/5/0/16	6
Himalayan Monal (*Lophophorus impejanus*)	Schedule I	Least Concern	2/3/0/5	3
Western Tragopan (*Tragopan melanocephalus*)	Schedule I	Vulnerable	18/20/0/38	2
Family Columbidae				
Nicobar Pigeon (*Caloenas nicobarica*)	Schedule I	Near Threatened	0/0/30/30	1

Family Accipitridae

Analysis of the studbooks of the three species reveals the presence of large proportion of unsexed birds in the populations of all three species. The populations of Long billed vulture and Slender billed vulture have a significant proportion of birds hatched in captivity; however, for White rumped vulture reproduction has been limited and wild origin birds continue to form a major portion of the population in majority of the birds of wild origin; however, relatedness between individuals is not known.

Recommendations

The species are monomorphic and determination of gender is possible using molecular methods. All new wild origin birds should be suitably marked at the time of their entry into captivity and appropriate samples collected for determination of gender. Collection of samples and marking of birds already in captivity may be opportunistically carried out as and when they are handled. The housing and husbandry practices adopted for White rumped vulture need review and shortcomings if any, need to be addressed appropriately. Relatedness between individuals can be assessed by using appropriate molecular genetics analyses of biological samples collected for determination of gender and population management plans developed according to the findings.

Family Phasianidae

The populations of pheasants in captivity have consistently remained small (N < 50) with the exception of Cheer pheasant. Increase in number of specimens in all the populations is accounted for by captive hatches. Lack of information on life history events of specimens in the population of Himalayan monal limited a detailed demographic analysis. The populations of Cheer pheasant and Grey peacock pheasant consist of a large proportion of reproductively senescent birds; however, the population of Western tragopan includes 79% birds of reproductively active ages.

Lack of information on ancestries of individual specimens constrained the genetic analysis of all populations with the exception of Western tragopan that retains 87.26% of the genetic diversity originating from 8 founders, with the founder genome unequally represented in the population. The limited number of wild origin specimens and continued small size of the other populations are suggestive of the presence of low levels of genetic diversity present with closely related specimens.

Recommendations

Lack of records on individual life history events and parentage highlights the need for use of effective marking techniques matched with accurate record keeping to ensure development of effective population management plans for the species. The limited use of wild origin birds in the populations highlights the need for inclusion of additional wild origin specimens to kick-start the populations and to enhance the genetic variability present in the populations. The use wild origin birds acquired for the programs should be judiciously used based on an understanding of the population genetic structure of the populations using appropriate molecular genetics techniques.

Family Columbidae

The population was initiated with 6 birds and the current population includes their descendants. The population has continuously remained small (N < 50). A detailed demographic and genetic analysis of the population could however not be carried out due to lack of records on life-history events and lineages of individual specimens.

Recommendations

It is suggested that detailed records of life-history events of individuals/ groups need to be maintained through tagging of birds.

Biological samples can be collected at the time of tagging for molecular genetics studies for assessing:

- The sex of individual specimens.
- Relatedness between individuals and the heterozygosity retained by the existing population.

The information obtained from the molecular genetic studies can be used for developing pairing recommendations for the species in captivity and the level of supplementation required for maintaining desired levels of genetic heterozygosity.

1. INTRODUCTION

The current extinction crisis is largely an outcome of anthropogenic activities, and has been equated as the sixth mega-extinction crises since the advent of life on earth (Pimm, et. al. 2014). Intensive measures to protect habitats and ecosystems are in place globally, particularly in biodiversity hotspots. These efforts have a mixed effect, with efforts leading to successful conservation of several species/habitats while there are several others that continue to decline. For species whose declines cannot be addressed by *in-situ* measures, management in *ex-situ* facilities within or outside their natural range offers a last chance of survival. Such facilities besides maintaining *ex-situ* populations for insurance and reintroduction also function as centres of conservation education (WAZA, 2005). A major goal identified for operating zoos by the 'Recognition of Zoo Rules, 2013' is the supporting of *in-situ* conservation efforts in the country. The maintenance of sustainable demographically stable and genetically viable populations is the basis for achieving conservation goals of zoos

Sustainable Populations:

Ex-situ conservation is not merely the breeding and maintenance of threatened species in captivity; it is more about maintaining a sustainable population that is able to persist over a predetermined time-span/number of generations with resources made available for its conservation.

"Our current paradigm for managing essential populations is to minimize the rate of genetic decay (Lacy, 1994, 2009), slow adaptation to the captive environment (Frankham, 2008; Williams and Hoffman, 2009), and retain as many species-typical behavior as is practical (McPhee and Carlstead, 2010)."(Lacy, 2012)

The sustainability of a population greatly depends on the population size with larger populations having greater likelihood of being sustainable. (Willis and Wiese, 1993; Frankham et al., 2002).

Populations of species included under *ex-situ* conservation programs thus need to be genetically viable and demographically stable to ensure retention of evolutionary potential and adaptability to changing environmental conditions. Establishment and operation of effective *ex-situ* conservation programs involves collecting as many

unrelated founders as possible during the establishment phase and subsequent judicious management of this founder stock in a manner that minimizes relatedness in the population while maximizing reproductive output during the growth phase. The process of their establishment and management is summarized in Box and Figure 1.

Box 1: Phases of an ex-situ conservation program

Ex-situ conservation programs are a three-step process (figure 1) involving:

1. **Establishment phase:** Acquisition of animals from the wild and initiating captive populations.
2. **Growth phase**: Intensive management for achieving target population size and conservation goals.
3. **Maintenance phase:** Maintaining the population at the target population size and using surplus individuals for restocking/ reintroductions if conditions warrant.

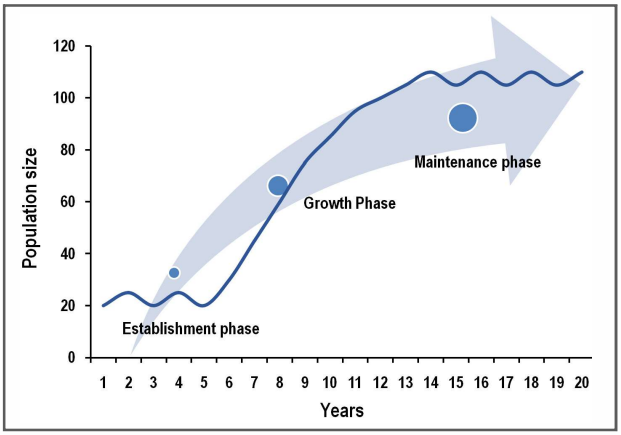


Figure 1.1: Stages in a conservation breeding program
Adapted from: Ralls and Ballou (2013)

Institutions involved in *ex-situ* conservation programs have limited resources and space available. The pooling together of resources and populations at different locations as a single population enables in overcoming these limitations. Achieving the twin goals of maintenance of genetic viability and demographic stability can thus be effectively ensured by pooling together records of individual animals maintained at each location and planning the management of populations based on analysis of this data. The pooled records on each individual specimen constituting the population in the form of studbooks provides an effective tool for management of *ex-situ* populations and the information required for developing them.

Studbooks are primarily a compilation and source of genealogical and demographic data on those individuals of genus, species, sub-species or otherwise defined taxon that make up the whole or part of a captive population (Olney, 2001).

Thus, studbooks contain relevant records of a single species maintained at multiple institutions unlike other zoo records that include information from a single location on the various species held by it and form the basis for scientific management of captive wildlife with an assessment of the genetic and demographic status providing insights into the management strategy to be adopted for ensuring sustainability (Olney, 2001).

Origin of Studbooks:

The origin of studbooks can be traced back to efforts in trying to improve livestock by selectively breeding individuals with preferred traits (Olney 2001). The development of civilization and increase in the number of animals led written records to replace verbal records. The first official studbook was the "General Studbook for Thoroughbred Horses" set up in England in 1791 (Olney 2001). Studbooks used in management of purebred stocks of livestock, horses etc. formed the toolkit of choice though with a reverse planning process (Olney

2001). For livestock management, the purity of stock through pairing of close relatives formed the strategy of choice while for populations of captive wildlife, the avoidance of consanguineous mating to maximize genetic diversity forms the priority (Olney 2001).

The use of studbooks for the management of captive wildlife began with the European bison (*Bison bonasus*). The species became extinct in the wild during the beginning of the 20th Century, prompting their *ex-situ* conservation. As the captive population was fragmented and distributed over a number of zoos, the zoo owners decided to initiate an international studbook for the species in 1923 to avoid a similar fate in captivity. A studbook for the species was published in 1932 and included all the available records of captive specimens from 1880 onwards and formed basis for further management of the population. It led to the realization of the necessity of studbooks for managing captive wildlife populations. Subsequently studbooks for various species were initiated (Olney 2001). Since 1965, studbooks have become an integral part of the management of endangered species living in zoological parks (Lackey 2010). As of 2011, there were 1350 regional and 190 international studbooks used for managing ex-situ populations (Anon. 2016).

Studbook Contents

Studbooks essentially contain all available information regarding a species in captivity besides information on the natural history and threats that the species faces. The major information includes:

- Records of all specimens/ individuals ever held in the geographic domain of the studbook. (The national studbooks contain all information made available on specimens held in Indian zoos and conservation breeding centres.)
- Known specimens present outside India, if relevant to the population.
- All direct ancestors of these specimens (regardless of location), tracing lineage to original wild-caught founders.
- All stillbirths, premature births and early deaths.

The developing of effective population management plans requires the following information to be maintained for each individual (Lackey, 2010):

Identifiers:	Any specimen identifiers (e.g. house names, local identification numbers, tags, transponders, tattoos, international studbook numbers etc.).
Events:	Date and location of birth, death and movement between institutions.
	Full transaction history (names of owners and dates of ownership changes); where the holding institution is not the owner of the specimen, the studbook should record both the actual location of the animal and the owner institution.
Location:	A specimen during the course of its life may be moved between multiple locations. The studbook should record the duration for which it stays at each location including dates of entry and disposal.
Sex:	Sex of the individual
Parentage details:	Identities of sire and dam (parentage information).

Disposal: Where animals have been obtained from or released into the wild, the studbook should record, if possible, details of the capture or release location; Date and location of death.

Death: Cause(s) of death and information on disposal of carcass.

Assumptions: Where inevitable assumptions have been made, such as date of birth or death, these should be clearly documented in a separate section (Scope of the studbook) if they pertain to the entire studbook or as remarks if they pertain to individual animals.

Use of Information Contained in Studbooks:

The information contained in studbooks on analysis using SPARKS and PMx provides an insight into the demographic and genetic status of the population. These are further used for development of species management plans that include pairing recommendations and the size of population to be maintained in captivity for achieving conservation goals.

The project

The Central Zoo Authority and Indian zoos have initiated a conservation breeding program for identified species in Indian zoos. As a part of this endeavour the Wildlife Institute of India was assigned the task of development and maintenance of studbook of identified 34 species (table 1.1) that are facing imminent extinction threats. The project was initiated in 2012 with the funding support of Central Zoo Authority. As a part of this project studbooks of 14 species for which studbooks were developed earlier, were updated while new studbooks of additional 20

Table 1.1: Species identified for development and maintenance of studbooks

Group	Species
Canids	*Canis lupus pallipes* (Indian wolf), *Canis lupus chanco* (Tibetan wolf), *Cuon alpinus* (Wild dog - Dhole)
Felids	*Panthera tigris tigris* (Bengal tiger) *Panthera leo persica* (Asiatic lion), *Panthera uncia* (Snow leopard), *Neofelis nebulosa* (Clouded leopard)
Primates	*Hoolock hoolock* (Hoolock gibbon), *Trachypithecus geei* (Golden langur), *Trachypithecus johnii* (Nilgiri langur), *Trachypithecus phayrei* (Phayre's leaf monkey), *Macaca silenus* (Lion tailed macaque), *Macaca leonina* (Pig-tailed macaque), *Macaca arctoides* (Stump-tailed macaque)
Ungulates	*Capricornis thar* (Serow), *Pseudois nayuur* (Blue sheep), *Gazella bennettii* (Indian Gazelle - Chinkara), *Bos gaurus gaurus* (Gaur – Indian bison), *Moschiola indica* (Mouse deer), *Tetracerus quadricornis* (Four-horned antelope), *Rucervus eldii eldii* (Sanagai), *Rucervus duvaucelii* (Swamp deer), *Equus hemionus khur* (Indian wild ass), *Rhinoceros unicornis* (One horned rhinoceros)
Small mammals	*Ailurus fulgens* (Red panda), *Manis crassicaudata* (Indian pangolin)
Vultures	*Gyps bengalensis* (White-rumped vulture), *Gyps indicus* (Long billed vulture), *Gyps tenuirostris* (Slender billed vulture)
Pheasants	*Catreus wallichi* (Cheer pheasant), *Polyplectron bicalcaratum* (Grey peacock pheasant), *Lopophurus impejanus* (Himalayan monal), *Tragopan melanocephalus* (Western tragopan)
Columbidae	*Caloenas nicobarica* (Nicobar pigeon)

Table 1.2: Species for which studbooks updated/ new studbooks developed.

Group	Studbooks updated	New studbooks developed
Canids	*Canis lupus chanco* (Tibetan wolf), *Cuon alpinus* (Wild dog - Dhole)	*Canis lupus pallipes* (Indian wolf)
Felids	*Panthera tigris tigris* (Bengal tiger) *Panthera leo persica* (Asiatic lion), *Panthera uncia* (Snow leopard), *Neofelis nebulosa* (Clouded leopard)	
Primates	*Hoolock hoolock* (Hoolock gibbon) *Trachypithecus geei* (Golden langur), *Trachypithecus johnii* (Nilgiri langur), *Macaca silenus* (Lion tailed macaque)	*Trachypithecus phayrei* (Phayre's leaf monkey), *Macaca leonina* (Pig-tailed macaque), *Macaca arctoides* (Stump-tailed macaque)
Ungulates	*Bos gaurus gaurus* (Gaur – Indian bison), *Equus hemionus khur* (Indian wild ass), *Rhinoceros unicornis* (One horned rhinoceros)	*Capricornis thar* (Serow), *Pseudois nayuur* (Blue sheep), *Gazella bennettii* (Indian Gazelle - Chinkara), *Bos gaurus gaurus* (Gaur – Indian bison), *Moschiola indica* (Mouse deer), *Tetracerus quadricornis* (Four-horned antelope), *Rucervus eldii eldii* (Sanagai), *Rucervus duvaucelii* (Swamp deer), *Equus hemionus khur* (Indian wild ass), *Rhinoceros unicornis* (One horned rhinoceros)
Small mammals	*Ailurus fulgens* (Red panda)	*Manis crassicaudata* (Indian pangolin)
Pheasants	*Polyplectron bicalcaratum* (Gray peacock pheasant)	*Catreus wallichi* (Cheer pheasant), *Lopophurus impejanus* (Himalayan Monal), *Tragopan melanocephalus* (Westrern tragopan)
Vultures		*Gyps bengalensis* (White-rumped vulture), *Gyps indicus* (Long billed vulture), *Gyps tenuirostris* (Slender billed vulture)
Columbidae		*Caloenas nicobarica* (Nicobar pigeon)

2. METHODS

The work of developing and maintaining studbooks of identified species was carried out by using the following methods.

A review of literature to understand the taxonomy, natural history, distribution, threats and conservation actions was carried out from available sources. The distribution, taxonomy, threats and conservation actions of the species as described in the IUCN Red list of threatened species formed the basis for descriptions included in the respective studbooks.

Data Collection

The presence of species and the number of individuals present in individual zoos was ascertained on the basis of year-wise inventory of animals present on the Central Zoo Authority website and the species holdings preset on the ZIMS platform of the species 360 website.

Questionnaires for collection of pedigree records for species held at the zoos were mailed with a request to provide relevant records. Additionally efforts by way of visits to zoos were carried out collect the pedigree records.

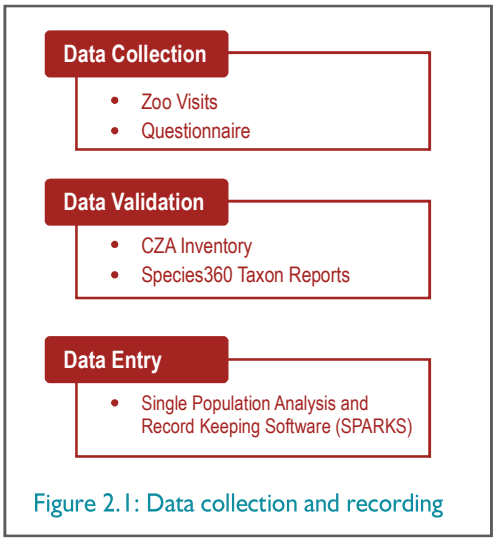


Figure 2.1: Data collection and recording

Recording Data

Data acquired by way of the above efforts was recorded in Single Population Analysis and Records Keeping Software (SPARKS) version 1.66 (ISIS 2004). Data of species for which information was received in the form of inventories was recorded on an annual pattern in a format based on the CZA inventory reports on an annual basis and recorded using MS-Excel.

Generating Reports and Data Analysis

The pedigree reports and historical listing of animals were generated using SPARKS, while data was exported to PMx version 1.0 for further analysis for understanding the demographic and genetic status of populations of identified species.

Demographic Analyses

Analysis of demographic parameters is based on dates of individual events in the life history of individual specimens. The analysis carried out provides information on the structure of the population i.e. its composition as indicated by census and age distribution. The vital rates indicated by natality/ fecundity and mortality enable an understanding of population growth rates and projections over defined periods of time. The understanding of the historical trends of the population, its current state and possible future fate of the population based on its past and present status enables defining realistic future population targets to ensure its long-term sustainability.

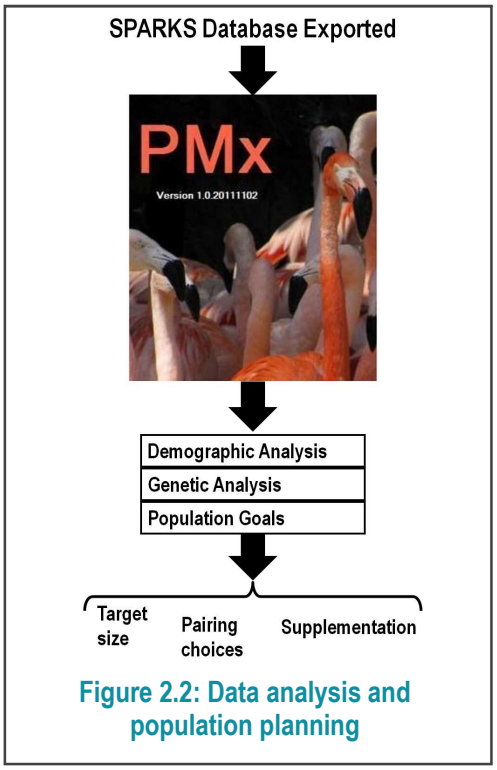


Figure 2.2: Data analysis and population planning

Genetic Analyses

The parentage record of individual specimens forms the basis for genetic analysis. The genetic status of the existing population is assessed based on the proportion of individuals of known ancestry and number of founders contributing genetically to the current population (death of lineages results in their loss from the population) in the current population. Additional parameters used are presented below:

Percent Ancestry Known: The accuracy of analysis is dependent on the quality of data available; similarly, for genetic analysis of studbook databases information of parentage of each individual animal is of critical importance as genetic analysis in studbooks is carried out based on Mendelian genetics. Populations for which percent ancestry known is less than 85% are said to be poorly managed and genetic analysis is of limited accuracy.

Gene Diversity Retained (GD): It is the level of expected heterozygosity in a population and ranges from zero to one. It is the principal measure of genetic diversity in populations. In conservation breeding, the proportion of heterozygosity of the source population that currently survives in the living population is of importance for maintaining the adaptive potential of the species (adaptive potential – ability of a species to adapt to changed environmental conditions).

Founder Genome Equivalents (FGE) : The number wild-caught individuals (founders) that would produce the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Average/ Mean Inbreeding: Inbreeding is defined as the breeding of closely related individuals. The degree to which an offspring is inbred is measured by its inbreeding coefficient 'f' which is the probability of receiving the same allele from each parent (i.e. the alleles are identical by descent). In managing captive wildlife populations, the objective is to retain the maximum possible genetic diversity therefore inbreeding avoidance is the strategy of choice.

Mean Kinship (MK) : The mean kinship coefficient between an animal and all animals(including itself) in the living, captive-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (captive-born) population relative to the founders and is also the mean inbreeding coefficient of progeny produced by random mating. Mean kinship is also the reciprocal of two times the founder genome equivalents: MK = 1 / (2 * FGE). MK = 1 - GD.

Effective Population Size (Ne): A key measure of the effective management of populations is their effective population size usually represented in studbooks as the ratio of the effective size to the census size (Ne/N). The value of Ne can theoretically range from zero to about twice the population's census size. In most captive populations, it is however, rarely above N. The ratio of effective population size to census size in captive populations ranges from 0.15 to 0.40 (average about 0.3) with species being

Population Planning and Pairing Recommendations

Establishing Population Targets: The demographic and genetic analysis carried out facilitates an assessment of the current population status. The demographic parameters used are the current population size, the generation time and the population growth rate. The genetic parameters used are the current genetic diversity in the population and the ratio of the census to the effective population size. These when analysed in combination provide an insight into the fate of the population over a predetermined time span. The results provide an insight into the likely size and the genetic diversity retained by the population at the end of the time span. Once an insight into the current status of the population is arrived the frequency and number of individuals to be supplemented and the minimum population size required for maintaining a demographically stable and genetically viable population can be arrived at.

Pairing Choices: Genetic analysis is used for making pairing recommendations (mating choices) for individual specimens. The preferred pairing choices are those that produce least related offspring with other members of the population i.e. the pairings should result in lowered mean kinship values, and have minimal inbreeding coefficients. Additional factors that govern the choice of mates are the feasibility of moving specimens between institutions and age of the specimens chosen. Movement of individuals over long distances is avoided while pairing between unproven breeders and old individuals is avoided.

3. STATUS OF IDENTIFIED CANIDS IN CAPTIVITY

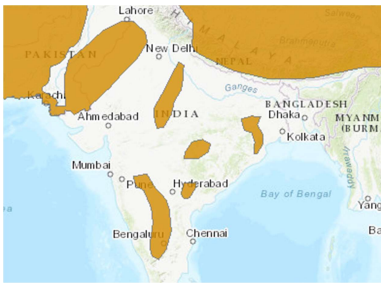
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Carnivora
Family	Canidae

Species

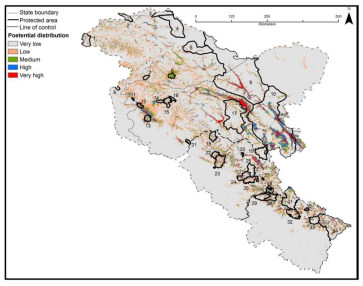
Canis lupus pallipes (Indian wolf)	*Canis lupus chanco* (Tibetan wolf)	*Cuon alpinus* (Dhole)

Distribution



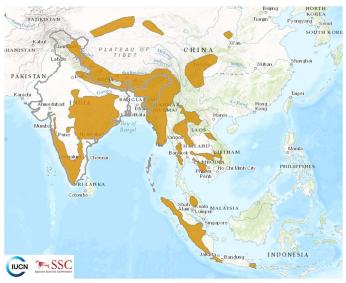
Mech and Boitani 2010

The subspecies *C. l. pallipes* has a wide distribution range, extending from India in the east to Turkey in the west, with populations reported from Pakistan, Iran, Iraq, Syria and Israel (Mendelssohn 1982, Shahi 1982, Mech and Boitani 2010). In India, they inhabit scrublands in three biogeographic zones that include the hot desert, the semi-arid zone and the Deccan plateau (Jhala 2013).



Habib et. al. 2012

Tibetan wolf have been reported to occur in the Trans-Himalayan regions of India (Fox et al. 1986; Chundawat 1992; Chundawat and Qureshi 1999). They have been recently sighted in the Trans-Himalaya region of Uttarakhand, i.e., in Nanda Devi Biosphere Reserve (BR) and Gangotri National Park (NP) (Bhattacharya and Sathyakumar, 2010). Sign surveys and interviews with local communities carried out by Habib et al. (2013) in the states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand suggest a patchy distribution.



Kamler et al. 2015

In India, the species inhabits southern part of the Indo-Gangetic plains, Eastern and Western Ghats and most parts of North-Eastern India including Arunachal Pradesh, Assam, Meghalaya, West Bengal. Dholes also occur in some parts of Ladakh and Kashmir. Recent taxonomic revisions identify two major sub-groups of the species rather than 11 subspecies attributed to it. The range of the first major subgroup extends from the south of Ganges to Myanmar while the second extends from the north of Ganges into north-eastern India, Myanmar, Thailand and the Malaysian Peninsula (Iyengar et al., 2005).

Threats

Livestock depredation by them has resulted in a negative perception leading to retaliatory killing by pastoralists across their range, thus effectively limiting recruitment and survival of populations (Habib et al., 2013). Pathogens such as canine parvovirus (CPV), canine distemper virus (CDV) and canine adenovirus (CAV) that cause diseases in dogs (Canis familiaris) and sympatric wild canid species are an additional threat (Laurenson et al., 1998; Belsare et al., 2014).

Retaliatory killing in association with increased anthropogenic activities in their habitat has impacted populations.

The species is threatened by loss of prey base (Durbin et al., 2004; Gopi et al., 2012), habitat loss and transformation (Kamler et al., 2015). Additionally, the species is vulnerable to multiple disease threats from domestic dogs; these include rabies, canine distemper, canine parvovirus and sarcoptic mange (Durbin et al., 2004).

Status and Conservation Actions

Canis lupus pallipes (Indian wolf)	*Canis lupus chanco* (Tibetan wolf)	*Cuon alpinus* (Dhole)
IUCN Red list considering the wide distribution range of the subspecies has listed it as a species of least concern (Mech and Boitani 2010); however, the Wildlife (Protection) Act of 1972 in view of the threats faced by the animal across its range in India places it in Schedule I	The species is listed in Schedule I Part I of the Wildlife Protection Act (1972) of India. Taxonomic uncertainties between Tibetan wolf and Himalayan wolf limit conservation measures at an international level.	It is listed under Schedule I of the Wildlife Protection Act (1972) of India and as endangered in the IUCN Red list of threatened species (Kamler et al., 2015).

Biological Attributes

Preferred Habitat

The Indian wolf inhabits areas dominated by scrub, grasslands and semi-arid pastoral agro-ecosystems (Jhala 2013); however, in the eastern parts of its range extending across parts of Odisha, Bihar and West-Bengal they are known to inhabit more humid low density forested habitats (Shahi 1982). The availability of undisturbed patches that offer shade during the day besides protection for whelping, denning and play areas for pups are crucial for habitat selection	The trans-Himalayan region characterised by low temperatures, and rainfall, limited floristic diversity and vegetation cover and low prey density (Rawat, 2008) is home to this apex predator (Habib et al. 2013). Field studies based on sign surveys in Nepal part of the trans-Himalayas revealed a preference for grasslands (68% of scats recovered) and a close association to pastoral communities with livestock with domestic livestock forming 65% of the prey base of the animal	They inhabit a variety of habitat types that include primary, secondary and degraded forms of tropical dry and moist deciduous forests, evergreen and semi-evergreen forests, dry-thorn forests, scrublands etc. In India, the species inhabits tropical dry and moist deciduous forest supporting adequate prey base (Karanth and Sunquist, 1995, 2000). In peninsular India, they inhabit dense forests and thick scrub jungles (Krishnan,1972; Davidar, 1975)

Food Habits

Canis lupus pallipes (Indian wolf)	Canis lupus chanco (Tibetan wolf)	Cuon alpinus (Dhole)
The small body size of Indian wolves allows them to sustain themselves on smaller ungulates, lagomorphs and rodents (Habib 2007). Wolves are capable of hunting prey much larger than themselves; this is achieved by hunting in packs, using different strategies like stalking and rushing or chasing.	Davidson et al. (2012) reported that on the Tibetan Plateau; plateau pikas (*Ochotona curzoniae*) represented as much as 50% of their diet. In Kargil and Drass areas of Jammu and Kashmir, Maheshwari et. al. (2010) recorded domestic and wild ungulates to be a major portion of their diet with wild rodents contributing significantly to food consumed.	The preferred prey consumed has been reported to vary at different locations; in Nagarahole, the body-mass of prey ranged from 31 kg to 175 kg in weight (Karanth and Sunquist 1995, 2000) with an average weight of 43 kg, while in Bandipur prey weighing less than 50 kg were preferred (Johnsingh, 1992). Recent studies at Kalakad-Mundanthurai Tiger Reserve by Selvan et al. (2013); a review of literature by Hayward et al. (2014) and in the Silent Valley National Park by Dar and Khan (2016) revealed sambar to be the principal prey species followed by spotted deer/ wild pig/ mouse deer and hare depending on the area.

Table 3.1: Reproductive attributes of identified canids

	Indian wolf	Tibetan wolf	Dhole
Age at first reproduction	18 months	Not well studied but assumed to be similar to gray wolf	1 – 1.5 years (Paulraj et al., 1992)
Mating season	October and November		
Gestation period	62 – 63 days		60-63 days
Litter size	2 to 6		5 to 8
Age at dispersal	18 months		

Table 3.2: Status of canids in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Indian wolf	10	26	19	16	60	17	38	35	24	97	12	39	33	16	88
Tibetan wolf	3	6	7	0	13	2	2	4	4	10	2	2	7	4	13
Dhole	4	5	3	0	8	7	30	21	7	58	7	65	38	0	103

Demographic Status

Historical population:

The first recorded entry of Indian wolf in captivity was in 1971, while Tibetan wolf and Dhole entered captivity in 1990 and 1985 respectively. Since their first recorded entry 223 Indian wolves, 75 Tibetan woves and 224 Dholes have been recorded in captivity that include 62, 3 and 26 animals respectively of wild origin. Captive born specimens have contributed to the growth in the populations of Indian wolf (161), Tibetan wolf (72) and Dhole (198) while at the same time deaths of 126, 61 and 121 animals respectively have been recorded.

Living Population:

The living population of Indian wolf, Tibetan wolf and Dhole include 89, 13 and 103 individuals in captivity respectively, of this 14 Indian wolf and 19 Dhole are wild origin animals while 75 and 84 specimens respectively and all specimens of Tibetan wolf are born in captivity. The populations include 12, 4 and 16 individuals of Indian wolf, Tibetan wolf and Dhole respectively that have contributed to their populations.

Age structure of the populations of Indian wolf and Tibetan wolf indicate the presence of majority of individuals to be of pre-reproductive and reproductive ages with 12% and 24% respectively having contributed to the population. Lack of information on life-history events of individuals of Dhole constrained detailed demographic analysis of the population.

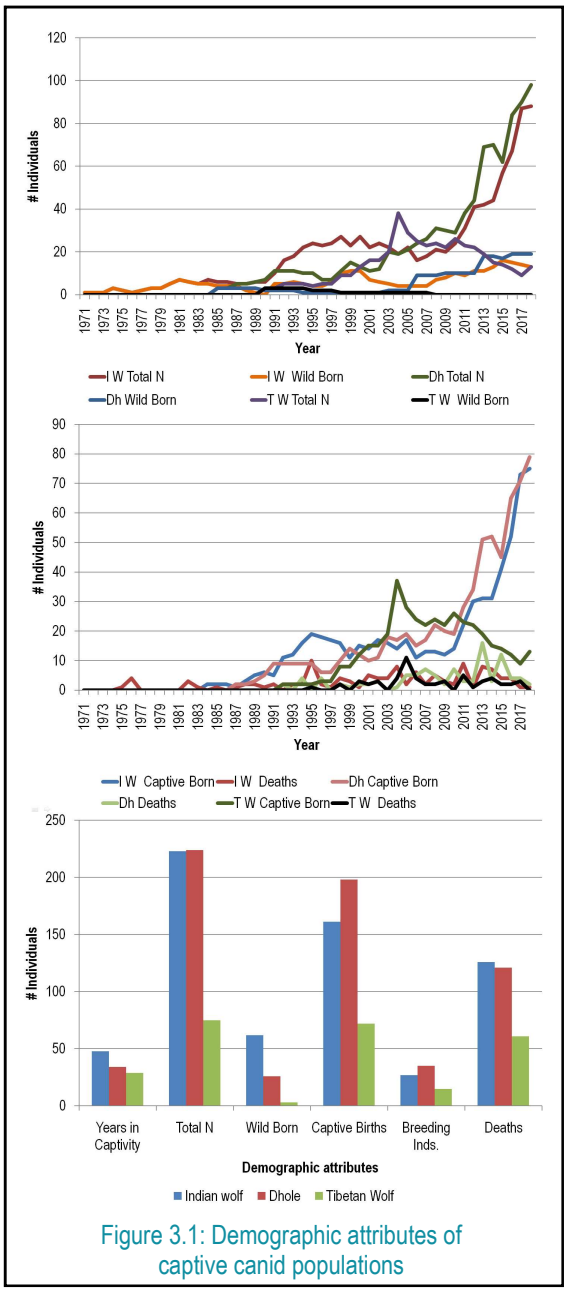


Figure 3.1: Demographic attributes of captive canid populations

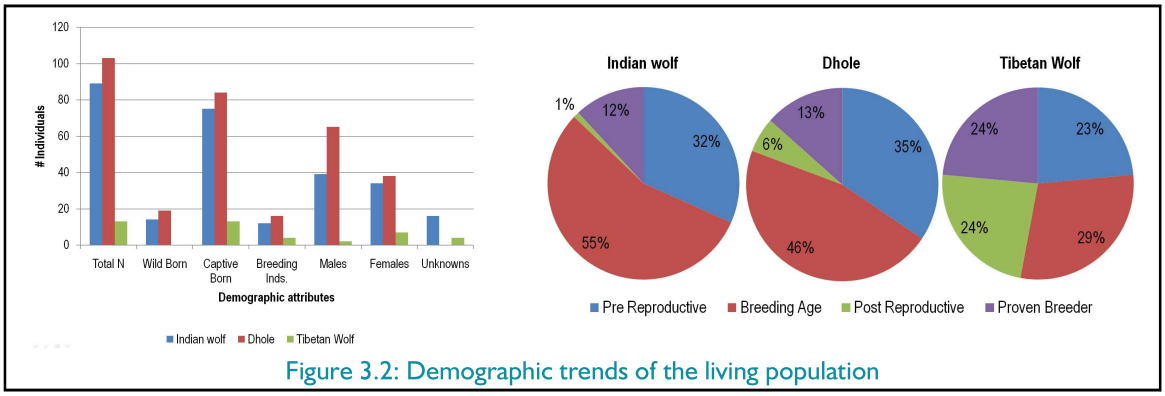


Figure 3.2: Demographic trends of the living population

Genetic Status:

Pedigree records were available for 54% of the Indian wolf while 25% animals had known pedigrees in the case of Dhole. The population of Tibetan wolf could not be traced back to wild origin animals due to lack of records on ancestries of animals. The current captive population of Indian wolf comprising of 89 animals originates from 8 founders, while that of Dhole population includes 103 animals and originates from 5 founders. Based on available records, the population of Indian wolf includes 34.63 living descendants while the population of Dhole includes 6.5 living descendants. The populations of Indian wolf and Dhole respectively have the founder genome equivalents of 3.39 and 2.18 founders in the current population.

Based on available records the Indian wolf and Dhole respectively have retained 85.27% and 77.07% of the genetic diversity of the founders used to establish them. The coefficient of mean inbreeding of the Indian wolf population is 0.0298 and the mean kinships of Indian wolf and Dhole respectively are 0.1473 and 0.2293; while approximately 12% and 15% of the population are contributing to the population.

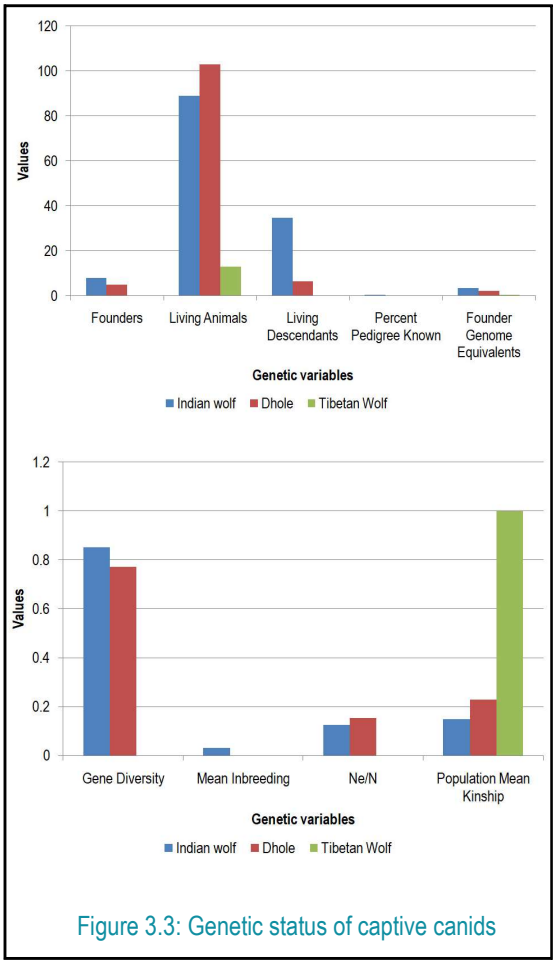


Figure 3.3: Genetic status of captive canids

Salient Features of the Populations of Canids in Captivity

The populations of Indian wolf and Dhole include adequate specimens to ensure their rapid population growth, whereas the population of Tibetan wolf continues to remain small (N < 20).

Inadequate record keeping with limited information available on dates of life-history events of individual specimens and their lineages limited accurate demographic and genetic analysis for all the three species/ sub-species.

The populations of Indian wolf and Dhole contain limited genetic diversity that is non-representative of the free ranging populations while for Tibetan wolf no specimens could be traced to wild origin parents.

The proportion of effective to census population size is small for Indian wolf and Dhole and indicates a limited proportion of the population to be present in the breeding pool.

Individuals in the populations of Indian wolf and Dhole are closely related to each other as is indicated by the values of mean kinship.

Recommndations

The population of Tibetan wolf needs to be supplemented with wild origin animals to ensure a representation of the wild genes in the captive population and to ensure a population size that can kick-start the population.

Specimens need to be marked using appropriate marking techniques for individual identification to ensure accurate record keeping and implementation of the breeding recommendations.

The populations of Indian wolf and Dhole need to be supplemented with wild origin founders to ensure the adequate representation of the genetic diversity present in the free-ranging populations.

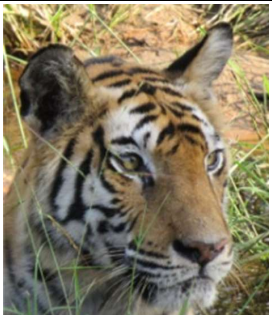
The individuals used for supplementation should target lineages that are over-represented in the current population. The use of relevant molecular genetics tools is recommended for identifying lineages for supplementation.

4. STATUS OF IDENTIFIED FELIDS IN CAPTIVITY

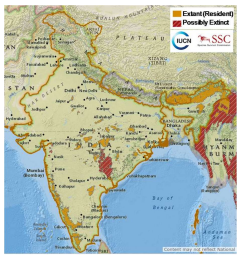
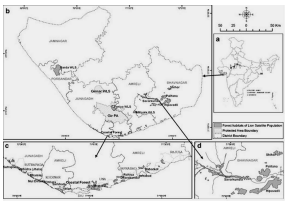
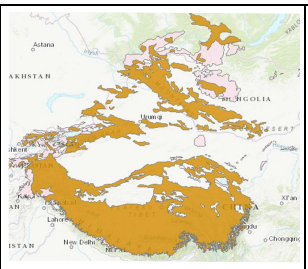
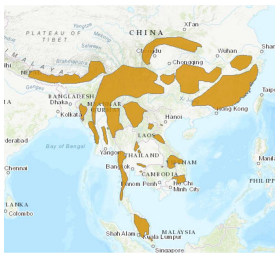
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Carnivora
Family	Felidae

Species

Panthera tigris tigris (Bengal tiger)	*Panthera leo persica* (Asiatic lion)	*Panthera uncia* (Snow leopard)	*Neofelis nebulosa* (Clouded leopard)
			

Distribution

			
Goodrich et al. 2015	Meena 2009	McCarthy et al. 2017	Grassman et al. 2016
India, Nepal, Bhutan and Bangladesh (Chundawat et al. 2015). In India they range from Lesser Himalayas, Gangetic Plains, Central India, Eastern Ghat, Western Ghat, North-eastern hills, Brahmaputra Plains and Sunderbans (Goodrich et al. 2015).	The sub-species have been reduced by hunting and habitat loss to a single population in the Gir forests of Gujarat (Chellam and Johnsingh 1993).	Widely distributed across central- Asia in twelve countries; namely Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Russia, Tajikistan, and Uzbekistan. The core areas include mountainous regions in Altai, Tian Shan, Kun-Lun, Pamir, Hindu Kush, Karakorum and Himalayas (Mallon 1985; Fox 1994; Schaller, 1998; McCarthy 2000; McCarthy et al. 2003).	From eastern and southern foothills of the Himalayas in Nepal (Dinerstein and Mehta 1989), through Bhutan and India (Arunachal Pradesh, Sikkim; Assam) (Mishra et al. 2006) south to Myanmar, southern China, Taiwan, Vietnam, Laos, Thailand, peninsular Malaysia (Azlan and Sharma 2006; Wilting et al. 2006) and Cambodia (Sunquist and Sunquist 2002).

Threats

Panthera tigris tigris (Bengal tiger)	*Panthera leo persica* (Asiatic lion)	*Panthera uncia* (Snow leopard)	*Neofelis nebulosa* (Clouded leopard)
Tigers across their distribution range are threatened by extensive poaching, habitat destruction due to development of linear infrastructure. It is also responsible population fragmentation leading to reduced gene-flow (Goodrich et al. 2015; Natesh et al. 2017).	The species currently exists as a single population, and are vulnerable to extinction from random catastrophes.	Poaching, retaliatory killing associated with livestock depredation and habitat loss due to the high density of livestock all threaten the long-term viability of Snow leopard in various parts of its range (Wang 1998; McCarthy and Chapron 2003; Hussain 2003; Din and Nawaz 2011).	The species is threatened by habitat destruction and degradation resulting in prey-base reduction, and poaching for trade in body parts and pelts. The animals are also killed for meat for exotic dishes throughout Asia and Europe (Low 1991, Nowell and Jackson 1996, Hearn et al. 2008).

Status and Conservation Actions

It is protected under the Schedule I, Part I of the Wildlife (Protection) Act, 1972, listed as endangered under IUCN Red data list (Chundawat et al. 2011; Goodrich et al. 2015), and is placed under Appendix I of CITES.	Listed as endangered under the IUCN Red List, 2008 (Breitenmoser et. al. 2008). CITES Appendix I and Schedule I of the Wildlife Protection Act (1972) GOI.	Protected in India under the Wildlife (Protection) Act of 1972 as well as under the Jammu and Kashmir Wildlife (Protection) Act of 1978, and is listed in Schedule I in both acts. IUCN Red List of Threatened Species lists it as Vulnerable (McCarthy et al. 2017); while CITES places it in Appendix I	IUCN Red List of Threatened Species lists it as Vulnerable (Grassman et al. 2016) It has been listed in Appendix I of CITES (UNEP-WCMC, 2009). In India it is listed in Schedule I of the Indian Wildlife (Protection) Act, 1972.

Biological Attributes

Preferred Habitat

Occur in thorny, tropical dry and moist deciduous forest, evergreen and semi-evergreen forest, and mixed sub-tropical forests on foothills of Himalayas. They are also found in riparian terai grasslands and swampy mangrove forests	The Gir landscape of Gujarat has a dry deciduous forest cover interspersed with moist mixed riverine valley forest patches along the perennial rivers and tropical thorn forest (Berwick 1976). They remain in cooler mixed forest riverine patches during day time and emerge out when temperatures and human activity are lower (Jhala et. al. 2009)	Snow Leopards inhabit alpine and sub-alpine ecological zones (McCarthy et al. 2003). The habitat preference of Snow leopards is guided by the presence of sheltered places for bedding sites, close to ridgelines, stream-beds and other linear features that are used for travelling around their home range and prey availability (Chundawat 1991; Jackson 1996).	Preferred habitat of the species is dense evergreen forest (Fletchall 2000); however they are also reported from other habitats, like, scrub, grassland, dry tropical forests, mangrove swamps, hill evergreen forest and mixed deciduous forests (Nowell and Jackson 1996). They are found in the Himalayas up to 2,500 - 3,000 m.

Food Habits

Panthera tigris tigris (Bengal tiger)	*Panthera leo persica* (Asiatic lion)	*Panthera uncia* (Snow leopard)	*Neofelis nebulosa* (Clouded leopard)
Opportunistic predators with a diverse prey base that includes sambar, chital, barasingha/swamp deer, wild boar, hog deer, barking deer, nilgai/blue bull, chousingha, chinkara, black buck, gaur, wild buffalo serow porcupine, Hanuman langur, rhesus macaque, bonnet macaque, peafowl. Apart from the wild prey, domestic cattle constitute a large part of their diet.	Chital and Sambar are the preferred prey species (Chellam 1993; Khan 1994). they also show a significant dependence on domestic livestock outside protected areas (Meena et al. 2011). A recent study by Chakrabarti et al. (2016) indicates that lions have a higher preference for medium sized prey rather than the earlier reported preference for large sized prey.	The preferred prey includes medium-sized ungulates (blue sheep, Himalayan tahr, musk deer and livestock). Smaller prey like rodents, mustelids, and canids and game birds are also a part of their diet (Schaller 1977; Mallon 1984; Schaller et al. 1988; Heptner and Sludskii 1992; Oli et al. 1993; Chundawat and Rawat 1994; Jackson 1996; Bagchi and Mishra 2006).	They prey on primates such as pig-tailed macaques, slow loris and gibbons in Thailand while; Muntjac and Argus pheasant form the main prey in Nepal (Nowell and Jackson 1996, Grassman et al. 2005). In Malaysia, the prey species includes palm civets, gray leaf monkeys, birds, squirrels, fish, porcupines, sambar, barking deer, mouse deer, and wild boar (Sunquist and Sunquist 2002).

Table 4.1: Reproductive attributes of identified felids

	Bengal tiger	Asiatic lion	Snow leopard	Clouded leopard
Age at first reproduction	Free ranging: (♂) 4.8 years (♀) 3.8 years	Free ranging: (♂)5-8 years (♀) 4 years Captivity: (♂) 3-4 years (♀) 2-3 years	2-3 years	Free ranging: 2 years
Gestation period	106 -112 days	116 days approx	93-110 days	89.2 days
Litter size	Ranging from 1 – 7 cubs (mostly 2-4)	Ranging from 1 – 5 cubs	Average=2-3; range= 1-5 (in wild); Average=2.2; range= 1-4 cubs, 2.2 (in captivity)	Ranging from 1 – 3 cubs

Table 4.2: Status of identified felids in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Bengal tiger	10	100	89	0	189	50	173	174	2	349	50	186	178	1	365
Asiatic lion	16	90	94	0	184	31	91	107	12	209	28	89	104	0	193
Snow leopard	2	4	8	0	12	2	3	9	2	14	2	4	9	0	13
Clouded leopard	3	9	5	0	14	5	10	7	0	17	5	9	7	0	16

Demographic Status

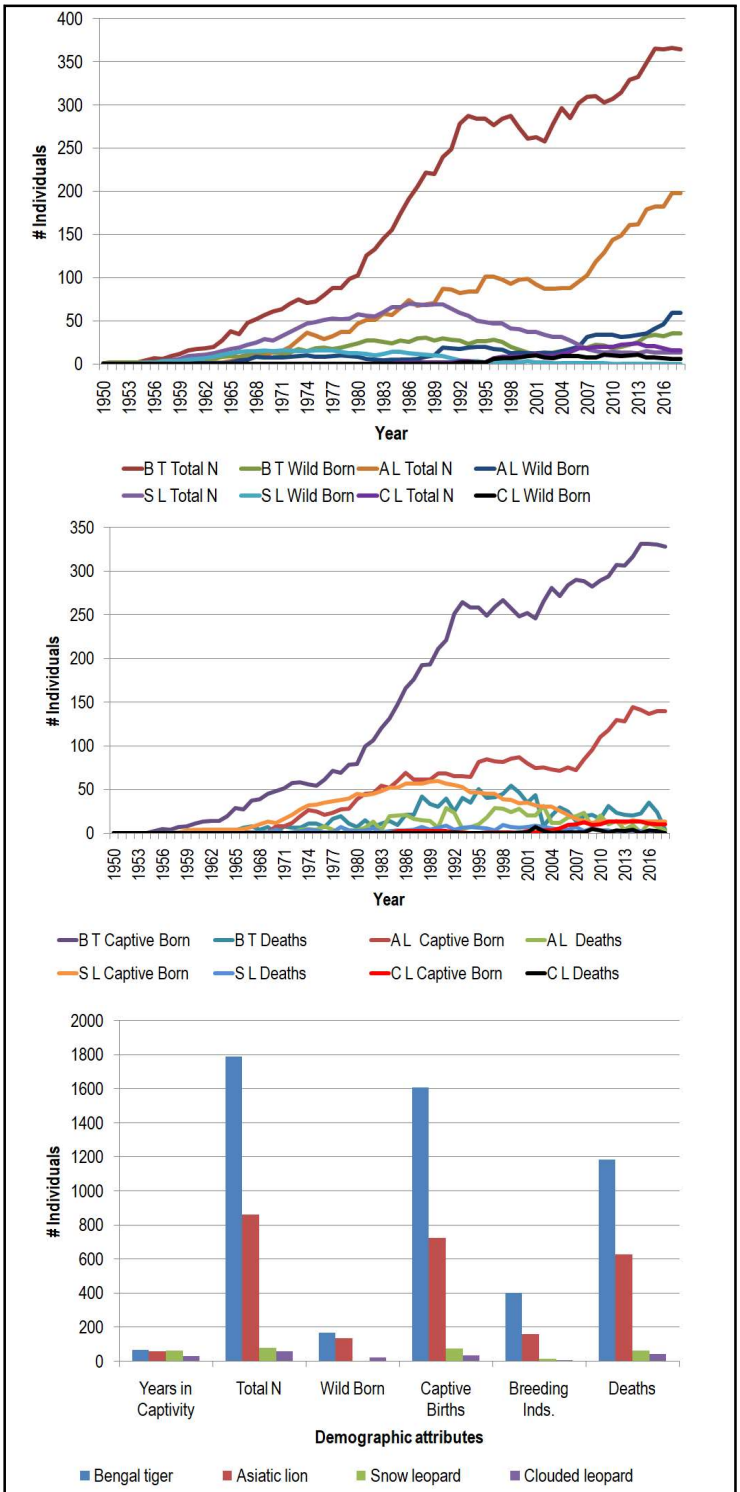


Figure 4.1: Demographic attributes of the historical population of captive felids

Historical Population:

The first recorded entry of Bengal tiger in captivity was in 1950, while the first records of Asiatic lion, Snow leopard and Clouded leopard in captivity were in 1958, 1986 and 1985 respectively. Since then a total of 1791, 861, 77 and 59 specimens of respectively have been reported in Indian Zoos; these include 169, 136, 2 and 24 wild origin animals respectively that have entered captivity. During the same period 1607 (Bengal tiger), 725 (Asiatic lion), 75 (Snow leopard) and 35 (Clouded leopard) births have been reported while deaths of 1186, 628, 64 and 43 specimens respectively have occurred. The populations include 404 (Bengal tiger), 160 (Asiatic lion), 16 (Snow leopard) and 10 (Clouded leopard) individuals in Indian zoos that have contributed to the population.

Living Population:

The current population of Bengal tiger, Asiatic lion, Snow leopard and Clouded leopard has been reported as 365, 193, 13 and 16 respectively based on data made available by holding zoos, this includes 35, 59, 0 and 6 respectively of wild origin while the remaining are born in captivity. The populations include 71, 49, 3 and 1 specimens of Bengal tiger, Asiatic lion, Snow leopard and Clouded leopard respectively that have contributed to the population.

The age structure of Bengal tiger indicates the presence of 13 specimens of pre-reproductive age, 349 of reproductive age of which 71 have contributed to the population, while 3 specimens have reached reproductive senescence. The population of Asiatic lion includes 2 specimens of pre-reproductive age, 185 of reproductive age of which 49 have contributed to the population, while 6 specimens have reached reproductive senescence. The population of Snow leopard includes 7 of reproductive age of which

3 have contributed to the population, while 6 specimens have reached reproductive senescence, while that of Clouded leopard includes 6 specimens of pre-reproductive age 7 of reproductive age of which 1 has contributed to the population while 3 specimens are reproductively senescent.

Genetic Status:

The living population of Bengal tiger includes 365 specimens originating from 36 founders has 239.45 living descendants that can be traced back to these founders. Records from holding zoos were available for 76% of these specimens. The population retains 90% of the genetic diversity introduced by the founders, with the genome of 5.06 founders present in the population that has resulted in a mean inbreeding coefficient of 0.2054 and mean kinship of 0.0987. Approximately 21% percent of the population is in the reproductive pool. The living population of Asiatic lion includes 193 specimens and originates from 40 founders with 127 living descendants that can be traced back to these founders. Records from holding zoos were available for 96.9% of these specimens. The population retains approximately 96% of the genetic diversity introduced by the founders, with the genome of 11.34 founders present in the population that has resulted in a mean inbreeding coefficient of 0.0408 and mean kinship of 0.0441. Approximately 18% percent of the population is in the reproductive pool.

The living population of Snow leopard includes 13 specimens originates from 40 founders and has 11 living descendants that can be

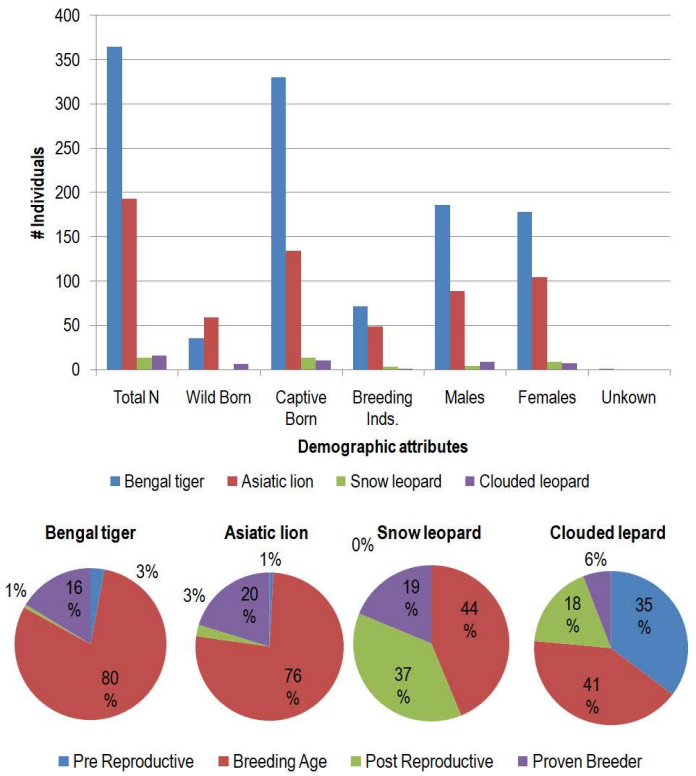


Figure 4.2: Demographic status of the living population

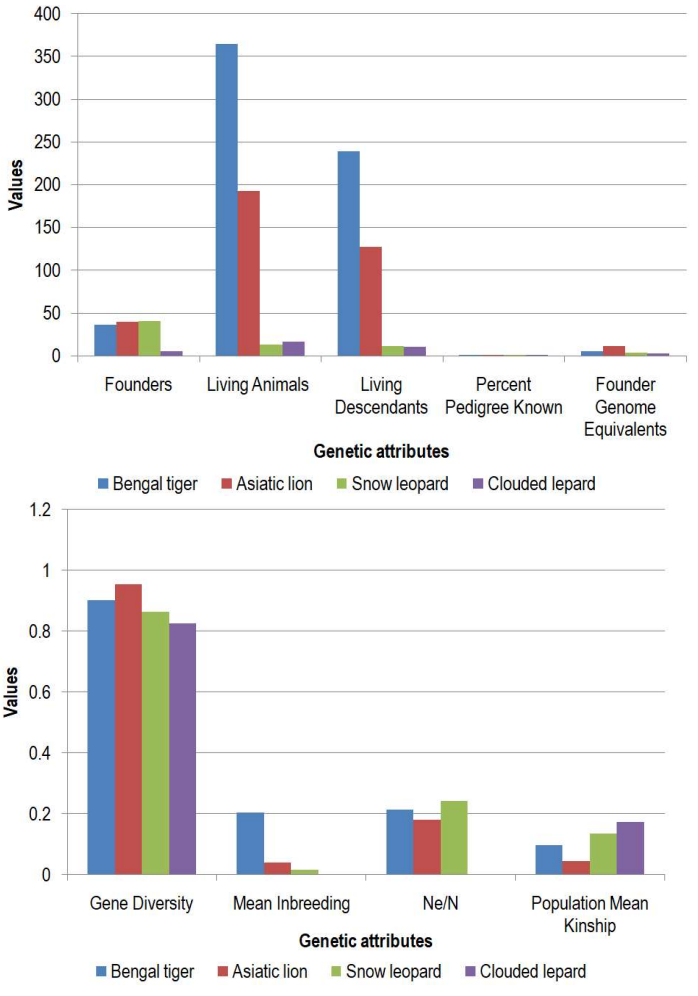


Figure 4.3: Genetic status of the living population

traced back to these founders. Records from holding zoos were available for 85% of these specimens. The population retains approximately 86.54% of the genetic diversity introduced by the founders, with the genome of 3.72 founders present in the population that has resulted in a mean inbreeding coefficient of 0.0168 and mean kinship of 0.1346. Approximately 25% percent of the population is reproductively active.

The living population of Clouded leopard includes 16 specimens originates from 5 founders and has 11 living descendants that can be traced back to these founders. Records from holding zoos were available for all the specimens. The population retains approximately 83% of the genetic diversity introduced by the founders, with the genome of 2.86 founders present in the population with a population mean kinship of 0.1747.

Salient Features of the Populations of Identified Felids

The captive populations of Bengal tiger and Asiatic lion are characterized by their large size, while those of Snow leopard and Clouded leopard have consistently remained small (N < 50). The populations of the former two also include a majority of specimens of reproductive ages the same remains extremely small for the latter two and unlikely to initiate rapid growth in these populations. Further the number of specimens that actually contributed to the populations remains extremely small for the Snow leopard and Clouded leopard populations.

The captive populations of Bengal tiger and Asiatic lion are characterized by the presence of a representative founder population that can address genetic concerns as a consequence they retain significant proportion of the genetic diversity acquired from these founders. The Snow leopard population originates from a large founder base, while that of Clouded leopard originates from a small founder base.

A cause for concern in the populations of Bengal tiger and Asiatic lion is the unequal representation of the founder base in the living population as is indicated by the values of founder genome equivalents. Additionally the population of Bengal tiger includes closely related individuals as is indicated by the high values of the mean inbreeding coefficient. The populations of Snow leopard and Clouded leopard in addition to their small founder bases include specimens that are closely related to each other as is indicated by the values of population mean kinship. Further, the founder base is unequally represented in the current population as is indicated by the values of founder genome equivalents.

Recommndations

Based on the above findings the following are suggested:

Additional specimens of Snow leopard and Clouded leopard should be acquired and made available to zoos that have appropriate housing facilities for the species. The acquisitions may be through import of animals from zoos outside India or capture of wild origin specimens.

For the population of Bengal tiger and Asiatic lion attempts at equalizing the founder genome in the current population may be made by pairing unrepresented and under represented with the existing specimens of over-represented lineages. The same considerations may be used for equalizing the representation of the founder genome in the populations of Snow leopard and Clouded leopard.

5. STATUS OF IDENTIFIED PRIMATES IN CAPTIVITY

5.1 Status of Hoolock Gibbon (*Hoolock hoolock*) in Captivity

Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Hylobatidae

Species

Hoolock hoolock (Hoolock gibbon)

Distribution

They have distribution range extending from eastern Bangladesh, through the north-eastern Indian states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, and north-western part of Myanmar (west of the Chindwin River). The distribution in India was believed to be restricted to south of the Brahmaputra and east of the Dibang (Dingba Qu) rivers (Choudhury 2001). However, studies by Das et al. (2006) have recorded the occurrence of the eastern species (*Hoolock leuconedys*) from Lohit district of Arunachal Pradesh, India.

Brockelman et al. 2008

Threats

Threatened by the destruction, degradation and fragmentation of forests for agriculture, plantations, logging, fuel wood collection, and development projects such as mining, roads, and railways (Chetry et al. 2007);and poaching for bush meat and trade (Srivastava 1999; Choudhury 2006).

Status and Conservation Actions

The species is protected under Schedule I, of the Indian Wildlife (Protection) Act 1972. It is categorized as 'Endangered' in the IUCN Red List Criteria, 2009.

Biological Attributes

Preferred Habitat

Inhabit mature forest; tropical evergreen forest, the wetter tropical semi-evergreen forests, sub-tropical monsoon evergreen broadleaf forests, and sub-tropical evergreen broadleaf hill or mountain forests. Western hoolock gibbon home ranges include woodlands or orchards, in the villages surrounding Nokrek National Park in the Garo Hills, Meghalaya, and in the Barikuri area in Tinsukia district of eastern Assam (Chetry et al. 2007; Choudhury 2001; Kakati 1997) and prefer the mixed patches and pockets of evergreen forests (Choudhury 2009).

Food Habits

All gibbons are fruit-pulp specialist feeders (Chivers 1984). Tilson (1979) noted that hoolock gibbons used 43 species of plants as a source of food, whereas up to 101 species were recorded by Ahsan (1994). A variety of food species including *Artocarpus chapalasha*, *Bixa orellana, Dipterocarpus spp., Syzygium spp., Mangifera sylvatica, Protium serratum, Entada spp*., *Ficus spp.*, and *Lagersrtoemia speciosa*, have been reported for hoolocks in Bangladesh (Muzaffar et al. 2007).

Table 5.1.1: Reproductive attributes of Hoolock gibbon

Age at sexual maturity	Gestation period	Birth seasonality	Inter-birth interval	Reproductive tenure
6-8 years (Tilson 1979)	180-240 days (Ahsan 2000)	November to March (Sati and Alfred 2001)	2.5–3 years (Cunningham and Mootnick 2009)	10-20 years from the age of sexual maturity (Das et al. 2005)

Table 5.1.2: Status of Hoolock gibbon in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Hoolock gibbon	5	16	8	5	29	9	24	17	6	47	9	25	16	7	48

Demographic Status

Historical Population

A perusal of figure 5.1.1 indicates that the first recorded entry of the species in captivity was in 1980 with a total of 121 specimens recorded in 9 Indian zoos. This includes 101 wild origin specimens, and 18 individuals that have contributed to the population. Deaths of 71 specimens have been reported since the first recorded entry.

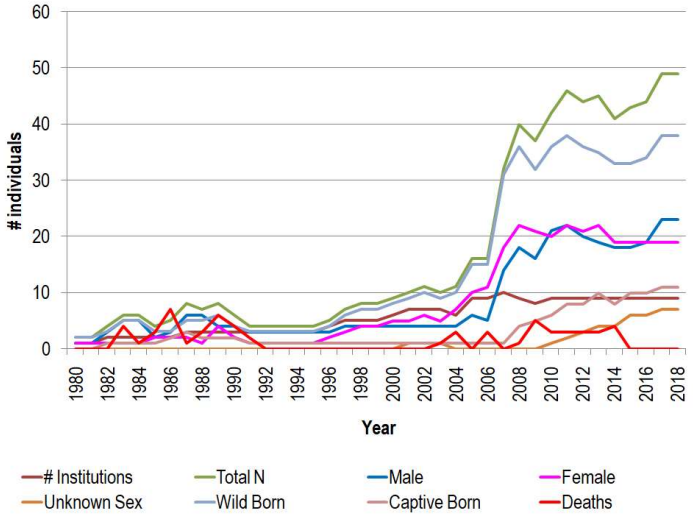


Figure 5.1.1: Historical population trends

Living Population

The living population includes 48 specimens housed at 9 Indian zoos of this 39 specimens are of wild origin and 9 individuals have contributed to the population. A perusal of Wildlife Institute of India (2018) reveals that a majority of these specimens are housed at 2 locations.

A perusal of figure 5.1.2 indicates that 51% of the population is of reproductive age; however, only 16% have contributed to the population. The population also includes 25% specimens of pre-reproductive ages and 9% individuals that are reproductively senescent.

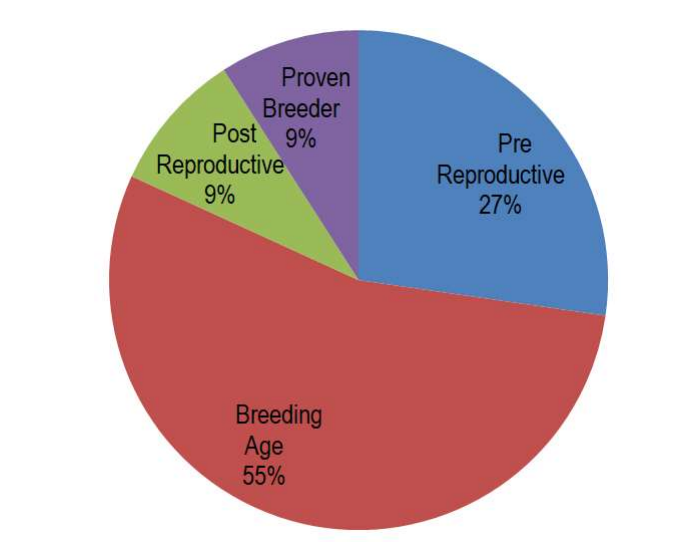


Figure 5.1.2: Demographic status of the living population

Genetic status

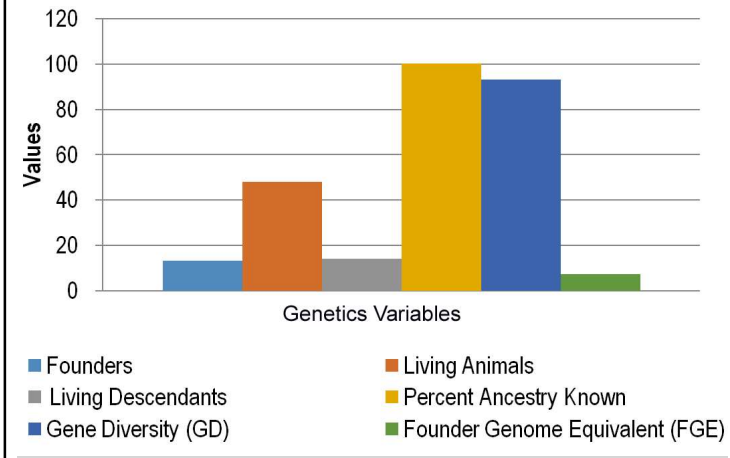


Figure 5.1.3: Genetic status

The living population of 48 individuals originates from 13 founders and has 14 living descendants that originate from these founders. The population retains a significant proportion (93%) of the genetic diversity of these founders. The founder genome is however, unequally distributed as is indicated by the value of founder genome equivalents (FGE = 7.19). The ancestry of all captive specimens has been recorded and a perusal of Wildlife Institute of India (2018) indicates that specimens in the population are distantly related to each other (population mean kinship = 0.0695).

Salient Features of the Captive Population

The population has remained continuously small (N < 50) in captivity and the living population includes a large proportion of specimens of reproductive age; however only a small proportion are actually reproducing. It originates from 13 founders and retains 93% of their genetic diversity that is unequally represented in the population.

The limited reproductive output of the population suggests of shortcomings in the housing and husbandry practices adopted for managing the species in captivity.

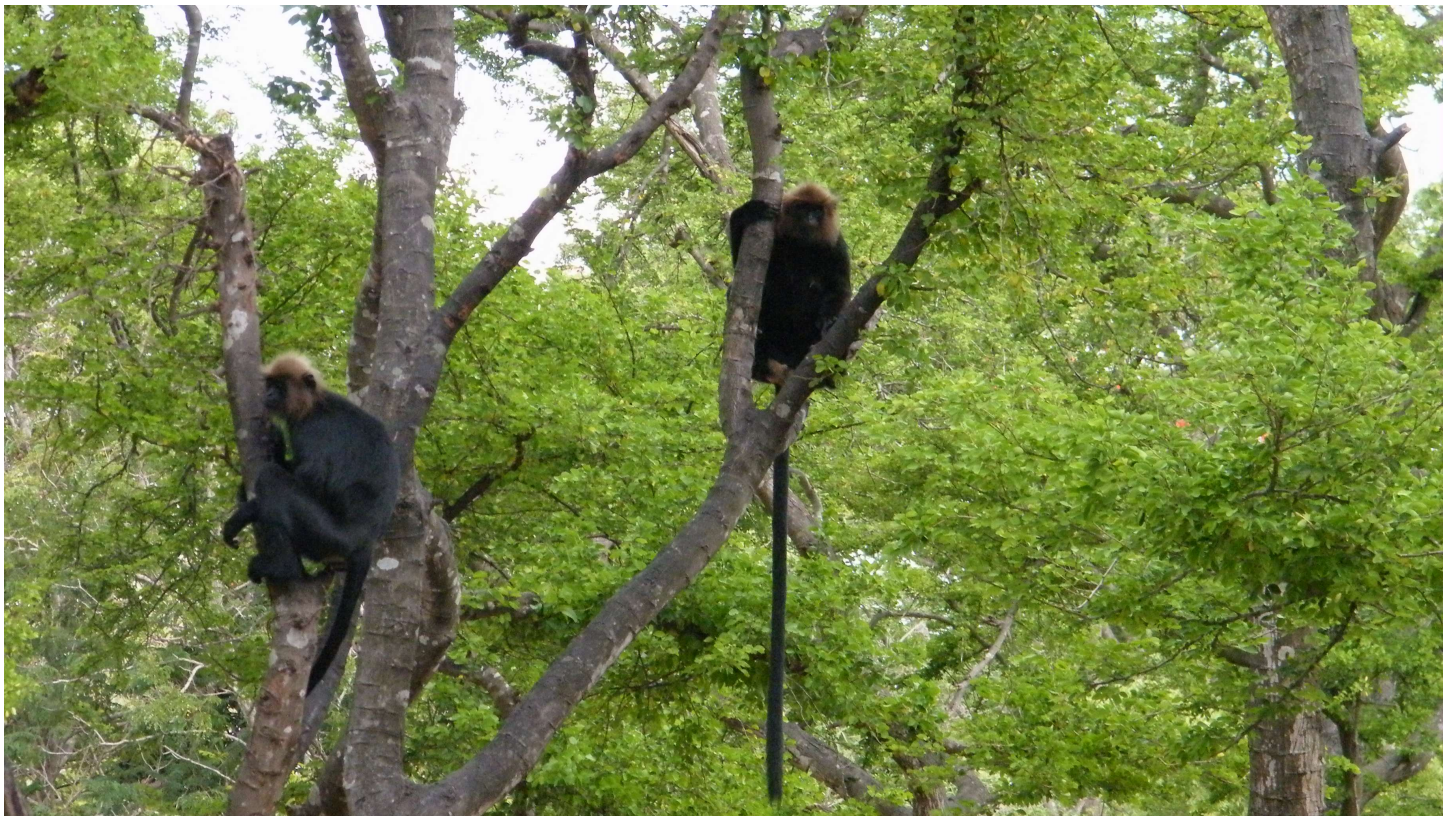
Recommendations

A review of the existing housing and husbandry practices adopted for managing the species in captivity needs to be undertaken based on the habitat requirements and behaviour of the species.

It is also essential to equalize family sizes and ensure an equal representation of founder animals to retain the maximum possible genetic diversity in the captive population.

The formation of breeding pairs as suggested in the breeding recommendations should be carried out with appropriate socialization prior to the mating season. As a prerequisite towards ensuring effective socialization, all new introductions should be in controlled conditions and supervision.

5.2 Status of Identified Leaf Monkeys in Captivity



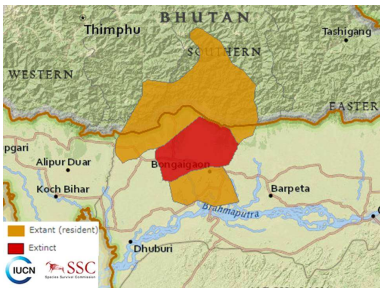
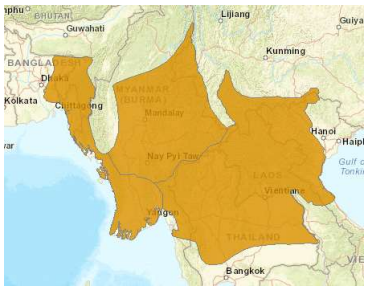
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Cercopithecidae
Sub-Family	Colobinae

Species

Trachypithecus geei (Golden Langur)	*Trachypithecus johnii* (Nilgiri langur)	*Trachypithecus phayrei* (Phayre's leaf monkey)
		

Distribution

Trachypithecus geei (Golden Langur)	*Trachypithecus johnii* (Nilgiri langur)	*Trachypithecus phayrei* (Phayre's leaf monkey)
		
Das et al. 2008	Singh et al. 2008	Bleisch et al. 2008
Restricted range in southern Bhutan and a small forest belt in western Assam. In Assam, the main population resides in the Kachugaon, Ripu and Manas reserve forests with some major populations in other isolated forests south of the Manas Biosphere Reserve (Horwich et al. 2013).	The distribution is across three landscapes with separated populations in Brahmagiri hills in the north to the Silent Valley National Park in the south. Anaimalai hills, Nelliampathy including Chimmony, Nemmara, Vazachal and Parmbikulam Wildlife Sanctuaries and Palani Hills. Periyar Tiger Reserve, Theni Division, Srivilliputtur Wildlife Sanctuary and southwards till the tip of the Western Ghats (Singh et al. 2008).	Occur in eastern Bangladesh, south-western China (southern, western and central Yunnan), north-eastern India (Assam, Mizoram, and Tripura), Lao PDR, Myanmar, Thailand (north of the peninsular zone) and northern Vietnam (Groves 2001). 2005).

Threats

Habitat loss and fragmentation are the major threats for the Golden langur in India (Srivastava 2001b; Choudhury 2002). Its habitat area is predicted to decline by >20% in the next 10 years due to encroachment and anthropogenic activities (Molur et al. 2003).	Threatened by poaching (Roonwal and Mohnot 1977), habitat loss due to crop plantations, mining, dams, fragmentation, human settlement, hunting, road kills, deliberate fires, storms/flooding, landslides and local trade for pets (Molur et al. 2003).	Threatened by habitat fragmentation and human encroachments (Molur et al. 2003). Interspecific competition from exotics, pollution, inbreeding, and trade in live animals are additional threats (Molur et al. 2003).

Status and Conservation Actions

Trachypithecus geei (Golden Langur)	*Trachypithecus johnii* (Nilgiri langur)	*Trachypithecus phayrei* (Phayre's leaf monkey)
Golden langur is listed as Endangered of the IUCN Redlist of threatened species. It is also placed in Appendix-I of CITES. It is placed under Schedule-I of the Wildlife (Protection) Act, 1972.	The species has been listed under Annexure II of CITES. They are also protected under the Schedule I Part I of Wildlife (Protection) Act, 1972 and are listed as Vulnerable under IUCN Red data list.	The species is listed as Endangered in the IUCN Red List of Threatened Species (2008) and in Appendix II of CITES. Further, it is listed under Schedule I, part I of the Wildlife (Protection) Act 1972.

Biological Attributes

Preferred Habitat

They occur in subtropical and temperate broadleaf forests in Assam, India and Bhutan with a substantial range in elevation, ranging from near sea-level in the south to above 3,000 m in the north has been observed (Wangchuk et al. 2003). They occur in lowland evergreen, semi-evergreen and riparian moist deciduous and sal-dominated, moist deciduous forest (Srivastava et al. 2001a; Biswas 2005; Bezbaruah 2004) in the Brahmaputra river valley of Assam and the foothills of the Black mountains of Bhutan (Srivastava et al. 2001b).	Tropical moist deciduous, riverine, wet evergreen and montane wet temperate forests (Oates et al. 1980; Poirier 1970) and riparian forests at lower elevations (Roonwal and Mohnot 1977; Kurup 1979; Singh et al. 1997). They are also found inhabiting montane shola forest patches.	Phayre's leaf monkeys are primarily arboreal and prefer primary and secondary evergreen and semi-evergreen forest, mixed moist deciduous forest, but are also found in bamboo-dominated areas, light woodlands, and near tea plantations. In areas lacking primary and secondary forests, they utilize bamboo and small shrubs (Choudhury, 1987, 1994a and b, 1996; Raman et al., 1995; Bose 2003).

Food Habits

Trachypithecus geei (Golden Langur)	Trachypithecus johnii (Nilgiri langur)	Trachypithecus phayrei (Phayre's leaf monkey)
Predominantly folivorous diet. Their diet consists of young and mature leaves, ripe and unripe fruits, leaf buds, flower buds, seeds, twigs, and flowers. The main proportion of their diet consists of young leaves throughout the year (Gupta and Chivers 2000). Yellow blossoms and buds of balu tree (*Dillenia pentagyna*) are other preferred food items (Wayre 1968). They prefer foraging in deciduous trees that are budding and have also been seen to forage on leguminous shrubs.	Their feeding ecology indicates the presence of young and mature leaves, flowers and fruits in the diet (Horwich 1972, Roonwal and Mohnot 1977, Ramachandran 1995, Srivastava, et al. 1996), with foliar components dominating. Other items present include fruits, seeds, flowers, bark, petioles, small twigs, mushrooms etc. (Roy et al. 2012). nine species; *Derris pinnata, Terminalia bellerica, Syzygium cumini, Tamarindus indica, Albizia lebbeck, Albizia amara, Dalbergia paniculata, Acacia pennata and Commiphora caudata* have been considered as key species for the survival of Nilgiri langurs in the riverine forests at low elevations.	Their diet consists of fibre rich foliage, shoots, petioles, leaves, flowers and buds with Leguminosae and Moraceae providing the highest proportion (32%) of their food. Aziz and Feeroz (2009) observed that Phayre's leaf monkeys in Bangladesh consume more leaves during winter (76%), fruits and seeds during monsoon (57%) and flowers and buds are consumed mostly during summer (41%). However, bamboo shoots form a significant part (19%) of their diet throughout the year. Bose and Bhattacharjee (2004) reported that plants like Havea brasiliensis (67.4%), Delonix regia (5.8%) and Acacia auriculiformis (4.3%) contribute more than 75% of the annual diet of the species in Tripura. Bose and Bhattacharjee (2002) observed that in Tripura the species has adapted to include twigs and leaves of rubber tree which are also used for night roosting.

Table 5.2.1: Reproductive attributes of identified langurs

	Golden langur	Nilgiri langur	Phayre's leaf monkey
Age at first reproduction		3 – 5 years	5 years
Gestation period	180 days	140 – 220 days	205.3 days
Litter size	1	1	1

Table 5.2.2: Status of identified langurs in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Golden langur	1	5	1	0	6	1	5	1	0	6	1	5	2	0	7
Nilgiri langur	4	11	9	3	23	5	6	9	10	25	5	11	11	3	25
Phayre's leaf monkey	2	6	14	7	27	2	7	12	9	28	2	7	15	9	31

Demographic Status

Historical Population:

The first recorded entry of Golden langur in captivity was in 1960 while Nilgiri langur and Phayre's leaf monkey entered captivity in 1972 and 1997 respectively. The historical population of Golden langur comprises mainly of wild born specimens that form approximately 86% of the animals. While captive births account for 75% of the specimens for Nilgiri langur and 49% for Phayre's leaf monkey. Since their entry in captivity Golden langur, Nilgiri langur and Phayre's leaf monkey 163, 60 and 16 deaths have occurred respectively in the populations. The reproductive activity has been limited to 12, 13 and 21 individuals in Golden langur, Nilgiri langur and Phayre's leaf monkey respectively.

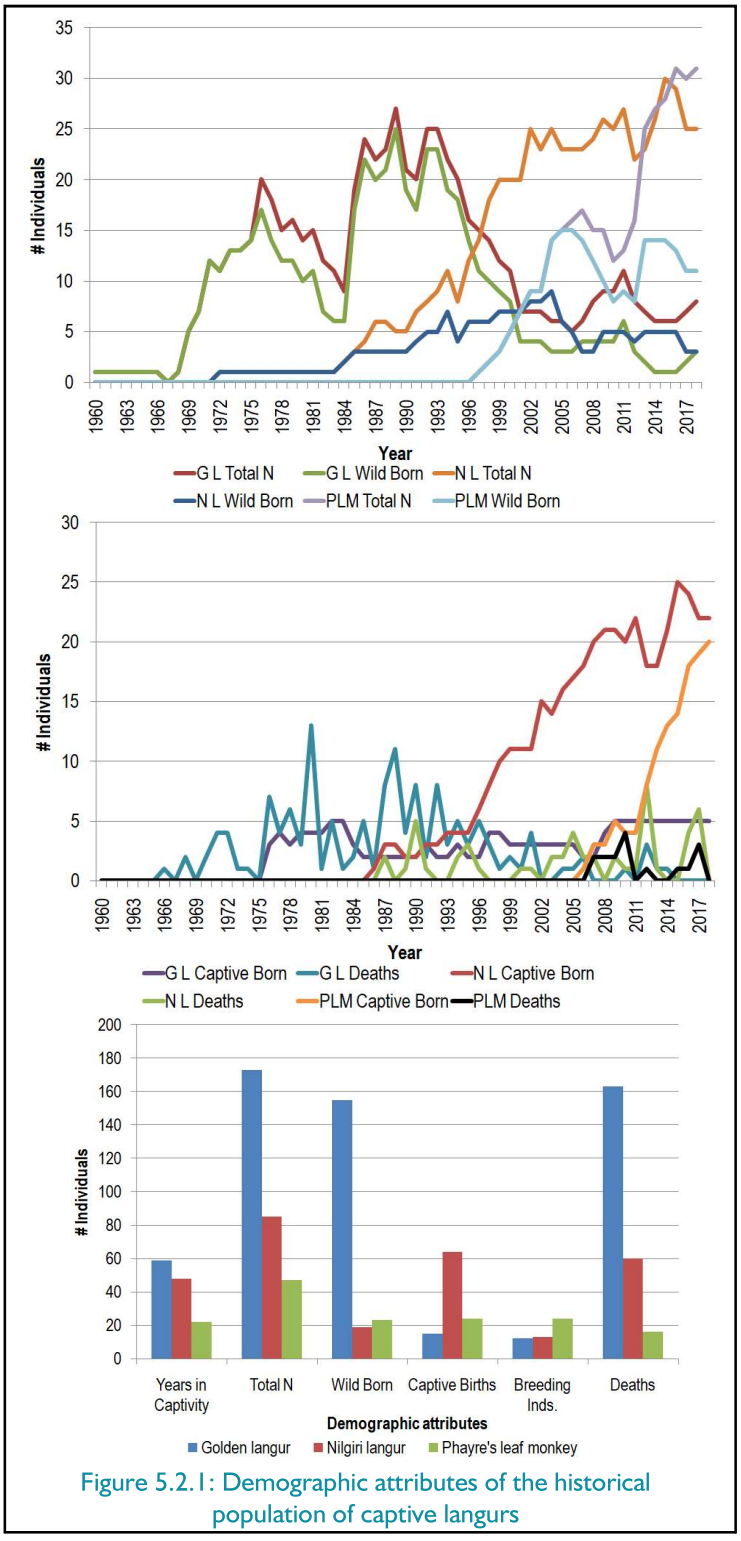


Figure 5.2.1: Demographic attributes of the historical population of captive langurs

Living Population:

The living populations include 7 (5.2.0), 25 (11.11.3) and 31 (7.15.9) specimens of Golden langur, Nilgiri langur and Phayre's leaf monkey respectively. Of this 5, 3 and 11 specimens of Golden langur, Nilgiri langur and Phayre's leaf monkey respectively are of wild origin while the rest are born in captivity. Reproduction in captivity is not observed in the living population of Golden langur while 2 and 11 individuals are reproductively active in Nilgiri langur and Phayre's leaf monkey populations.

The population of Golden langur, includes 6 individuals of reproductive age and 1 of post-reproductive age. Nilgiri langur includes 4 specimens of pre-reproductive age 20 of reproductive age and 1 that is reproductively senescent. Phayre's leaf monkey includes 5 specimens of pre-reproductive age 24 of reproductive age and 2 that is reproductively senescent. Golden langur, Nilgiri langur and Phayre's leaf monkey respectively have 0, 2 and 11 animals that have reproduced in the past.

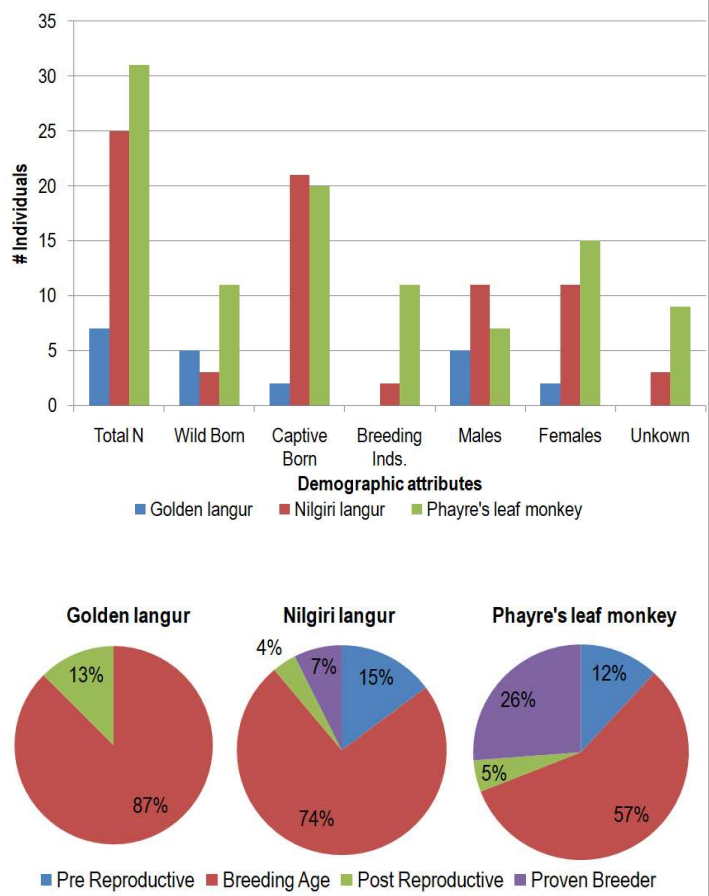


Figure 5.2.2: Demographic status of the living populations of langurs

Genetic Status

The current population of Golden langur originates from 2 founders and has 2 living descendants; however, the founder genome of only 1.33 founders is present in the population. The population retains 62.5% of the genetic diversity acquired from the founders. Records of parentages are available for 87.5% of the population. Limited reproductive output of the captive population limits further genetic analysis.

The current population of Nilgiri langur originates from 6 founders and has 5 descendants of these founders that are present in the current population, with founder genome of 2.90 of the founders present in the population. It retains approximately 83% of the genetic diversity acquired from these founders. The individuals in the population are related to each other with a population mean kinship value of 0.1725 and inbreeding coefficient of 0.0250. Records on parentages of only 32% of the population are available.

The population of Phayre's leaf monkey originates from 12 founders and has 18.25 living descendants of these founders in the current population. It retains approximately 92% of the genetic diversity acquired from these founders. Records on parentages of 94.4% of the population are available.

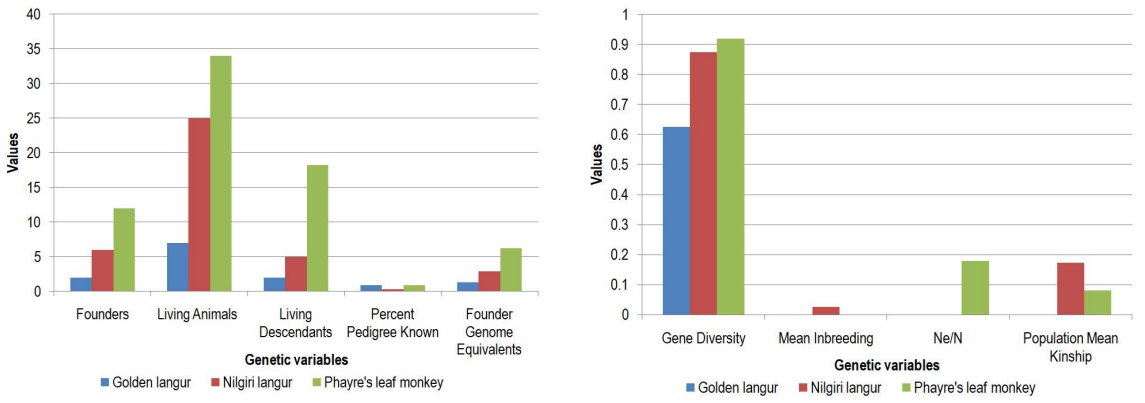


Figure 5.2.3: Genetic status of the current population

Salient Features of the Populations of Langurs in Captivity

The population of the three species have consistently remained small (N << 50), with increase in number of specimens of Golden langur being primarily through acquisition of specimens from the wild and that for Nilgiri langur and Phayre's leaf monkey through captive births. The living population of Golden langur is extremely small, has only 6 individuals of reproductive age, and retains limited genetic diversity. It is therefore unlikely to achieve conservation goals. Further, both the in-situ and ex-situ populations of the species due to its small distribution range and continued threats remain highly susceptible to extinction.

The populations of Nilgiri langur and Phayre's leaf monkey with supplementation can however be managed to increase rapidly as the living populations have 20 and 24 specimens respectively of reproductive age, they further retain significant amounts of genetic diversity, though from a small founder base.

Records of only 32% of the specimens of Nilgiri langur could be traced back to founders, while for specimens of Golden langur and Phayre's leaf monkey records of 87.5% and 94.4% specimens could be traced back to founders.

Recommendations

The population of Golden langur due to its continued small size and limited reproductive output requires supplementation to kick-start the population. The housing and husbandry practices adopted need to be critically reviewed as the population has continued low reproductive output. Additional wild origin specimens may be acquired only after shortcomings in husbandry are identified and addressed.

The populations of Nilgiri langur and Phayre's leaf monkey with supplementation using additional wild origin specimens as described in the studbook can successfully achieve their conservation goals. This would require the creation of additional housing facilities to house the growing population.

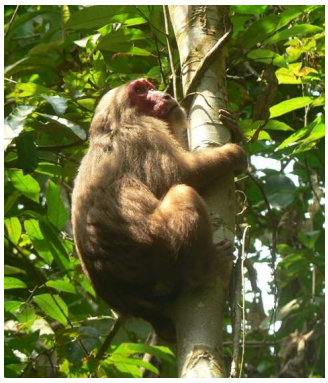
All specimens need to be marked for individual identification using appropriate techniques to enable maintenance of accurate records of individual life history events and parentages.

5.3 Status of Identified Macaques in Captivity

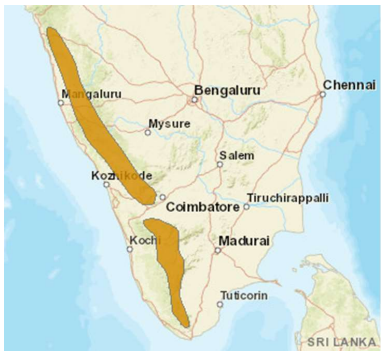
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primates
Family	Cercopithecidae
Sub-Family	Cercopithecinae

Species

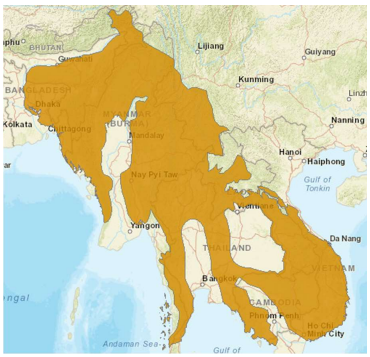
Macaca silenus (Lion-tailed macaque)	*Macaca leonina* (Pig-tailed macaque)	*Macaca arctoides* (Stump-tailed macaque)
		

Distribution



Kumar et al. 2008

Endemic to the Western Ghats, roughly distributed from 8°25'N Kalakad Hills to 14°55'N north of Anshi Ghat (Groves, 2001) in south western India, with its range passing through the three states of Karnataka, Kerala and Tamil Nadu.



Boonratana et al. 2008

Distributed throughout north-eastern India (north of the Brahmaputra river), eastern Bangladesh, Cambodia, southern China (south-western Yunnan), Lao PDR, Myanmar, Thailand (from about 8°N and including adjacent islands), and central and southern Vietnam (Groves 2001; Boonratana et al. 2008).

Htun et al. 2008

Southeast Asia, ranging from southeast of the Brahmaputra river, in north eastern India, to northern Myanmar, and south western China (Guangdong, Guangxi, Guizhou, and Yunnan provinces) and throughout Thailand, Lao PDR, Vietnam, Cambodia, north western Malaysia (Htun et al. 2008).

Threats

Macaca silenus (Lion-tailed macaque)	*Macaca leonina* (Pig-tailed macaque)	*Macaca arctoides* (Stump-tailed macaque)
Primarily frugivorous with a narrow dietary niche, makes them particularly vulnerable to habitat disturbances (Rode et al., 2006; Bicknell and Peres, 2010). This impacts their demography, ranging patterns, feeding habits and reproductive rates (Kumar et al., 1995; Singh et al., 2001; Kumara and Singh 2004). Habitat fragmentation has resulted in isolated groups (Singh et al., 2002). Ram et al. (2015) have observed depleted mitochondrial DNA diversity in such troops.	Threats include hunting and trade for food, sport and traditional medicine, and live animals as pets (Molur et al. 2003). Habitat loss and poaching are the major threats in India and Bangladesh. There has been a reduction in forest cover in Assam by over 10% in two years between 2001 and 2003 (Forest Survey of India 2003).	Habitat disturbances (such as selective logging, timber and firewood collection for charcoal and infrastructure development), hunting for food, sport and traditional medicine, and accidental mortality due to trapping (Molur et al. 2003; in: Htun et al, 2008).

Status and Conservation Actions

The lion tailed macaque is categorized as endangered in the IUCN Red List of Threatened Species.The species is listed in Annexure I of CITES, and in Schedule I, Part I, of the Indian Wildlife (Protection) Act, 1972.	It is listed under Schedule II in India in the Indian Wildlife (Protection) Act, 1972 (Chetry et al. 2003) amended up to 2002 and as Vulnerable in the IUCN Red List of Threatened Species.	Listed in CITES Appendix II since 1977 and as Vulnerable in the IUCN Red List of threatened species (2008). It is listed under Schedule II in India in the Indian Wildlife (Protection) Act, 1972.

Biological Attributes

Preferred Habitat

They are habitat specialists, restricted to evergreen forests of the Western Ghats (Singh et al., 1997). They inhabit mature mountainous forests, at altitudes between 610-1070 m, with a dense canopy cover (Kumara and Singh, 2008) with home ranges varying between 1.25 km2 (Kumar, 1987) and 5 km2 (Green and Minkowski, 1977) that include perennial water resources.	It occupies tropical evergreen and semi-evergreen forest, tropical wet evergreen forest, tropical moist deciduous forest, coastal forest, swamp forest, low elevation pine forests (in Lao PDR and China) and montane forest, including degraded forests. In China the species occupies elevations between 50-2,000 m asl (Molur et al. 2003; Choudhury 2003). In Lao PDR and Vietnam the species is associated with lowlands, usually below 500 m.	The natural habitat of Stump-tailed macaques consists of subtropical and tropical broadleaf evergreen forest (Fa 1989). They are found in lowland forests, monsoon forests, dry forests and mountain forests of India, which are upto 2000 m asl in altitude.

Food Habits

Macaca silenus (Lion-tailed macaque)	*Macaca leonina* (Pig-tailed macaque)	*Macaca arctoides* (Stump-tailed macaque)
They are selective feeders (Sushma and Singh, 2006), with widely dispersed food resources (Ganesh and Davidar, 1999). They are primarily a frugivorous species, but their diet also includes a variety of fauna (Green and Minkowski, 1977; Kumar, 1987). The diet is dominated by plant parts (fruit flesh, nectar and resins), rich in simple sugars or polysaccharides, but poor in protein (Kumar, 1987). The faunal component of the diet consist mostly arachnids and arthropods, frogs and frog nests, lizards, small birds, their eggs and nestlings, and giant squirrels and nestlings (Kumar 1987; Kumara et al., 2000).	Pigtail macaques are primarily frugivorous, with 74% of their diet consisting of fruits, but they also consume a wide variety of food including insects, seeds, young leaves, leaf stems, dirt, and fungus (Crockett & Wilson 1980; Caldecott 1986). They also feed on nestling birds, termite eggs and larvae, and river crabs (Rowe, 1996). In a study on captive pig tail macaques, it was found that they preferred food rich in carbohydrates and fructose over food that is low in these nutrients and they also tend to prefer foods that are low in zinc (Laska 2001).	Stump tailed macaques feed on fruits, seeds, insects, small vertebrates and young leaves (Smith et al. 2008). They also feed on spiders, worms, snails, insects, frogs, lizards, birds and field mice and also search out turtle and bird eggs (Fooden 1990). They are also known to raid crops preferring corn and other cultivated fruits.

Table 5.3.1: Reproductive attributes of identified macaques

	Lion-tailed macaque	Pig-tailed macaque	Stump-tailed macaque
Breeding season	Major birth peak period during January–April (Singh et al., 2006a; Sharma et al., 2006)	Non-seasonal breeders with estrus peaks in November to January (Oi 1990a, b)	October-November (Fooden et al. 1985)
Age at first reproduction	Free ranging:80 months Captivity: 48 months (North American population) (Lindburg et al., 1989) 65.2 months (European population) (Krebs and Kaumanns, 2001)	3 – 4 years	4.9 years in captivity (Nieuwenhuijsen et al. 1985)
Gestation period	172 days	170±8.5 days (Sirianni and Swindler 1985)	176.6 days (Nieuwenhuijsen et al. 1985)
Litter size	1	1 (twinning is rare)	1 (Smith et al. 2008)
Parental care	Maternal	Maternal	Maternal
Age at weaning	10.5 months (Krishna et al., 2008)		

Table 5.3.2: Status of identified macaques in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Lion-tailed macaque	10	18	22	7	47	10	21	24	6	51	10	22	26	9	57
Pig-tailed macaque	3	12	11	9	32	9	29	23	11	63	8	29	23	12	64
Stump-tailed macaque	5	3	7	1	11	9	19	22	2	43	9	19	25	1	45

Demographic Status

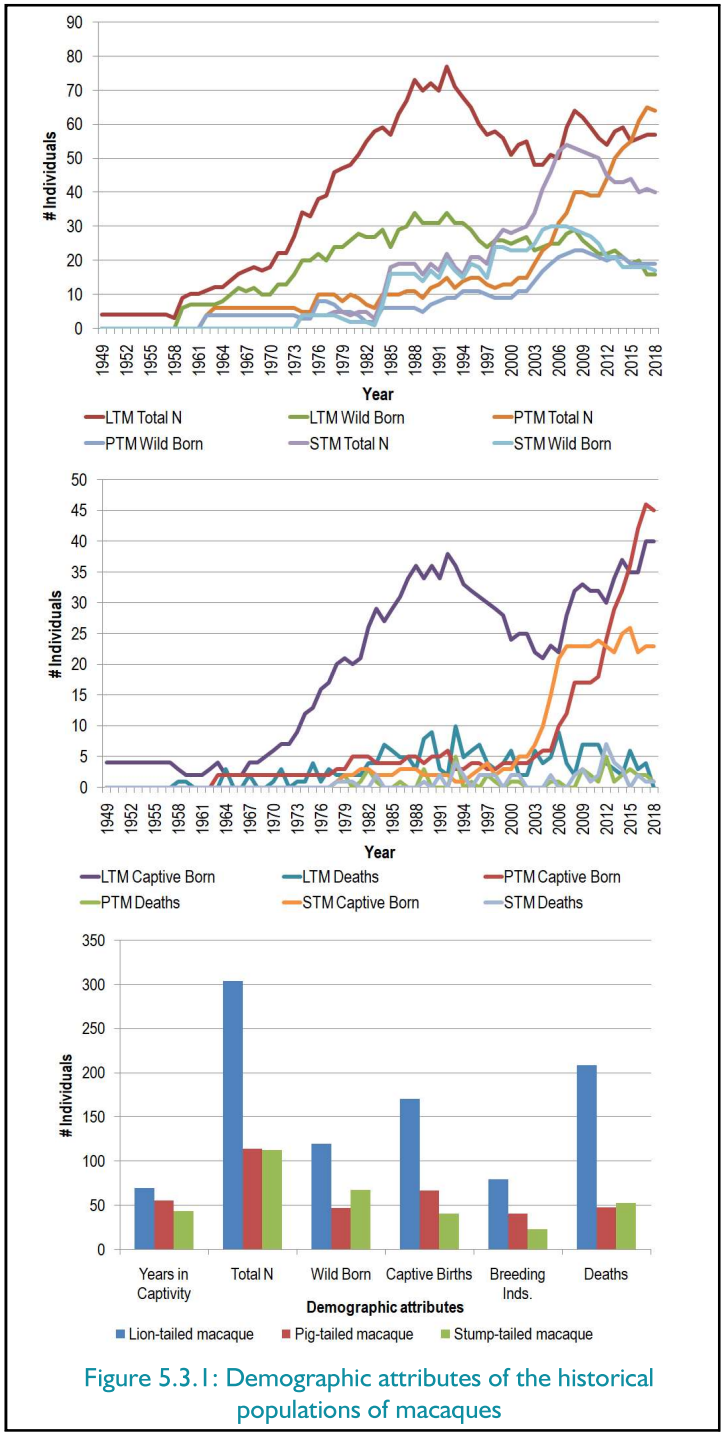


Figure 5.3.1: Demographic attributes of the historical populations of macaques

Historical Population

The demographic trends of the captive populations of the identified macaques since their first recorded entry in captivity based on records made available by zoos is presented in figure 5.3.1. The first recorded entry of Lion-tailed macaque in captivity was in 1949, while Pig-tailed macaque and Stump-tailed macaque entered captivity in 1962 and 1974 respectively. The historical populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque include 304, 114 and 113 specimens recpectively. Of these 120, 47 and 68 specimens recpectively are of wild origin. Since their entry in captivity deaths of 209, 48 and 53 Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque respectively have been recorded. The populations include 80, 41 and 53 deaths respectively of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque. The populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque include 80, 41 and 23 individuals respectively that have reproduced in captivity.

Living Population

The living populations of macaques are summarized as figure 5.3.2, a perusal of the figure indicates the current captive populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque consist of 57 (22.26.9), 64 (29.23.12) and 45 (19.25.1) specimens respectively; of these 17,19, and 21 are acquired from the wild while the rest are born in captivity. The populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque include 19, 26 and 10 individuals that are reproductively active.

The Lion-tailed macaque population includes 10 specimens of pre-reproductive, 43 of reproductive ages while 4 are reproductively senescent, of these 19 specimens have reproduced in the past. The Pig-tailed macaque population includes 15 specimens of pre-reproductive, 47 of reproductive ages while 2 are reproductively senescent, of these 26 specimens have reproduced in the past. The Stump-tailed macaque population includes 11 specimens of pre-reproductive, 11 of reproductive ages while 23 are reproductively senescent, of these 10 specimens have reproduced in the past.

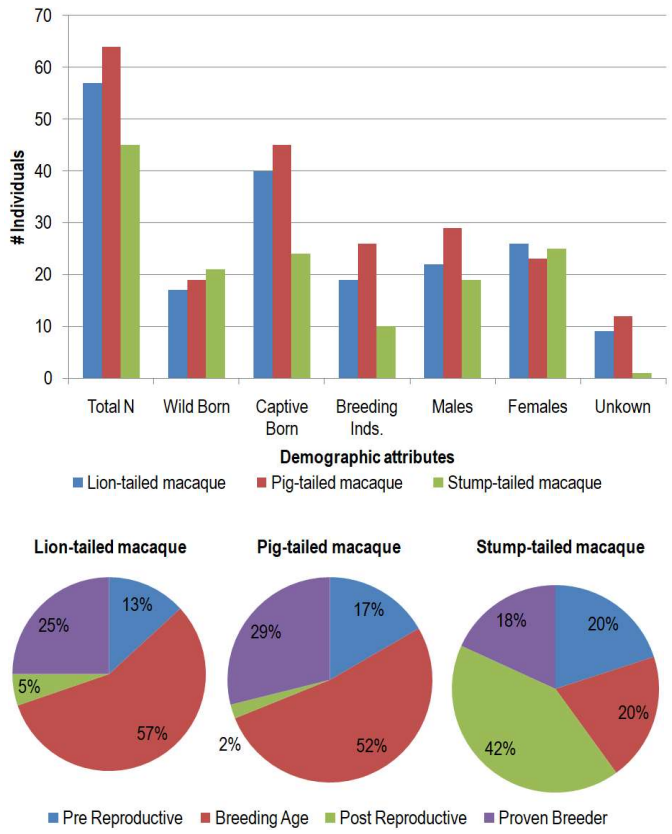


Figure 5.3.2: Demographic status of the living populations

Genetic Status

A perusal of figure 5.3.3 reveals the genetic status of the captive macaque populations. The populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque were established using 15, 21 and 9 wild origin founders respectively. They include 34, 41.50 and 19.25 living descendants respectively. Pedigree records were available for 87.7%, 94.05% and 89.04% of the specimens respectively of the populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque. The populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque contain the founder genome equivalents of 3.29, 11.73 and 6.07 of the founders used to establish them. The population of Lion-tailed macaque retains 84.79% genetic diversity. While the populations of Pig-tailed macaque and Stump-tailed macaque, retain 95.74 and 89.4% of the genetic diversity respectively. The mean inbreeding coefficient for Lion-tailed macaque is 0.1174 and 0.0375 for Pig-tailed macaque. While the population mean kinship respectively for the populations of Lion-tailed macaque, Pig-tailed macaque and Stump-tailed macaque are 0.1521, 0.0426 and 0.0823.

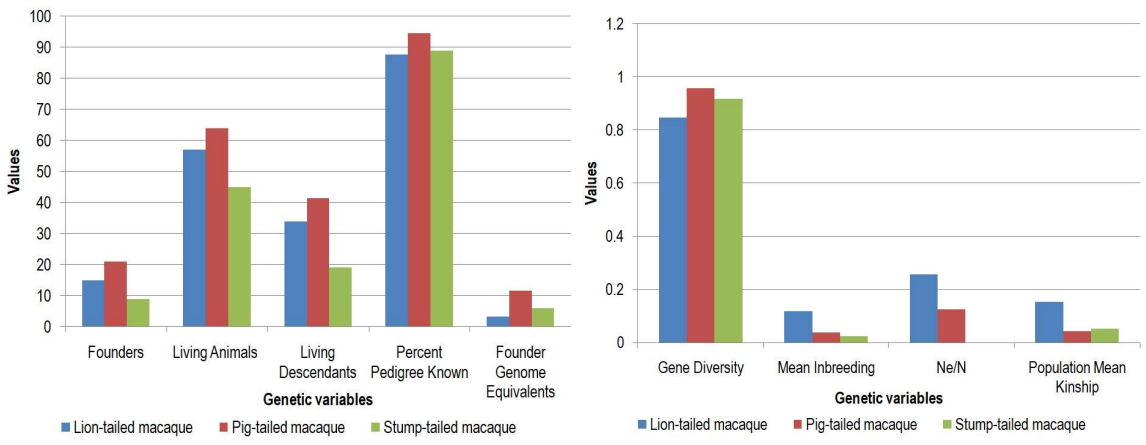


Figure 5.3.3: Genetic status of the macaque populations

Salient Features of the Populations of Macaques in Captivity

The populations of the three species show continued small sizes for most of their history in captivity, with captive births being able to offset losses due to mortality only after 2000. The living populations of the three species include adequate number of specimens that can ensure their rapid growth with specimens of reproductive and pre-reproductive ages forming significant proportion of their populations.

They additionally retain significant proportion of the genetic diversity acquired from founder animals, though with unequal representation of individuals. The limited proportion of specimens that have contributed to the respective populations has resulted in close relationships between specimens.

Recent studies indicate the segregation of the Lion tailed macaque populations north and south of the Palghat Gap as distinct sub-species; the captive population has however been managed as a single population with attempts at segregation being made only after the identification of the two sub-populations.

Recommendations

The captive population of Lion-tailed macaque needs to be intensively managed with segregation of specimens into respective sub-populations based on appropriate molecular genetics techniques. The individuals thus identified should be managed as separate populations with creation of additional housing facilities.

Supplementation to augment the genetic diversity of populations as suggested in the respective studbooks may be carried out along-with implementation of the pairing recommendations to ensure genetically viable and demographically stable populations with equitable representation of the genetic diversity of wild origin specimens to ensure achievement of their conservation goals.

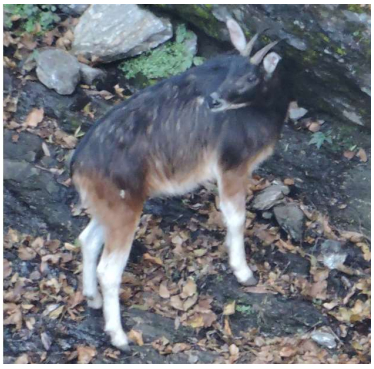
6. STATUS OF IDENTIFIED HERBIVORES IN CAPTIVITY

6.1 Status of Identified Caprids and Antelopes in Captivity

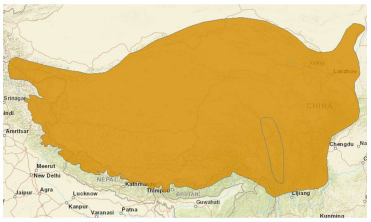
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla
Family	Bovidae
Sub-Families	Caprinae Antilopinae

Species

Capricornis thar (Serow)	*Gazella bennettii* (Chinkara)	*Pseudois nayaur* (Blue sheep)
		

Distribution

		
Duckworth, and MacKinnon 2008	IUCN SSC Antelope Specialist Group. 2017	Harris 2014
Occur in east and southeast Bangladesh, Himalayas (Bhutan, northern India including Sikkim and Nepal), China (Tibet only), northeast India (provinces east of Bangladesh), and have uncertain presence in Myanmar (Grubb 2005).	Inhabits plains and undulating areas from India in the east to Iran in the west with highest densities recorded from Thar Desert. The southern boundary of its distribution range is the Krishna River in Telangana – Karnataka border in India while the north-eastern limit is Bihar, India.	Distributed across the central Asian mountains - from Kunjereb in Pakistan, to the Sichuan and Gansu provinces of China, through the Tibetan plateau. Southern limit of distribution is along the Greater Himalayan chain in India, Nepal and Bhutan, while the northern limit stretches across Altai Shan, and parts of the Tien Shan. In India, the species is found in Ladakh, high alpine meadows of Himachal Pradesh, Uttarakhand, Sikkim, and the western Tawang region of Arunachal Pradesh (Harris 2014).

Threats

Capricornis thar (Serow)	*Gazella bennettii* (Chinkara)	*Pseudois nayaur* (Blue sheep)
Habitat fragmentation, land use changes, conflicts, predators and villagers, livestock grazing in serow habitat, and poaching (Aryal, 2009; Giri et al., 2011).	Poaching across its distribution range outside India. In India the survival of the species is threatened by habitat loss occurring as a result of overgrazing, conversion to agriculture and industrial development (IUCN SSC Antelope Specialist Group 2017).	It is vulnerable to competition from livestock, disease threats and poaching (Harris 2014). In India the major threats are localized over-hunting and excessive competition from livestock grazing that causes habitat degradation across its natural range (Harris 2014).

Status and Conservation Actions

Categorised as Near Threatened in the IUCN Red List and listed in Appendix I of CITES and listed in Schedule I (revised March 1987) of the Wildlife (Protection) act (1972).	Schedule I of the Wildlife (Protection) Act 1972 though the IUCN SSC Antelope Specialist Group considers it a species of least concern	Listed as a species of least concern in the IUCN Redlist 2014, while local concerns have caused it to be listed as a Schedule I species in the Wildlife (Protection) Act (1972).

Biological Attributes

Preferred Habitat

They inhabit steep hills with rocky slopes, especially limestone regions up to 3,000 m asl, and also in hill and mountain forest areas with gentler terrain, preferring damp and thickly wooded gorges and typically occur at altitudes between 1,500-4,000 m (Prater 1993; Schaller 1977). Aryal (2008) showed that serow preferred 2,500–3,500 m altitude range in central Himalaya of Nepal, while in Sikkim, Himalayan serow inhabit subalpine habitats and temperate habitats within the low and mid-elevation range of 1,200–3,700 m preferring elevations > 2100 m (Bhattacharya et al. 2012).	The species inhabits varied habitats that range from dry deciduous forests to semi – arid to arid grasslands in deserts (Rahmani 1990), that are characterized by high noonday temperatures and low rainfall. The home range size varies depending on the availability of resources; Dookia (2002) reported home ranges to vary between 2.2 to 2.4 km2 for a herd in the Thar Desert of Rajasthan.	Blue Sheep inhabit open grass covered slopes in mountains from 2,500 – 5,500 m asl near cliffs and areas that provide easy escape from predators (Schaller 1977). The species successfully utilize resource poor habitats that are inhospitable for other wild species. The habitat of the species is characterized by low temperature and rainfall and poor vegetation growth. The species prefers open grasslands interspersed with shrubs and avoid patches with dense vegetation (Schaller 1998). During winters the species descends into valleys or use the southern aspects of their habitats along ridgelines with lesser snow (Schaller 1998).

Food Habits

Capricornis thar (Serow)	*Gazella bennettii* (Chinkara)	*Pseudois nayaur* (Blue sheep)
Himalayan serow is a generalist herbivore (Giri et al. 2011) feeding on oak leaves, shrubs, grasses, shoots, montane bamboo, ferns, moss and lichen (Nowak and Paradiso 1983, Sathyakumar 1997). A total of thirty four plant species have been identified to be consumed by (Giri et al. 2011). They show a preference for nutrient rich palatable plants (Aryal 2009).	Selective feeders preferring plants and plant parts that are nutrient and water rich. Dookia and Goyal (2007) reported crop raiding by animals inhabiting agricultural landscapes, feed on *Dipterygium glaucum* roots that are rich source of water, feed on soil to meet mineral requirements (Dookia and Jakher 2007).	Roberts (1977) suggested that during summers alpine grasses (*Poa alpina* and *Poa pratensis*) constitute an important part of their diet. While during winter they browse on the thorny clumps of Astragalus sp. and supplement their diet with Alpine willow, lichens and mosses. During autumn, winter, and spring, primary species consumed were *Stipa spp*., *Ulmus pumila*, and *Poa spp.* Graminoids form the largest proportion of their diet (36.7–58.8%).

Table 6.1.1: Reproductive attributes of identified caprids and antelopes

	Serow	Chinkara	Blue sheep
Age at first reproduction	–	(♂) 1-6 years (♀) 1-7 years	(♂) 2- 7 years (♀) 2- 7 years
Gestation period	215 days (Kita et al. 1987, Sugimura et al. 1981); 210–220 (captive populations) (Ito 1971).	150 -180 days	4 - 5.3 months
Litter size	Single offspring; twins are rare (Prater 1993)	Ranging from 1-3 fawns	–

Table 6.1.2: Status of identified caprids and antelopes in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Serow	2	1	3	0	4	6	5	5	0	10	6	4	5	0	9
Chinkara	6	33	26	15	74	18	49	73	27	149	9	32	24	10	66
Blue sheep	3	10	8	0	18	3	11	7	0	18	3	10	7	0	17

Demographic Status

Historical Population:

The first recorded entry of Serow in captivity was in 1979, while records of Chinkara are available from 1979 and that of Blue sheep from 1988, since their first entry in captivity a total of 37, 352 and 29 specimens respectively have been reported. The populations include 19 (Serow), 87 (Chinkara) wild origin animals while the Blue sheep population was established with captive born specimens from zoos outside India with no wild origin animals being reported in the population. The populations include 7 (Serow), 23 (Chinkara) and 11 (Blue sheep) individuals that have contributed to the population while deaths of 28, 286 and 12 animals respectively have been reported.

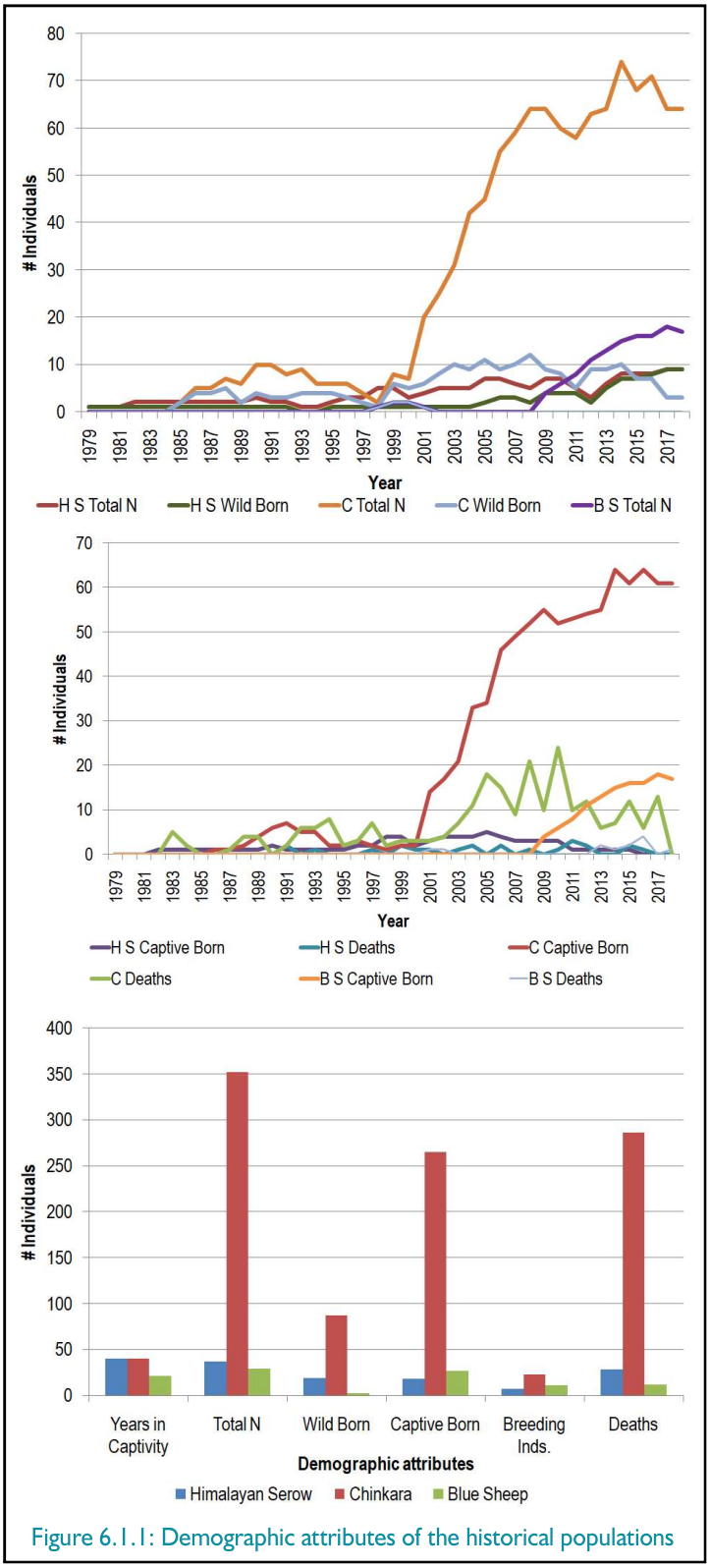


Figure 6.1.1: Demographic attributes of the historical populations

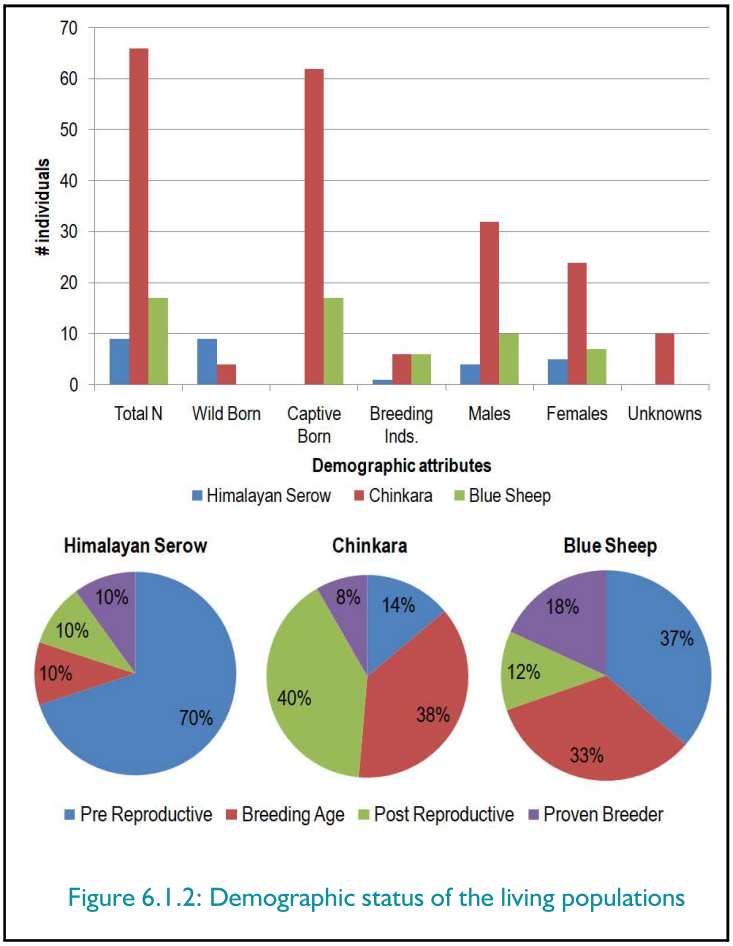


Figure 6.1.2: Demographic status of the living populations

Living Population

The current populations of Serow, Chinkara and Blue sheep include 9, 66 and 17 animals of which 9 and 4 specimens respectively are of wild origin while the Blue sheep population does not include wild origin animals. The populations include 1 (Serow), 6 (Chinkara) and 6 (Blue sheep) specimens that have contributed to the population.

The population of Serow includes 7 specimens of pre-reproductive age and 1 specimen each in the reproductive and post-reproductive ages while 1 specimen has contributed to the population. The population of Chinkara includes 10 specimens of pre-reproductive age, 27 of reproductive age and 29 of post-reproductive ages while 6 specimens have contributed to the population. While the population of Blue sheep includes 2 specimens of pre-reproductive age, 11 of reproductive age and 4 of post-reproductive ages while 6 specimens have contributed to the population.

The small population sizes of Serow and Blue sheep limit the accuracy of the demographic analysis.

Genetic Status

The small population sizes of Serow and Blue sheep and the availability of pedigree records for 18.2% of the population for Chinkara constrained accurate genetic analysis, accordingly the same has not been presented here.

Salient Features of the of Captive Populations

The captive populations of Serow and Blue sheep have remained small (N < 20) and are unlikely to achieve the goal of maintaining demographically stable and genetically viable populations due to the lack of breeding pairs that can initiate rapid growth through reproduction. The Chinkara population has a population size that is appropriate for initiating rapid population growth.

The unavailability of records on dates of entry, exit and parentages of a large proportion of specimens in all the three populations constrained detailed demographic and genetic analysis and development of recommendations for the populations.

Recommendations

Based on the information made available by the holding zoos it is recommended that additional specimens for Serow and Blue sheep may be acquired, preferably from the wild to kick-start these populations.

Supplementation of wild origin founders and pairing choices as described in the 'National Studbook of Indian Gazelle (*Gazella bennettii*) II Edition (2018) may be followed for achievement of conservation goals for the population of Chinkara.

Species appropriate housing and husbandry practices need to be adopted for the three species.

Accurate records that minimally include dates of entry and exit, parentage records and reproductive events of all specimens entering captivity need to be maintained.

6.2 Status of Identified Bovinae in Captivity

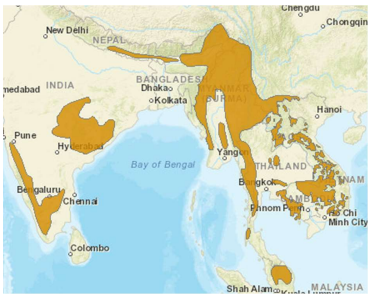
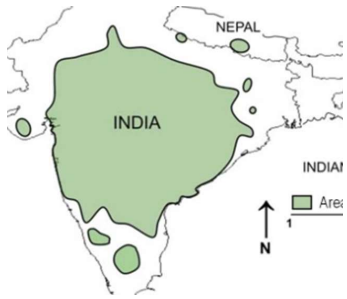
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Cetartiodactyla
Family	Bovidae
Sub-Family	Bovinae

Species

Bos gaurus (Gaur)	*Moschiola indica* (Mouse deer)	*Tetracerus quadricornis* (Four-horned antelope)
		

Distribution

		
Duckworth et al. 2008	Duckworth and Timmins 2015	Duckworth and Timmins 2015
Distributed in South and South-east Asia from India to peninsular Malaysia, occurring in India, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, China, Laos, Cambodia, Vietnam and Peninsular Malaysia (Grubb 2005). In India, the distribution is highly fragmented and is confined to the Western Ghats, Central Indian highlands and the foot hills of Himalayas, and hills the south of Brahmaputra River	Distributed across India, in the Deccan peninsula including Eastern and Western Ghats, Central India, Gangetic plains except West Bengal and the Terai region bordering India and Nepal. It is reported from most of the protected areas from the above landscapes (Duckworth and Timmins 2015).	Endemic to the Indian subcontinent, they inhabit dry deciduous savanna grasslands in Peninsular Indian and Indus divisions of the Indian Subregion in the Asian Indomalayan Region (Corbet and Hill 1992). They are restricted to India and Nepal, occupying a large area in Central India. Fragmented populations exist in southern India and Himalayan foothills and the Gangetic plains and an isolated population in Gir National Park (Sharma et al. 2005; Sharma 2006).

Threats

Bos gaurus (Gaur)	*Moschiola indica* (Mouse deer)	*Tetracerus quadricornis* (Four-horned antelope)
Habitat loss, degradation and poaching (Choudhury, 2002; Areendran 2007; Duckworth et al. 2008); competition from domestic livestock (Pasha et al. 2004); disease outbreaks in livestock (Salter 1983; Ranjitsinh 1997; Davidar 1997).	Poaching for consumption is a critical threat reported for the species (Madhusudan and Karanth, 2000, 2002). Conversion of forest for anthropogenic activities is an additional threat that has adversely affected the species (Duckworth and Timmins 2015).	Threatened by habitat destruction, poaching and competition with livestock (IUCN SSC Antelope Specialist Group, 2017).

Status and Conservation Actions

Categorized as "Vulnerable" in the IUCN Red List of Threatened Species, 2009. It is protected under Schedule I of the Wildlife (Protection) Act 1972 of India and is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Placed in Schedule I of the Wildlife (Protection) Act (1972); however, the IUCN Red List (2015) based on an assessment by Duckworth and Timmins (2015) considers it a species of Least Concern (LC).	It is listed in Schedule I of the Wildlife Protection Act (1972) and as Vulnerable in the IUCN Red List of Threatened Species (IUCN SSC Antelope Specialist Group, 2017).

Biological Attributes

Preferred Habitat

The species inhabits forest tracts in hilly terrain with abundant sources of forage and water (Schaller 1967). In India the species inhabits evergreen, semi-evergreen and moist-deciduous forests and dry deciduous forests (Schaller 1967). The preference for hilly terrain is attributed to the conversion of plains and other low-lying areas to croplands and pastures, forcing the species towards areas with low human densities (Wharton 1968).	They inhabit a variety of forest types that include tropical deciduous, moist evergreen and semi-evergreen forests up to around 1,850 m elevation (Prater 1971). Recent studies indicate that the understory vegetation structure and availability of cover from predators dictates habitat choice (Sridhar et al. 2013).	The species is a habitat generalist inhabiting dry deciduous mixed savanna forests with limited human disturbance (Prater 1971; Singh 2001; Sharma et al. 2005; Sharma 2006). Sharma and Rahmani (2004) observed a tendency of the animal to hide rather than flee. This characteristic of the animal was attributed for its preference for forested areas with thickets in savanna. They use areas with closed canopy and dense understory vegetation for resting and rearing young.

Food Habits

Bos gaurus (Gaur)	*Moschiola indica* (Mouse deer)	*Tetracerus quadricornis* (Four-horned antelope)
A polyphagous feeding habit has been reported that enables them to colonize a wide range of vegetation types (Ashokkumar et al. 2011). A total of 151 species of food plants were identified to be consumed by gaurs (Easa 1998). In the tropical dry deciduous forest of Mudumalai, Gaurs have been observed to feed on 155 species of plants with majority of food plants belonging to Poaceae, Fabaceae, Asteraceae and Malvaceae. A total of 78 species of plants belonging to 28 families were also recorded in the diet of gaur (Sankar et al. 2000) with the family Leguminoseae accounting for the highest proportion.	Fruits form an important component of the diet and the animals play an important ecological role as seed dispersers, besides forming a prey base for small and large carnivores (Prater 1971). Ramesh et al. (2012) suggest that they prefer areas that provide them with high-energy foods such as fungi, tubers and fallen fruits and cover that provides protection from predators. A study from Mudumalai documents their frugivorous nature and the role they play in seed dispersal (Prasad, 2010).	Herbivorous animals with a ruminal digestive system, they prefer to feed on nutrient rich fruits, flowers and fresh leaves (Sharma et al. 2005). Trials in captivity revealed in descending order, preference for legumes, other herbaceous species, woody species, and grasses, indicating a selection of the nutrient rich forage (Solanki and Naik 1998). Analysis of pellets from animals at Mudumulai Wildife Sanctuary revealed the presence of 24 plant species to be a part of the diet of the animals (Baskaran et al. 2011) with grasses contributing 28.6% of the diet followed by shrubs (5.6%), trees (8.2%) and herbs (6.7%).

Table 6.2.1: Reproductive attributes of identified Bovinae in captivity

	Gaur	Mouse deer	Four-horned antelope
Age at first reproduction	37.6 months	–	Free ranging: 1 year Captivity: 1-2 years
Gestation period	~9.5 months	150-163 days	240 days
Litter size	1	1	2 approx

Status in Captivity

Table 6.2.2: Status of identified Bovinae in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Gaur	12	46	44	7	97	17	74	58	5	137	17	80	67	5	152
Mouse Deer	5	81	85	32	198	33	122	146	26	294	10	142	110	12	264
Four-horned antelope	13	47	56	35	138	28	83	128	49	260	19	47	81	24	152

Demographic Status

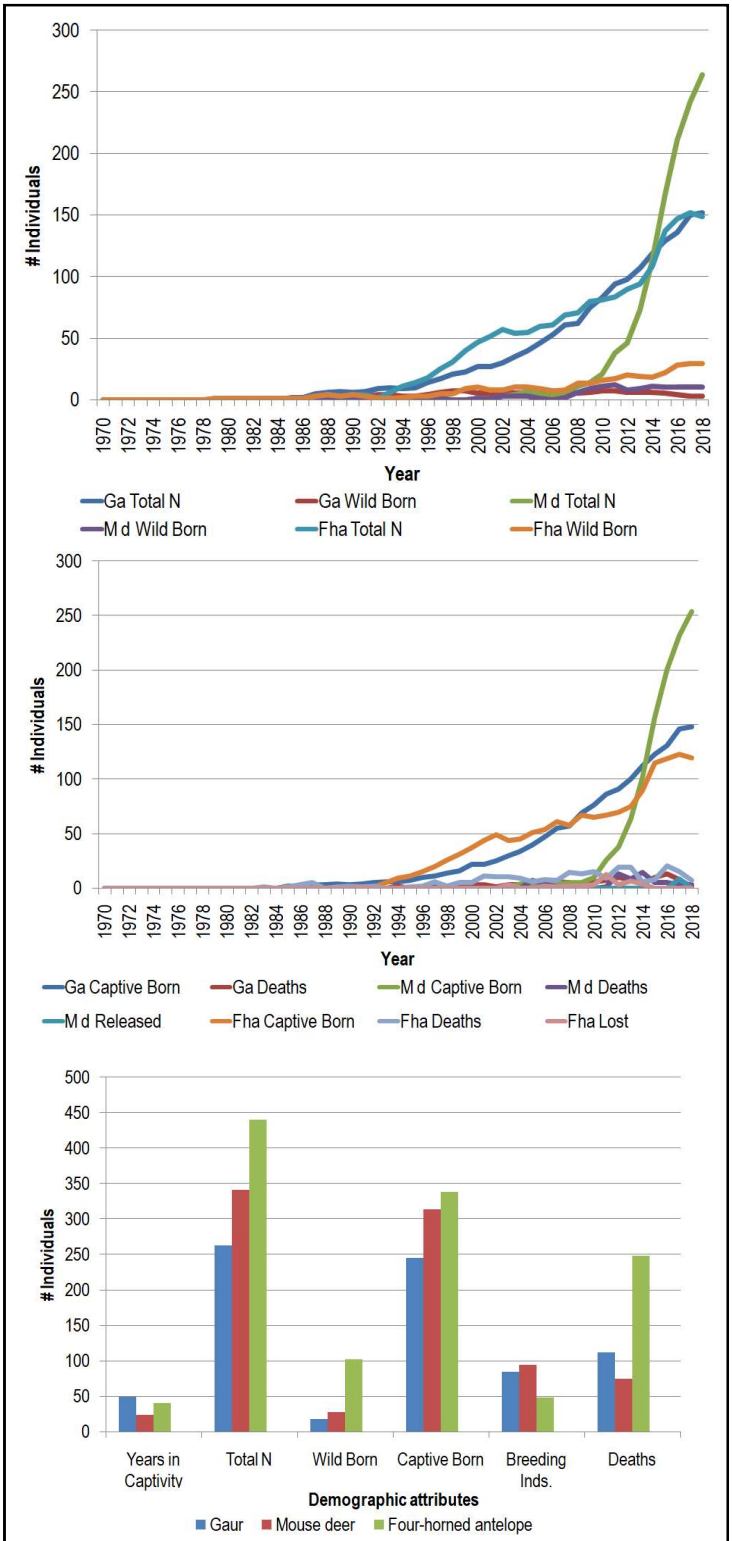


Figure 6.2.1: Demographic attributes of the historical populations

Historical Population

A perusal of figure 6.2.1 revealed that the first recorded entry of Gaur in captivity was in 1987, records of Mouse deer are reported from 1994 and that of Four-horned antelope since 1979. During this period a total of 263, 341 and 440 specimens of the three species respectively have been reported. The population of Gaur includes 18 wild origin animals that of Mouse deer 27 while the Four-horned antelope population includes 102 animals acquired from the wild. During this period a total of 112 (Gaur), 75 (Mouse deer) and 248 (Four-horned antelope) deaths have been reported in the captive populations. The captive populations of the three species include 84 specimens of (Gaur) that have contributed to the population, 94 specimens in the (Mouse deer) and 48 (Four-horned antelope).

Living Population

Figure 6.2.2 indicates that the living population includes 152 (Gaur), 264 (Mouse deer) and 152 (Four-horned antelope), of this 3, 10 and 31 specimens respectively were acquired from the wild, while the rest are born in captivity. Of the living populations 46 of Gaur, 78 of Mouse deer and 20 specimens of Four-horned antelope respectively have contributed to the populations.

The current population of Gaur includes 21 pre-reproductive age, 129 of reproductive age and 2 reproductively senescent specimens; while 46 specimens have contributed to the population. The current population of Mouse deer includes 2 pre-reproductive ages, 254 of reproductive age and 78 reproductively senescent specimens. The current population of Four-horned antelope includes 37 pre-reproductive age, 78 of reproductive age and 33 reproductively senescent specimens.

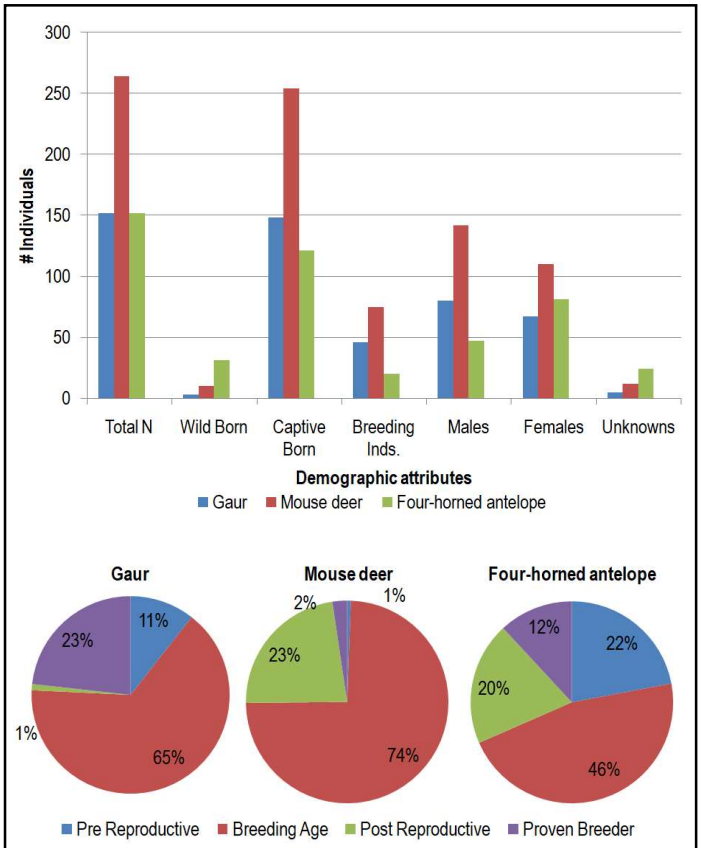


Figure 6.2.2: Demographic status of the living population

Genetic Status:

The current populations of 152 (Gaur), 264 (Mouse deer) and 252 (Four-horned antelope), originate from 13, 11 and 25 founders respectively. Available records indicate the presence of 109.3 (Gaur), 142.53 (Mouse deer) and 37.5 (Four-horned antelope) living descendants of these founders. Pedigree records were available for 74.4% (Gaur), 57.8% (Mouse deer) and 45.1% (Four-horned antelope); while the founder genome equivalents of 3.66, 3.63 and 11.93 wild origin founders respectively were present.

The populations retain 86.33% (Gaur), 86.24% (Mouse deer) and 95.8% (Four-horned antelope); while the mean inbreeding coefficient respectively were 0.2121 (Gaur), 0.0912 and 0.0208. The populations had mean kinships of 0.1367, 0.1376 (Mouse deer) and 0.042 (Four-horned antelope); while the proportion of effective population to total population size (Ne/N) respectively was 0.3415, 0.4066 and 0.1422.

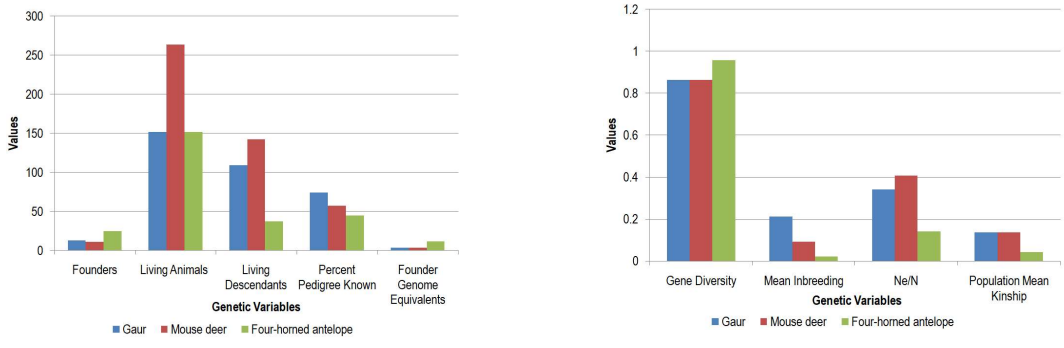


Figure 6.2.3: Genetic status of the populations

Salient Features of the Captive Populations

The population of Gaur includes 152 specimens of which 61% are of reproductive age indicating its potential for rapid growth. The population; however, originates from a small founder base and remains vulnerable to stochastic events due to limited genetic variability retained by it due to the close relationship between its members (Mean Inbreeding: 0.2121 and Population Mean Kinship: 0.1367).

The Mouse deer population includes 264 specimens of which 74% are of reproductive age indicating population capable of rapid growth. The population also includes approximately 40% specimens that are contributing to the growth of the population. The small founder base and unequal representation of founders in the current population however renders it vulnerable to stochastic events.

The population of Four-horned antelope includes 252 specimens of which 46%are of reproductive age classes indicating its potential for rapid growth. The population originates from 25 founders and retains a significant proportion of this genetic diversity.

Recommendations

The populations of the 3 species in Indian zoos are demographically stable; however, interventions aimed at increasing the genetic diversity and a more equitable representation of the founder genome in the population is necessitated.

A large proportion of the populations of all three species include specimens of unknown lineage. The lineages can be identified using appropriate molecular genetics techniques thereby enabling the development and implementation of more effective population management plans and pairing recommendations.

6.3 Status of Identified Cervids in Captivity

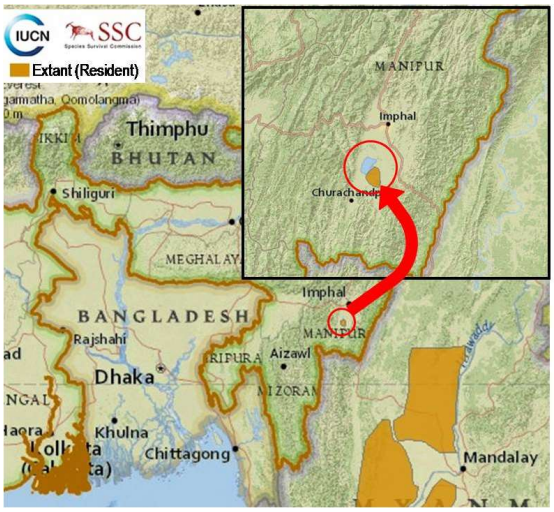
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Cetartiodactyla
Family	Cervidae

Species

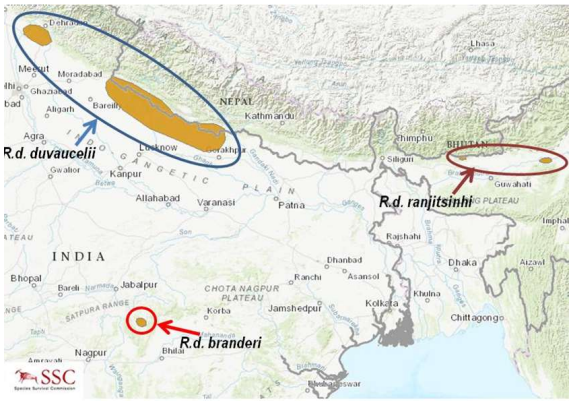
Rucervus eldii eldii (Sangai)	*Rucervus duvaucelii* (Swamp deer)
	

Distribution



Gray et al. 2015

Sangai has an extremely limited distribution range and is restricted to a single location, the Keibul Lamjao National Park, of Manipur. The total area of the park is 40 km^2; however, the actual area utilized by the animals is only about 15 km2 (Hussain et al. 2004).



Duckworth et al. 2013

The distribution is restricted to isolated pockets at few protected areas of north and central India, and south-western Nepal. Dudhwa Tiger Reserve in Uttar Pradesh supports a single large population of 1200–1400 animals while in Nepal, about 2000 animals occur in Suklaphanta Wildlife Reserve and Bardia National Park. The species is reported to be extinct from Pakistan and Bangladesh (Qureshi et al. 2004). A small population of swamp deer (N = 320) was recently rediscovered in Uttarakhand (in 2005) at Jhilmil Jheel (Sinha and Chandola 2006).

Threats

Rucervus eldii eldii (Sangai)	*Rucervus duvaucelii* (Swamp deer)
Threatened by the degradation of their unique 'Phumdi' habitat at the single location – Loktak Lake due to the construction of dam that limits the seasonal changes in water level crucial for the uptake of nutrients from the bottom by the phumdi. An additional cause for concern is the limited genetic diversity present as a consequence of the small population size. This has led to both the captive and wild populations retaining limited genetic diversity (Angom et al. 2017).	Threatened by habitat alteration, fragmentation and poaching. Isolation into small, restricted pockets increases the likelihood of localized extinctions, as has been the case in Bangladesh. Additional threats include change in river dynamics due to human developmental activities, increase in siltation and reduced flow of water during critical periods of summer (Duckworth et al. 2013), weed infestation (e.g. *Sesbania spp*.) (Qureshi et al. 1995, 2004).

Status and Conservation Actions

They are accordingly listed in Schedule I of the Wildlife Protection act; the IUCN Redlist of threatened species has listed it as Endangered based on a species wise assessment (Gray et al. 2015). The Government of India in association with the Forest Department of Manipur and the Wildlife Institute of India has initiated a species recovery program.	The species is included in Schedule I of the Wildlife Protection Act and listed as Vulnerable in the IUCN Redlist of threatened species. A cause of concern voiced in a recent publication by Kumar et al. (2016) based on molecular genetic studies suggest of an admixture of *R. d. duvaucelii* and *R. d. branderi* in the Indian captive population. The paper also highlights the need for managing distinct populations at the sub-species level in captivity for maintaining the distinctness of the separate geographic clines.

Biological Attributes

Preferred Habitat

The subspecies is restricted to a small area of the Keibul Lamjao National Park in Manipur inhabiting wetland areas characterized by floating mats of soil and vegetation (Phumdis), patches with floating rooted vegetation, open water areas, small hillocks and shallow water areas (Sanjit et al. 2005). The animals spend considerable part of their time on the phumdis; however, drier areas that include tall reeds and grasses and hillocks are preferred for resting (Singh 1991 in Hussain et al., 2004, Angom 2012). The animals rest under tall reeds and grasses during most part of the day.	Swamp deer inhabit swampy grasslands and floodplains in the Indian sub-continent, and are highly dependent on the availability of water (Tewari and Rawat 2013b). They utilize variety of habitat types including open forest where grasses are present, with maximum abundance occurring in marshy and sandy grasslands (Schaller 1967, Martin 1977, Schaff 1978, Singh 1985, Qureshi et al. 1995). Forested areas are used during change of habitats for fulfilling seasonal needs (Martin 1977, Schaff 1978, Qureshi et al. 1995). The composite home range of herds varies from 10 to 30 km2, annually (Qureshi et al. 1995).

Food Habits

Rucervus eldii eldii (Sangai)	*Rucervus duvaucelii* (Swamp deer)
Vegetation forming the phumdis was reported to include 185 plant species of 50 families and 121 genera. The dominant species included *Zizania latifolia, Hedychium coronarium, Impatiens sp.,Cyperus difformis, Cyperus rotundus and Polygonum spp.* (Tuboi et al. 2015). Highest productivity reported was that of *Zizania latifolia* and formed approximately a third of the diet of Sangai while graminoids formed 80% of the diet of the species (Tuboi and Hussain 2014). Singh, (1991) reported 233 plant species belonging to more than 58 families forming part of the diet of brow-antlered deer.	They are primarily grazer and largely feed on grasses and aquatic plants with diet composition varying seasonally. Preferred forage includes *Sacharum spp, Imperata cylindrica, Narenga porphyrocoma, Phragmites karka, Oryza rufipogon, Hygroryza spp* and *Hydrilla spp* (Schaller 1967, Martin 1977, Schaff 1978, Singh 1985, Qureshi et al. 1995).

Table 6.3.1: Reproductive attributes of identified cervids

	Sangai	Swamp deer
Age at first reproduction	4 years for females	(♂)4 years onwards (♀) 2–3 years
Gestation period	245-273 days	240 to 250 days
Litter size	1	1

Table 6.3.2: Status of Sangai and Swamp deer in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Sangai	6	15	18	21	54	15	99	95	29	223	15	76	83	13	172
Swamp deer	11	50	93	66	209	16	71	131	53	255	16	71	131	53	255

Demographic Status

Historical Population

The first recorded entry of Sangai in captivity was in 1956 while Swamp deer were first recorded in captivity in 1962. Since then a total of 603 specimens of the former have been recorded while similar information could not be obtained from the data available for the latter.

Based on available records the Sangai population includes 8 wild origin animals while that of Swamp deer includes a total of 16 wild origin specimens, of this 7 can be distinctly identified as specimens of the

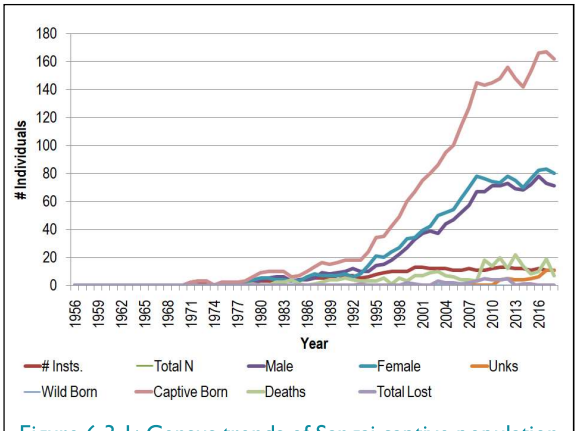


Figure 6.3.1: Census trends of Sangai captive population

central-Indian sub-species, *R. d. branderii*. Since their first recorded entry in captivity a total of 595 and 484 births have been recorded respectively for Sangai and Swamp deer populations while 404 and 257 deaths have been reported during the same period respectively for each of the populations. In the population of Sangai 66 individuals have contributed to the population; however the same could not be ascertained for Swamp deer due to lack of adequate records.

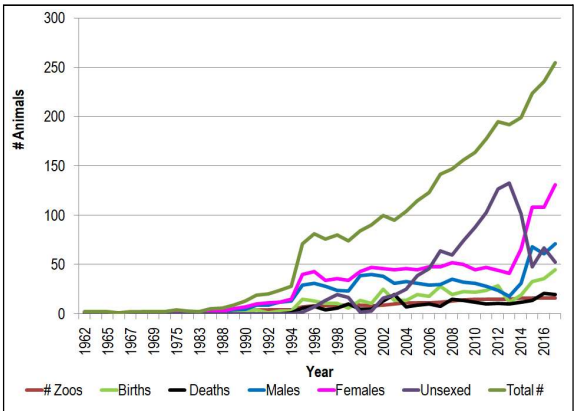


Figure 6.3.2: Census trends of Swamp deer in Indian Zoos

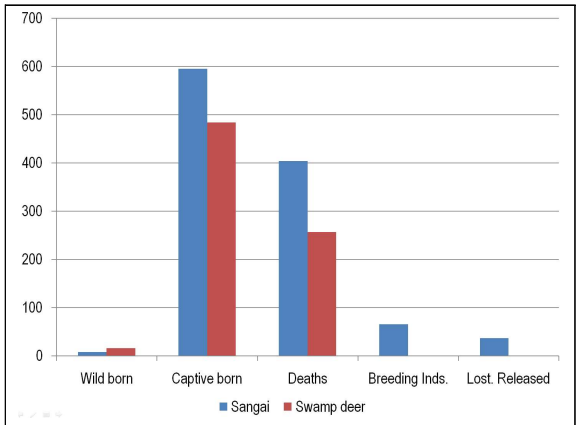


Figure 6.3.3: Demographic attributes of historical

Living Population

Based on available records the living population of Sangai includes a total of 162 specimens, of this 113 are of breeding age, 29 of pre-reproductive age and 20 specimens that are reproductively senescent, while 9 of the specimens have actually contributed to the population. The living population of Swamp deer includes 255 specimens; however, the absence of relevant records limits understanding of the age structure of the population.

Genetic Status

Lack of information on pedigrees of specimens in both the Sangai and Swamp deer populations limits an understanding of the genetic status of the populations.

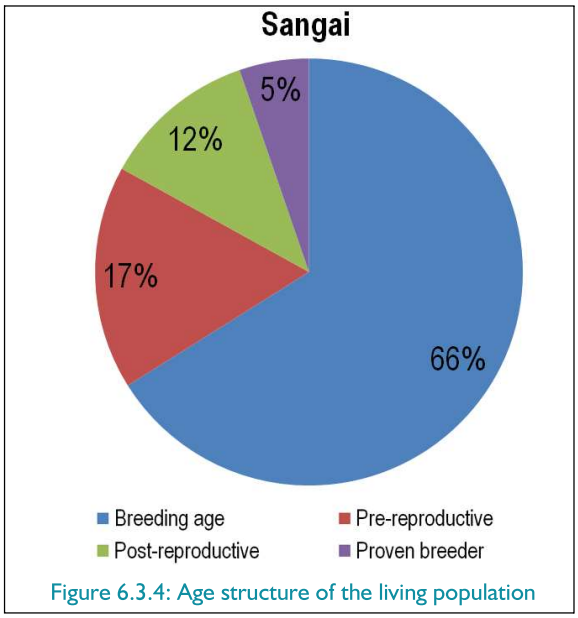


Figure 6.3.4: Age structure of the living population

Salient Features of the Populations of Cervids in Captivity

The current sizes of the populations indicate that they have been successfully reproducing in captivity and with appropriate interventions can act as insurance populations for the two species.

Based on records available an understanding of the demographic status of the captive Sangai population could be developed; however, lack of information of ancestries of specimens' limits genetic analysis, for Swamp deer information was available primarily in the form of an inventory limiting both demographic and genetic analysis of the populations.

Both populations originate from extremely small founder bases and are likely to retain limited genetic diversity, additionally the homozygosity of both the captive and free ranging populations of Sangai as suggested by Angom et al. (2017) further constrain the availability of new founders that can augment the limited genetic diversity present in the population.

Recommendations

Effective management of the captive populations of Sangai and Swamp deer requires intensive efforts aimed at:

Record keeping and marking: The zoos must ensure individual animal identification and effective record keeping for developing population management plans.

Ascertaining taxonomy: Swamp deer have been confirmed to include three distinct sub-species that are also geographically separated. It is imperative that an assessment of this distinctness be carried out for maintaining sub-species level integrity of the captive specimens of Swamp deer using molecular tools.

Assessment of genetic status: Limited information on parentage limits development of population management plans for the two populations in captivity. The use of appropriate molecular genetics tools to assess the genetic status of the captive population and understand relationships between individuals would assist in development of a population management plan.

6.4 Status of Identified Odd-toed Ungulates

Taxonomy

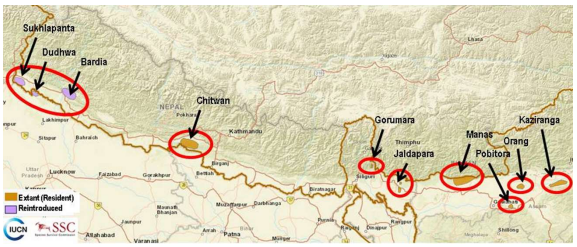
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Perissodactyla
Family	Equidae
	Rhinocerotidae

Species

Equus hemionus khur (Indian wild ass)	*Rhinoceros unicornis* (One- horned rhinoceros)
	

Distribution

Kaczensky 2016



Talukdar et al. 2008

Restricted to the Little Rann of Kutch (LRK) in Gujarat (Corbet and Hill, 1992). The Khur presently have expanded their range from beyond LRK to the Rajasthan and Pakistan borders in the north and west and Nalsarovar Sanctuary and Bhal areas of Gujarat (Singh, 2001) along with an increase in their population (Shah, 2004).

The historical range of the species extended across the floodplains of Indus, Ganga and Brahmputra rivers from Peshawar in northern Pakistan eastward along the base of the Himalayas, through the north-western provinces of India, northern Uttar Pradesh and Bihar, the Nepal terai and north Bengal into the Brahmaputra valley of Assam (Laurie 1978).

Threats

The population of Khur is vulnerable to disease threats as is evinced by outbreaks of Surra in 1958 and 1960 (Gee, 1963) and drought that resulted in severe population declines. Anthropogenic activities viz. construction of the Sardar Sarovar Project, grazing pressure from increased livestock presence, salt collection and land use changes are also potent threats (Goyal, et al. 1999; Shah, 1993; Sinha, 1993).

Conversion of alluvial plain grasslands to farmland, sport hunting during the late 1800s and early 1900s. Recent threats include poaching for use of horns in traditional Chinese medicine and habitat degradation caused by invasion of exotic plants into grasslands that reduces available habitats (Talukdar, et al. 2008).

Status and Conservation Actions

Equus hemionus khur (Indian wild ass)	*Rhinoceros unicornis* (One- horned rhinoceros)
This species is assessed as Near Threatened (NT); however, approaching Vulnerable status owing to a projected decline of at least 20% over the next three generations, due to prevailing and emerging threats (Kaczensky, 2015). They are listed as a Schedule I species in the Wildlife (Protection) act (1972).	The population has shown signs of recovery in the recent past. Accordingly the species threat perception of the species has declined. It is currently listed as vulnerable in the IUCN Red List of threatened species (Talukdar, et al. 2008) and in Schedule I of the Wildlife Protection Act (1972) of India.

Biological Attributes

Preferred Habitat

The sub-species inhabits arid and saline thorn scrub in the Little Rann of Kutch (LRK) (Champion and Seth, 1968). An exotic thorny shrub; *Prosopis juliflora* was introduced in areas adjoining LRK during 1899 – 1900, subsequently plantation of the shrub was adopted for limiting the spread of the desert (Joshi, 1959). Seasonal variation in habitat preference is observed with medium and high density scrubland being utilised during summer and winter seasons while croplands were preferred during monsoons and winter due to the concentrated availability of resources (Shah, 1993).	The species inhabits riverine grasslands in the alluvial floodplains throughout its range. The grasslands are interspersed with swamp patches dominated by emergent vegetation and riverine woodlands dominated by *Trewia, Bombax, Syzygium, Acacia, Dalbergia, Shorea* and *Terminalia* communities. Home range size varied proportionally to vegetation diversity of the area and ranged from two to more than 10 km2. They wallow in mud-pools for cooling themselves and avoiding insect pests during summer (Laurie et al. 1983).

Food Habits

Pods of *P. juliflora* form a major component of diet of the Wild Ass during summer, as most of the ground becomes devoid of vegetation due to trampling by cattle. They are generalist herbivores feeding on grasses during monsoon and winter. The preferred forage species include members of the Cyperacea family during monsoons and as the vegetation dries up (during late winter and summer) dried annual graminoid species and crops form a large part of their diet. Unlike other Equids (Pratt et.al. 1986), Khur have become nocturnal for raiding resource rich croplands (Shah, 1993). Proximity to water is another critical factor influencing habitat utilization by Wild Ass (Shah, 1993).	They are reported to feed on parts of 183 species of plants belonging to 57 families in Chitwan. Of these grasses (mainly *Saccharum, Narenga* and *Cynodon*) of 53 species made upto 70 – 89% of their diet that varies seasonally (Laurie, 1978). Fruits, leaves and branches of shrubs and trees, submerged and floating aquatic plants, sedges, ferns and agricultural crops are also reported to form a part of their diet (Laurie et al. 1983). Changes in seasonal availability of food plants results in movement between vegetation types (Laurie et al. 1983).

Table 6.4.1: Reproductive attributes of identified odd toed ungulates

	Indian wild ass	One- horned rhinoceros
Age at first reproduction	3-4 years	(♂) 10 years 5 months (♀) 9 years 2 months
Gestation period	339 days	462 – 491 days (mean 479 days)
Litter size	1	Single calf

Table 6.3.2: Status of Sangai and Swamp deer in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Indian wild ass	2	8	6	0	14	2	9	6	0	15	2	9	6	0	15
One-horned rhinoceros	9	19	15	0	34	10	20	14	0	34	9	20	15	0	35

Demographic Status

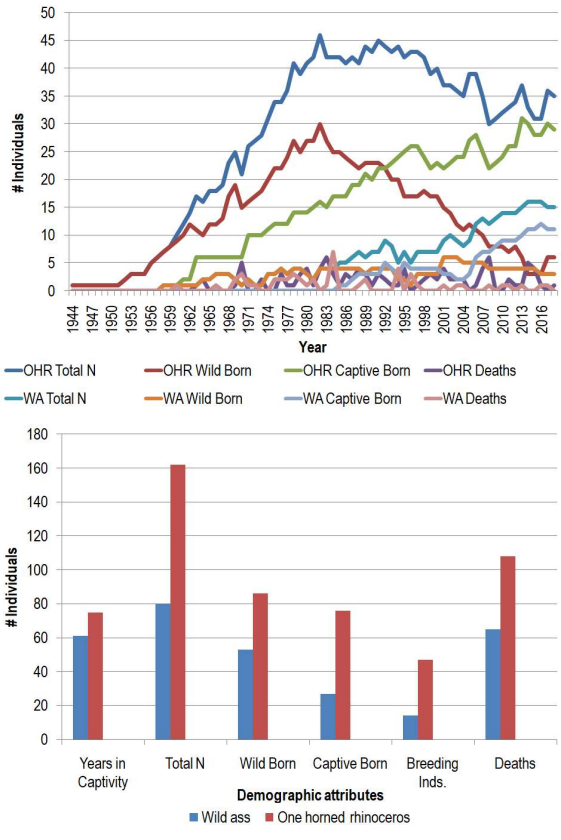


Figure 6.4.1: Demographic attributes of the historical populations

Historical Population

The Indian wild ass captive population was established in 1958 while the One-horned rhinoceros captive population was established in 1944. The populations since inception include 80 (Wild ass) and 162 (One-horned rhinoceros) specimens of which 53 and 86 respectively have been acquired from the wild. The populations include 14 (Wild ass) and 47 (One-horned rhinoceros) specimens that have contributed to the population while a total of 27 and 76 births respectively have been recorded, during the period a total of 65 (Wild ass) and 108 (One-horned rhinoceros) deaths of specimens have also been recorded.

Living Population

The current populations of Wild ass include 15 specimens of which 3 are of wild origin and 6 specimens have contributed to the population. The population of One-horned rhinoceros includes 35 specimens of which 6 are of wild origin and 12 individuals have contributed to the population.

The current population of Wild ass includes 2 specimens of pre-reproductive ages, 9 of reproductive ages and 2 specimens that have reached reproductive senescence, while the ages of the 4 wild origin specimens could not be ascertained. These include 4 specimens that have contributed to the population. The current population of One-horned rhinoceros includes 7 specimens of pre-reproductive ages, 26 of reproductive ages and 2 specimens that have reached reproductive senescence. These include 12 specimens that have contributed to the population.

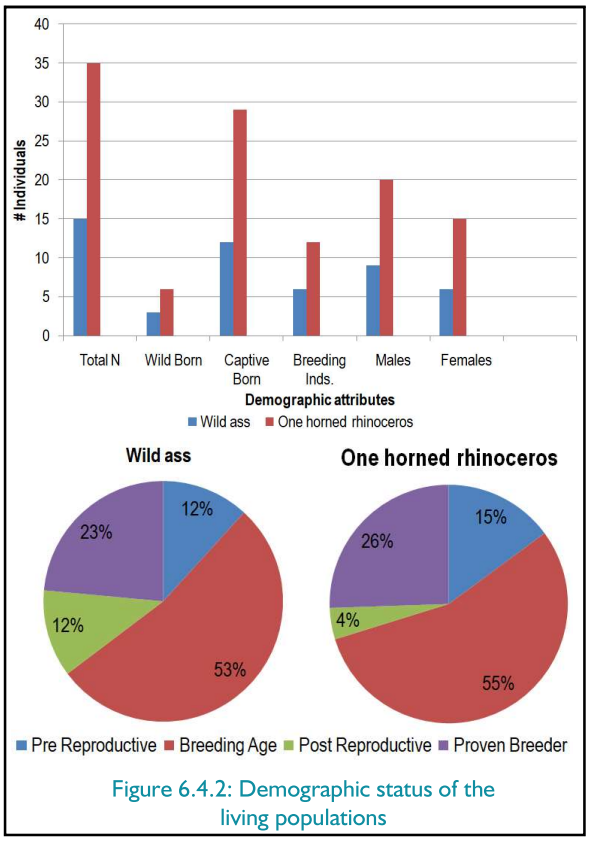


Figure 6.4.2: Demographic status of the living populations

Genetic Status

The population of Wild ass originates from 4 founders, 11.25 living descendants of these founders can be traced back to these founders. Pedigree records were available for 95% of the population. The population retains 78.17% of the genetic diversity of the founders, with a founder genome equivalent value of 2.29 and the ratio of effective population size to census size is 0.3556. The coefficient of mean inbreeding is 0.0233 and population mean kinship is 0.2183.

The population of One-horned rhinoceros originates from 12 founders, 26 living descendants of these founders can be traced back to these founders. Pedigree records were available for 91.4% of the population. The population retains 90.56% of the genetic diversity of the founders, with a founder genome equivalent value of 5.29 and the ratio of effective population size to census size is 0.3692. The coefficient of mean inbreeding is 0.0425 and population mean kinship is 0.0944.

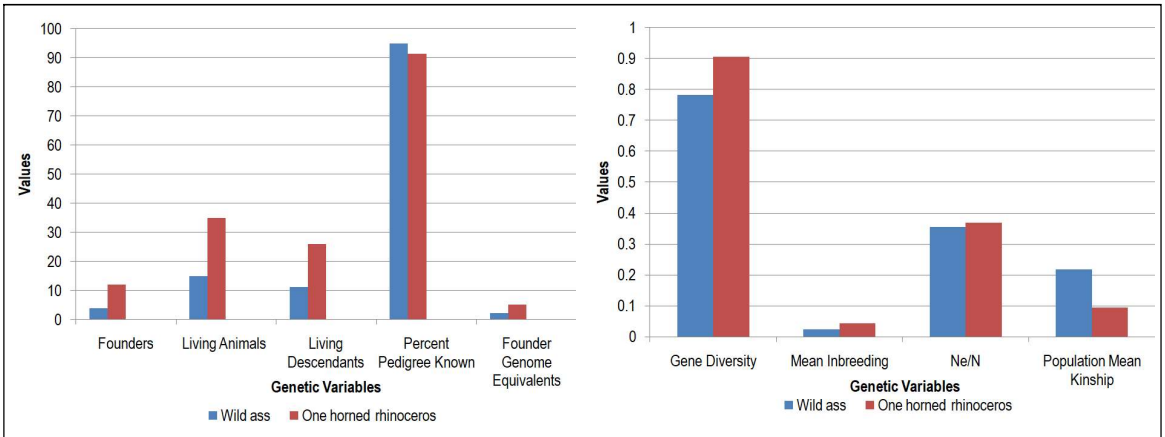


Figure 6.4.3: Genetic status of the populations

Salient Features of the Odd-Toed Ungulates Populations

The populations of both Wild ass and One-horned rhinoceros have continued small sizes (N < 50) with captive births inadequately addressing losses due to mortality. The small size of the living populations despite the majority of specimens being of reproductive ages limits the likelihood of the populations achieving conservation goals.

The low reproductive output of Wild ass is indicative of shortcomings in husbandry practices adopted for its captive management. Their continued small size and small founder base has resulted in limiting mating choices and breeding between closely related individuals as is indicated by the values of mean inbreeding and population mean kinship. Additionally, the small founder base is unequally represented in the populations.

Recommendations

The practices adopted for husbandry of Wild ass and One-horned rhinoceros need to be reviewed to identify shortcomings. These should be appropriately addressed along-with creation of additional infrastructure for housing the additional animals entering the population.

The pairing choices as included in the respective studbooks should be adopted to ensure an equal representation of the founder genome in the captive populations.

7. STATUS OF IDENTIFIED SMALL MAMMALS IN CAPTIVITY

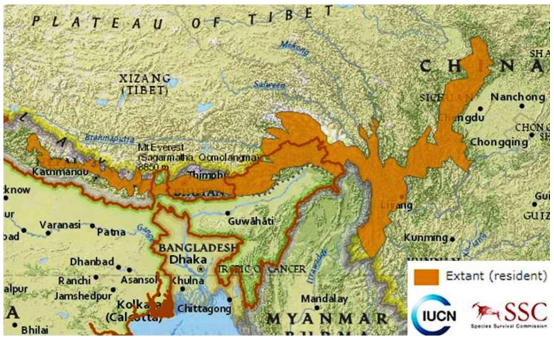
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Carnivora
Family	Ailuridae
	Manidae

Species

Ailurus fulgens fulgens (Red panda)	*Manis crassicaudata* (Indian pangolin)
	

Distribution



Wang et al. 2008

Their present distribution extends from Nepal through Bhutan, India, Burma and Myanmar in the Himalayas, to China (Roberts and Gittleman1984 and Glatston 1994). The distribution of Red pandas is restricted to temperate forests at an altitude between 1500-4800 m. (Roberts and Gittleman 1984 and Glatston 1994). However, Yonzon and Hunter (1991b) only found the species at an altitude between 2800-3900 m.

Baillie et al. 2014

The distribution of the species extends from eastern Pakistan, through India from the Himalayan foothills, sporadically throughout the plains to southern India (excluding the north-east), southern Nepal and Sri Lanka (Tikader 1983, Schlitter 2005, Srinivasulu and Srinivasulu 2012).

Threats

Threatened due to habitat loss caused by deforestation (Glatston 1994 and Wei et. al. 1999a). The declining panda population is also vulnerable to poaching and illegal trade (Glatston 1994 and Wei et. al. 1999).

Threatened by intense poaching for its meat, alleged medicinal properties and use of scales for curios (CITES 2000, Misra and Hanfee 2000, Challender 2011, Mahmood et al. 2012) leading to

Status and Conservation Actions

Ailurus fulgens fulgens (Red panda)	*Manis crassicaudata* (Indian pangolin)
The species is listed in the IUCN red list as an endangered species with a very high risk of extinction in the wild (Wang et. al. 2008). Since 1995 the species is also listed by CITES as an Appendix I species. In India it is listed in the Wildlife (Protection) Act as a Schedule I species and in China as Category II species under the Chinese Wild Animal Protection Law.	The species is listed as endangered in the IUCN Red List of Threatened Species (Baillie et al. 2014); under the Schedule I of the Wildlife (Protection) Act 1972 of India and included in Appendix II of CITES.

Biological Attributes

Preferred Habitat

The species is endemic to the temperate montane forests in the eastern Himalayas. Their habitat type is characterized by mixed deciduous and conifer forests having an understory of bamboo and hollow trees (Glatston 1994; Roberts and Gittleman 1984). They inhabit an altitudinal gradient between 1500 – 4800 m (Roberts and Gittleman 1984). Williams (2003) observed highest concentration of the species between 2800 – 3000 m.	It is reported from variety of habitat types that include open grasslands, scrub and rain forests, and near human settlements (Zoological Survey of India 2002). The habitat preferences for the species have been found to be closely associated to the presence of plant species like *Zizyphus mauritiana, Acacia nilotica, Zizyphus nummularia, Prosopis cineraria* and *Lantana camara,* possibly due to the availability of termite mounds and ant's colonies on the soil below and on the trunks of these tree species (Mahmood et al. 2014).

Food Habitat

Red pandas are specialized bamboo-feeders like the giant panda (Roberts and Gittleman 1984; Glatston 1989, 1994; Wei et al. 1999) with a diet consisting of bamboo leaves throughout the year, bamboo shoots during spring and fruits and mushrooms during autumn (Johnson et. al.1988; Yonzon 1989; Reid et. al. 1991; Yonzon and Hunter 1991a, b; Hu and Wei 1992; Wei et. al. 1995). Bamboo leaves and shoots account for >95% of the annual diets (Reid et. al. 1991; Wei et al. 1995).	Pangolins are obligate myrmecophages (Redford 1987) foraging on eggs, young and adults of ants and termites (Prater 1980, Roberts 1977, Yang et al. 2007, Mahmood et al. 2013) with a preference for insect eggs over adults (Prater 1980). The most favoured food sources have been reported to be leaf nests containing eggs and adults of large red ants (Heath 1995, Mahmood et al. 2013).

Table 7.1: Reproductive attributes of identified small mammals

	Red panda	Indian pangolin
Age at first reproduction	18 months	2 years
Gestation period	111–145 days	65 - 70 days (Hayssen and Tienhoven 1993; ZSI 2002); > 80 days (Roberts 1977); 165 days (Panda et al. 2010)
Litter size	Ranging from 1 – 4	1-2 (Israel et al., 1987; , Roberts 1977; Prater 1980)

Table 7.2: Status of identified small mammals in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Red panda	3	9	15	0	24	3	9	13	2	24	3	8	13	3	24
Indian pangolin	2	5	10	0	15	2	6	5	1	12	2	3	10	2	15

Biological Attributes

Historical Population

The first recorded entry of Red panda and Indian pangolin in captivity was in 1975 and 1995 respectively, since then a total of 110 and 63 specimens respectively have entered Indian zoos. These include 18 (Red panda) and 43 (Indian pangolin) that were acquired from the wild. During this period deaths of 82 (Red panda) and 45 (Indian pangolin) have been reported while 36 and 10 specimens respectively have contributed to the captive populations. A study of figure 7.1 reveals that the populations of both have remained consistently small with mortalities being compensated by captive births in the case of Red panda, while acquisitions from the wild have been used to replace specimens that died in the case of Indian pangolin.

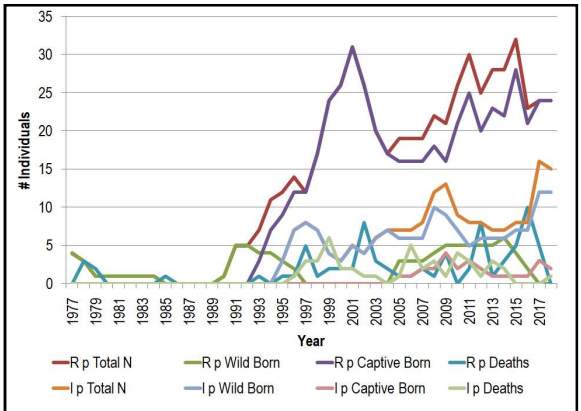


Figure 7.1: Census trends of small mammal populations

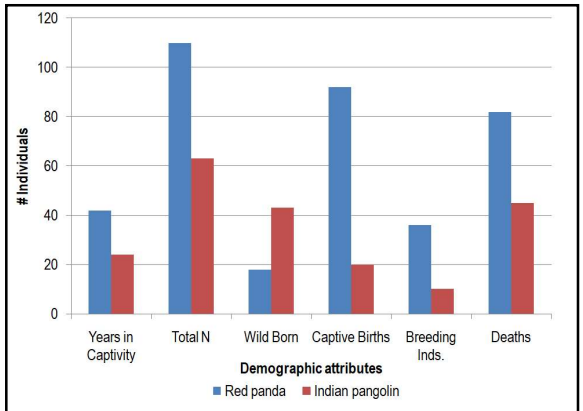


Figure 7.2: Demographic attributes of the historical populations

Living Population

The living populations of Red panda and Indian pangolin include 24 and 15 specimens respectively, of this 12 of the latter are of wild origin while all of the former are born in captivity. The populations include 10 and 4 specimens respectively that have reproduced in captivity. The age structure of Red panda reveals the presence of 65% of the population in reproductive age classes of this 29% are proven breeders. The presence of a large proportion of wild origin specimens in the Indian pangolin whose age could not be ascertained limits detailed demographic analysis.

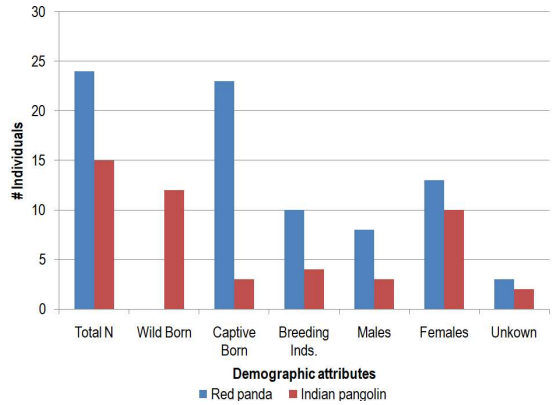


Figure 7.3: Demographic status of living populations

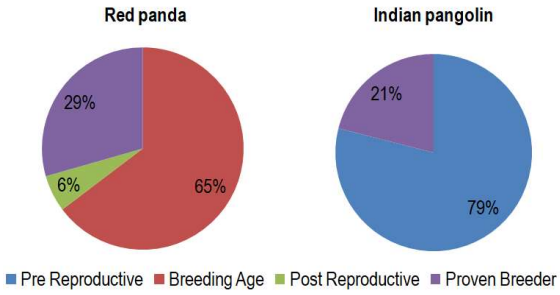


Figure 7.4: Age structure of populations

Genetic Status

The living population of 24 Red panda originates from 6 founders and has 18.25 descendants that could be traced to these founders. Complete pedigree records are available for 76% of the captive population with the presence of approximately 87% of the genetic diversity of the 6 founders. The small number of specimens in the captive population has resulted in mating between related individuals as is reflected in the values of population mean kinship (0.1348), additionally the founder genome is unequally distributed in the living population as is indicated by the value of founder genome equivalents (3.71).

The limited reproductive activity in the Indian pangolin populations constrains accuracy of genetic analysis.

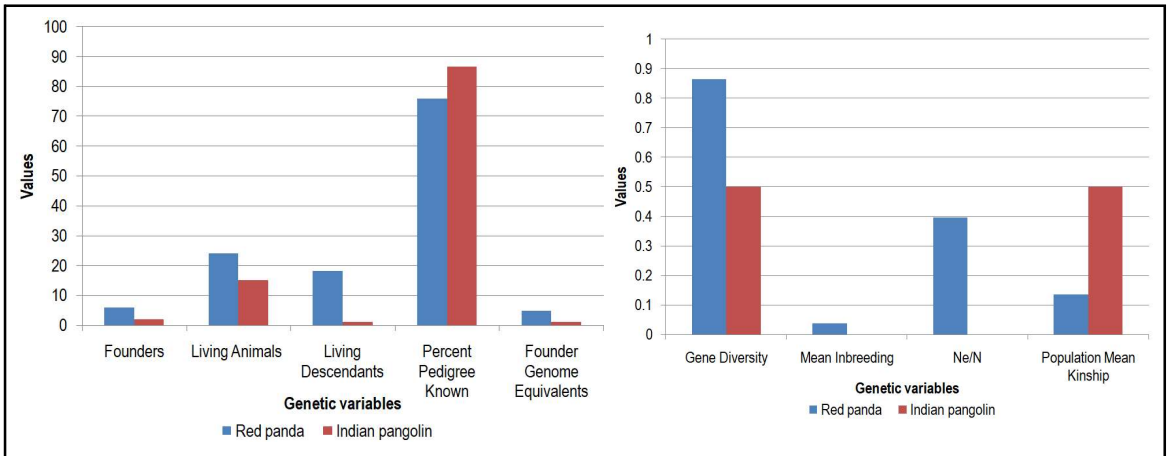


Figure 7.5: Genetic status of small mammal populations

Salient Features of the Populations of Small Mammals in Captivity

The populations of Red panda and Indian pangolin are characterized by their small size, and limited reproductive output of the latter in captivity. The small population size Red panda of has resulted in limiting mating choices and breeding between closely related individuals. The poor reproductive output and low survivorship of Indian pangolin remains a cause of concern and limits population growth.

Recommendations

Free ranging populations are susceptible to extinction as factors responsible for decline of *in-situ* populations remain operational. Intensive *ex-situ* efforts are therefore necessary to ensure maintenance of insurance populations.

The populations need to be supplemented with additional animals of breeding age to kick-start the populations to enable them to achieve conservation goals.

It is suggested that the husbandry practices of both species be critically evaluated to ascertain causes of the poor recruitment in the populations. Shortcomings identified should be addressed before acquisition of additional wild origin specimens.

8. STATUS OF IDENTIFIED AVIAN SPECIES IN CAPTIVITY

8.1 Status of Identified Pheasants in Captivity

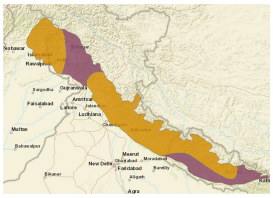
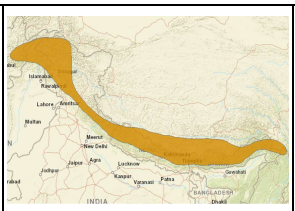
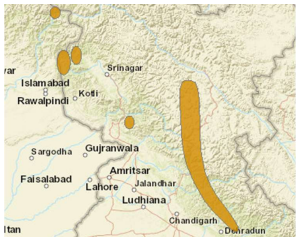
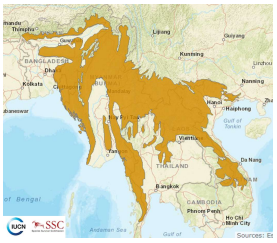
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Aves
Order	Galliformes
Family	Phasianidae
Sub-family	Phasianinae

Species

Catreus wallichii (Cheer pheasant)	*Lophophorus impejanus* (Himalayan monal)	*Tragopan melanocephalus* (Western tragopan)	*Polyplectron bicalcaratum* (Grey peacock pheasant)
			

Distribution

 BirdLife International 2014	 BirdLife International 2012	 BirdLife International 2013	 BirdLife International 2013
Foothills in the southern part of the western Himalayas, occurring in northern Pakistan, India and central Nepal.	Widely distributed from eastern Afghanistan through the Himalayas through Nepal, Bhutan till Myanmar.	Endemic to the western Himalayas, occurring from Indus-Kohistan district, north Pakistan, east through Kashmir and Himachal Pradesh to Bhagirathi River in Uttarakhand.	Across south-east Asia through north-eastern India, Bangladesh; Bhutan; Myanmar, Cambodia; China; India; Lao People's Democratic Republic; Thailand and Viet Nam.

Threats

Small isolated populations, poaching, habitat degradation, and anthropogenic disturbance (BirdLife International, 2014).	Poaching, habitat loss and degradation (del Hoyo et al. 1994). In Himachal Pradesh, the birds were poached for their meat and crests, which were used, for ornamentation.	Habitat degradation and fragmentation (Gaston et al., 1983; Jandrotia et al., 1995); disturbance (Pandey, 1993) and poaching (Islam and Crawford, 1987; Chauhan and Sharma, 1991).	Anthropogenic activities and development of linear infrastructure, in northeast India have led to habitat degradation, loss and fragmentation (Kaul, et al. 1995; BirdLife International, 2013; Lalthanzara et al. 2014).

Status and Conservation Actions

Catreus wallichii (Cheer pheasant)	*Lophophorus impejanus* (Himalayan monal)	*Tragopan melanocephalus* (Western tragopan)	*Polyplectron bicalcaratum* (Grey peacock pheasant)
Schedule I of the Wildlife (Protection) Act of India, 1972 Vulnerable on the IUCN Red List Appendix I of CITES	State bird of Uttarakhand Schedule I of the Wildlife (Protection) Act 1972 of India Least concern in the IUCN red list Appendix I of CITES.	Protected under Schedule I, of the Indian Wildlife (Protection) Act 1972. It is listed as "Vulnerable" by the IUCN (C2a (i) ver 3.1) and in Appendix I of CITES.	Schedule I of the Indian Wildlife (Protection) Act (1972); however, its large range and limited tolerance of anthropogenic disturbance has led to its listing as a species of Least Concern (BirdLife International, 2013) and accordingly in Appendix II of CITES.

Biological Attributes

Preferred Habitat

The species inhabits a wide altitudinal range in the Western Himalayas in areas having steep slopes and scattered trees, especially where rocky cliffs and ravines are present. They usually prefer terrain with steep gradients that are characterized by a combination of low shrubs and tall, dense grass during spring (Ali and Ripley, 1998; Kalsi, 1998; Roberts, 1991; Roberts, 1992; Gaston et al., 1981; Garson et al., 1992; Baral et al., 1996).	The Himalayan Monal is a high altitude species inhabiting steep slopes and cliffs with a rocky terrain interspersed with grass and wood patches. The altitudinal range utilized varies between 2400 and 4500 m, with highest occupancy occurring at a narrow stretch of 2700 and 3700 m asl (Grimmett, et al. 1998). They show seasonal altitudinal migrations (Gaston, et al. 1981), mostly distributed at altitudes between 2620 m and 3350 m in summer and 2000m and 2800m in winter; with relative preference to sub alpine oak forest in spring and conifer dominated forests during winter (Ramesh, 2003).	A habitat specialist (Ramesh, 2003) occurring in open moist deciduous and coniferous temperate forests with dense undergrowth at elevations of 2,400–3,600 m (Delacour, 1977, Grimmett, et al., 1998). They inhabit montane to sub-alpine areas with specific broadleaved (e.g., *Aesculus indica, Acer sp.* and *Betula utilis*) and coniferous (*Cedrus deodara, Pinus wallichiana, Abies pindrow, Picea smithiana*) vegetation (Duke, 1989).	Grey peacock pheasants inhabit tropical and sub-tropical montane and lowland moist, broad-leaved evergreen and semi-evergreen forests with dense under storey, including bamboo (Madge and McGowan, 2002). They commonly utilize hilly terrain dominated by dense thorny vegetation and bamboo forests, patches with thick cover along streamside banks, heavy undergrowth and relatively undisturbed small tree forests that are ideal habitats for the species (Johnsgard, 1986).

Food Habits

Catreus wallichii (Cheer pheasant)	*Lophophorus impejanus* (Himalayan monal)	*Tragopan melanocephalus* (Western tragopan)	*Polyplectron bicalcaratum* (Grey peacock pheasant)
Ali and Ripley, (1998) suggested that roots and tubers dug out of the ground, seeds, berries and grain, formed the main food of this pheasant. Wayre, (1969) regarded roots as an important food item of Cheer in addition to insects and grubs while Delacour, (1977) opined grubs to be an important food source for the species. Lelliott, (1981) from diet analysis regarded mosses as important part of the diet while Kaul, (1989) observed a completely herbivorous diet for the species.	Feed on tender leaves, seeds, shoots, berries, tubers, nuts and insects and their larvae (Ramesh, 2003). They mainly feed by digging with the beak, searching for underground tubers, bulbs or fleshy root.	Sprouting oak leaves, shrubs like ringal bamboo *Arindunaria spp*. and other plant materials (Johnsgard, 1986, Schales and Schales, 1994)	Grey peacock pheasants primarily feed on seeds, grains, berries, fruits and invertebrates, with a preference for termites (Ali and Ripley, 1978). They usually forage among leaf litter with slow and precise movements, with the birds gently scratching and moving silently through the dense undergrowth (Madge and McGowan, 2002).

Table 8.1.1: Reproductive attributes of identified pheasant species

	Cheer pheasant	Himalayan monal	Western tragopan	Grey peacock pheasant
Age of sexual maturity	3 year (Ramesh, K. Personal communication)	2 years		1 year (Flieg, 1973)
Mating System	Monogamous	Polygynous	Monogamous	Monogamous
Breeding Season	Late April- June	April to August	May- early June	March- June, mainly April-May (Johnsgard, 1986)
Nest Site/ Type	Nest, a hollow or pit in the ground in undergrowth; below the shelter of a rock or cliff,	Ground nester with shallow unlined scrapes in grass patches often sheltered by rocks or trees serving as nests.	Elevated nesters	On ground among thick vegetation (Baker, 1930)
Clutch Size	9 – 10	3 – 6	2 – 6	2 (Madge and McGowan, 2002)
Eggs	Pale yellowish -grey with reddish-brown speckles	Pale-yellow or reddish buff in colour with reddish brown markings.	Pale- buff to reddish-brown feebly freckled with dark brown	Pale cream to rich chocolate-buff, white-stippled (Madge and McGowan, 2002)
Incubation Period	26 days	26 – 29 days	28 days	21 days (Johnsgard, 1986)
Parental care	Incubation is done by female alone, males remain close by and attend to chicks after hatching	Provided by the female.	Incubation entirely by hen but males have been reported to attend to chicks	Incubation entirely by hen

Sources: Baker, (1930); Johnsgard, (1986); Madge and McGowan, (2002); Ali and Ripley, (1998); Ramesh, (2003)

Table 8.1.2: Status of Identified Pheasants in Captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Grey peacock pheasant	1	1	1	3	5	7	11	3	0	14	6	11	5	0	16
Cheer pheasant	3	6	6	19	31	5	14	21	3	41	3	14	26	5	45
Himalayan monal	2	1	2	0	3	5	19	8	0	27	3	2	3	0	5
Western tragopan	1	11	12	0	23	2	16	13	8	37	2	18	20	0	38

Demographic Status

Historical Population

The first recorded entry of Grey peacock pheasant was in 1971, while Himalayan monal, Cheer pheasant and Western tragopan entered zoos in 1988, 1990 and 1993 respectively. The census trends the four species indicate a continued small population size, with absence of relevant records on the source of birds used to establish the captive population of Grey peacock pheasant. While 7, 15 and 13 birds were acquired from the wild for establishing the populations of Himalayan monal, Cheer pheasant and Western tragopan respectively.

Since inception 86 captive hatches have been reported in the population of Grey peacock pheasant while 19, 346 and 55 captive hatches respectively are reported for the populations of Himalayan monal, Cheer pheasant and Western tragopan. At the same time 80 birds of Grey peacock pheasant 21, 316 and 30 respectively are reported to have died in captivity for the populations of Himalayan monal, Cheer pheasant and Western tragopan. All the populations except for Cheer pheasant have remained consistently small with the total number of birds in any given year remaining below 50 birds.

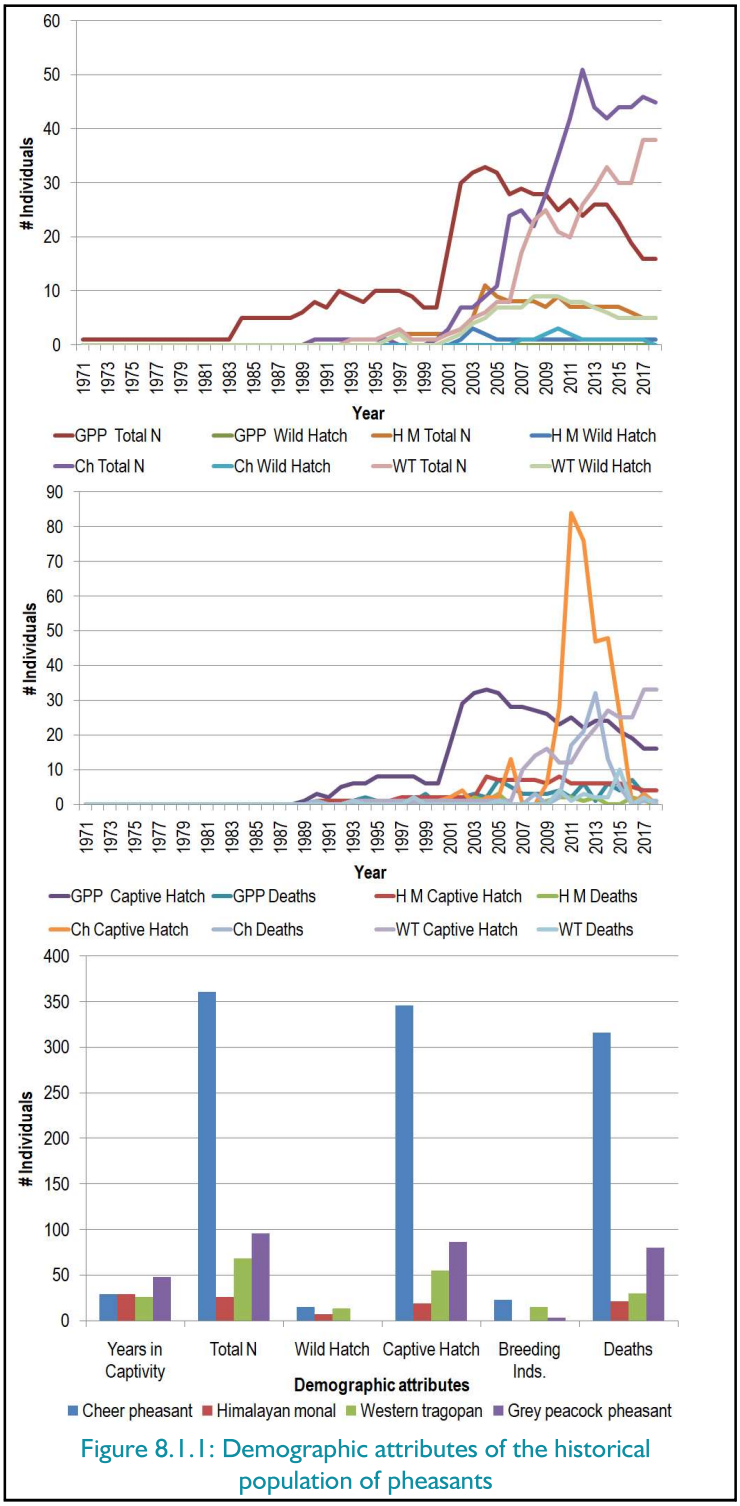


Figure 8.1.1: Demographic attributes of the historical population of pheasants

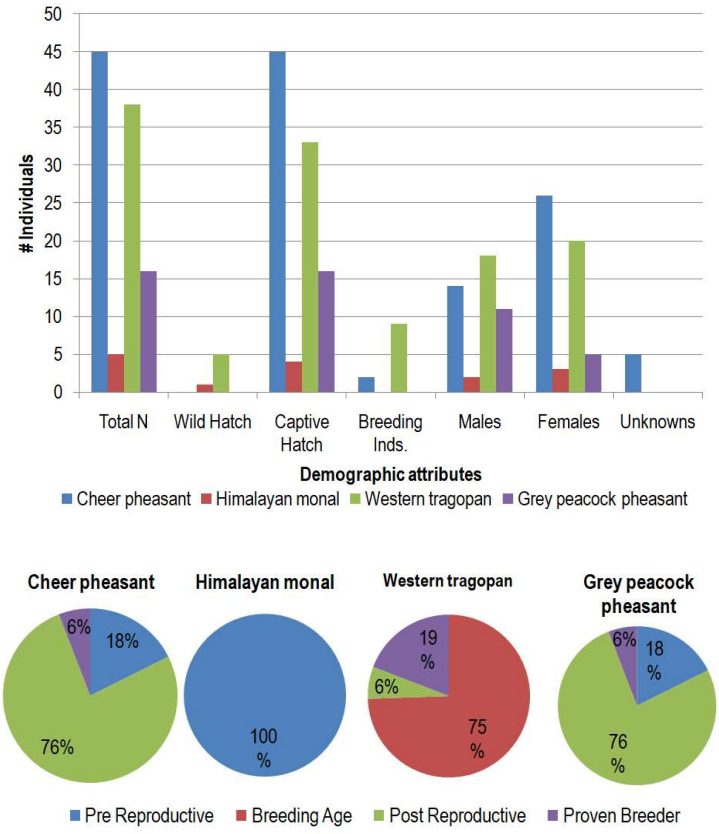


Figure 8.1.2: Demographic attributes of the living population of pheasants

Living Population

The living populations of all species except Cheer pheasant (N = 45) and Western tragopan (N = 38) are characterized by their exceedingly small size (≤ 20 birds). All birds in the populations of Cheer pheasant and Grey peacock pheasant are of captive origin, while one and five wild origin birds are present in the populations of Himalayan monal and Western tragopan respectively. Lack of necessary records limited an analysis of the age structure and reproductive activity for Himalayan monal while the analysis of available records indicates that the population of Cheer pheasant and Grey peacock pheasant consist of a large proportion of reproductively senescent birds (76% of the populations). The population of Western tragopan however includes 79% birds of reproductively active ages with 19% of the population having reproduced in the past.

Genetic Status

Lack of information of ancestry for Cheer pheasant, Himalayan monal and Grey peacock pheasant constrained genetic analysis of their captive populations. Parentage information was available for 74% of the population for Western tragopan and the genetic analysis performed revealed that the current population of 38 birds originates from eight wild origin founders and retains 87.26% of the genetic diversity originating from them; however, the founder genome of only 3.93 birds is present in the current population. The small population size and limited number of founders has resulted in a mean kinship coefficient of 0.127.

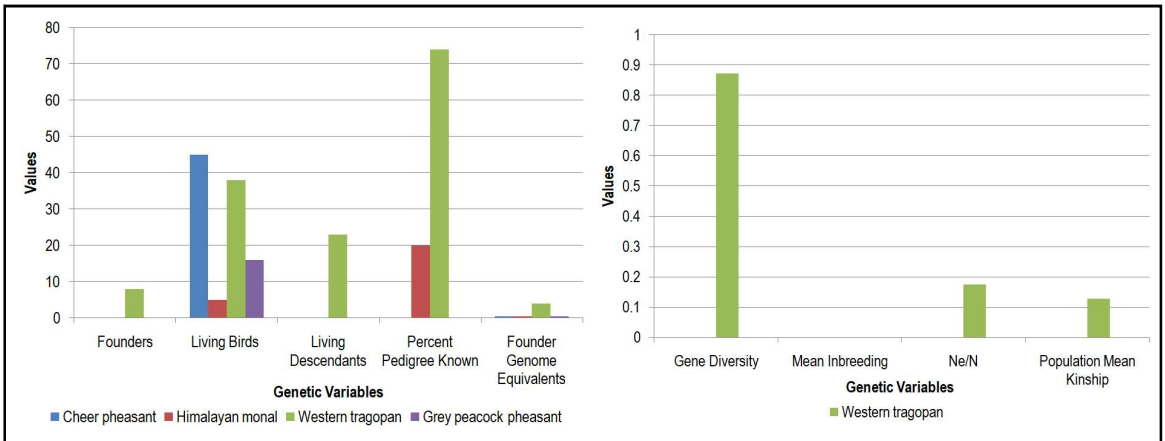


Figure 8.1.3: Genetic attributes of captive pheasant populations

Salient Features of the Populations of Pheasants in Captivity

The populations of pheasants in captivity have consistently remained small (N < 50) with the exception of Cheer pheasant. Increase in number of specimens in all the populations is accounted for by captive hatches. Lack of information on life history events of specimens in the population of Himalayan monal limited detailed demographic analysis. The populations of Cheer pheasant and Grey peacock pheasant consist of a large proportion of reproductively senescent birds; however, the population of Western tragopan includes 79% birds of reproductively active ages.

Lack of information on ancestries of individual specimens constrained genetic analysis of all populations with the exception of Western tragopan that retains 87.26% of the genetic diversity originating from 8 founders, with the founder genome unequally represented in the population.

The limited number of wild origin specimens and continued small size of the other populations are suggestive of the presence of low levels of genetic diversity present with closely related specimens.

Recommendations

Lack of records on individual life history events and parentages highlights the need for use of effective marking techniques matched with accurate record keeping to ensure development of effective population management plans for the species.

The limited use of wild origin birds in the populations highlights the need for inclusion of additional wild origin specimens to kick-start the populations and to enhance the genetic variability present in the populations.

The use wild origin birds acquired for the programs should be judiciously used based on an understanding of the population genetic structure of the populations using appropriate molecular genetics techniques.

8.2 Status of Identified Vultures in Captivity

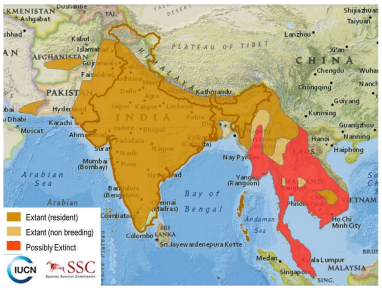
Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Aves
Order	Accipitriformes
Family	Accipitridae

Species

G. bengalensis (White-rumped vulture)	*G. indicus* (Long billed vulture)	*G. tenuirostris* (Slender billed vulture)
		

Distribution

 BirdLife International (2016a)	 BirdLife International (2016b)	 BirdLife International (2016c)
Distribution range extends from Iran, Pakistan and south-east Afghanistan in the west to southern Vietnam in the east. Extinct from large parts of its historic range east of Burma (BirdLife International 2016a).	Indo-Gangetic plains in the north to peninsular India in the south, (absent from most of Tamil Nadu) Sindh, Pakistan in the west to West Bengal, India in the east (BirdLife International 2016b).	The Ganga – Brahmputra basin in India and parts of Mynmar and Cambodia. Believed to be locally extinct across a large part of its range in south and south-east Asia. (BirdLife International 2016c).

Threats

Diclofenac, a non-steroidal anti-inflamatory drug is attributed for the drastic decline of the three *gyps* vulture species. Additional factors responsible for their decline include decline in availability of carrion, carcass poisoning and pesticide poisoning and diseases (Green et al. 2004, Oaks et al. 2004, Shultz et al.2004; Gilbert et al. 2006; Cuthbert, et al. 2011).

Status and Conservation Actions

Drastic declines were reported for the three species (Prakash et al., 2003). Based on the declines in population size, all the three species are listed as critically endangered by BirdLife International (2016 a, b and c) and in Schedule I of the Wildlife (Protection) Act.

The veterinary use of diclofenac has been banned and substituted by meloxicam, a drug that does not induce gout in vultures (Swarup, et al. 2007; BirdLife International, 2008; Prakash, et al. 2012). The three species have also been identified as priority species for *ex-situ* conservation in the country.

Biological Attributes

Preferred Habitat

The three species inhabit varied habitat types that range from evergreen to dry-deciduous to semi-arid areas. They roost and nest communally with group sizes varying between species (BirdLife International 2016 a, b, and c). White rumped and long billed vultures have been reported in large numbers from areas with abundant food supply whereas Slender billed vulture inhabits open or forested areas away from human settlements (BirdLife International 2016 a, b & c). The preferred roosting and nesting sites of White rumped and Slender billed vultures include tall branching trees and electricity pylons, (Naoroji, 2006) whereas Long billed vultures roost and nest on rocky cliffs (BirdLife International 2016 b).

Food Habits

All the three species of vultures are exclusive scavengers feeding on carrion of livestock and other large

Reproduction

They are monogamous species with an elaborate courtship flight followed by mating on or in close proximity of the nest. The peak breeding seasons extends from March–April (Prakash, 1999). A single egg is laid in a nest made of a platform of twigs (Sharma 1970; Prakash 1999). The incubation period is estimated to be 45–52 days 45 – 52 days with both parents providing parental care. The chick is fed on regurgitated pieces of meat (Brown and Amadon 1968; Sarker and Iqbal 1997; BirdLife International 2001), and chicks remain in the nest for 2–3 months (Brown and Amadon 1968).

Status in Captivity

The three species of vultures identified for ex-situ conservation are critically endangered and are maintained in *ex-situ* facilities primarily in India. The status of the captive populations of the three species based on data uploaded on the Species360 website, CZA inventory (2017 – 2018) and the information included in the studbook (based on information made available by holding zoos and the taxon report from the Species360 website is summarized below in table 8.2.1. The differences in the number of specimens reported from the three data sources indicate shortcomings in the reporting process.

Table 8.2.1: Status of identified vultures in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
White rumped vulture	7	28	18	130	166	11	24	21	133	178	8	17	15	120	152
Long billed vulture	4	20	22	112	154	8	19	18	135	172	7	19	21	147	187
Slender billed vulture	1	5	5	28	38	1	5	5	28	38	1	6	5	28	39

Demographic Status

Historical Population

The first recorded entry of White rumped vulture in captivity was in 1986, while that of Long billed vulture in 2002 and Slender billed vulture in 2007; since then respectively a total of 173, 187and 39 birds have been reported. These include 142 (White rumped vulture), 75 (Long billed vulture) and 14 (Slender billed vulture) that have been acquired from the wild, while 20, 35 and 11 birds respectively have contributed to the populations. During this period deaths of 21 (White rumped vulture) and 7 (Long billed vulture) have been recorded while no mortality has been reported for the population of Slender billed vulture.

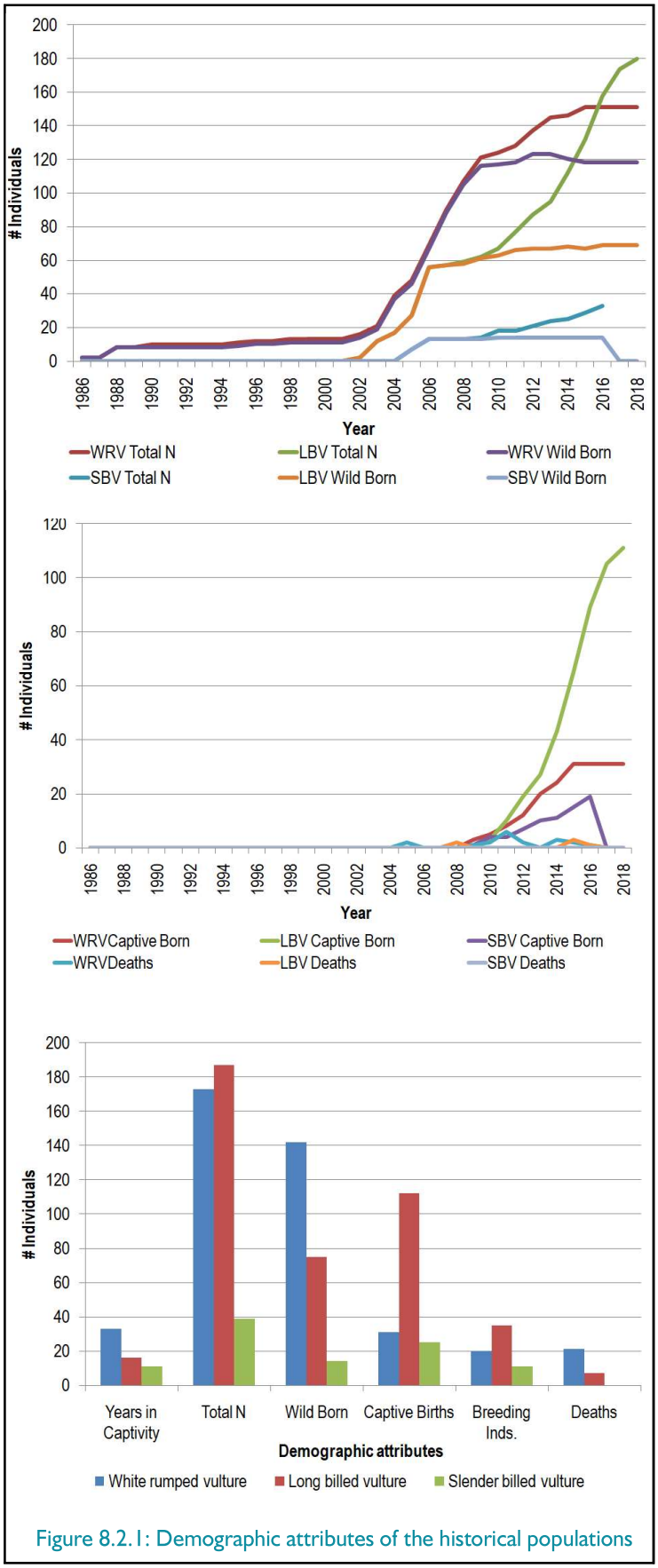


Figure 8.2.1: Demographic attributes of the historical populations

Living Population

The current captive populations include 152 (White rumped vulture), 180 (Long billed vulture) and 39 (Slender billed vulture) birds, of this 121, 69 and 14 respectively have been acquired from the wild. The populations include 20 (White rumped vulture), 35 (Long billed vulture) and 11 (Slender billed vulture) birds that have contributed to their populations.

Based on available records the population of White rumped vulture includes 148 birds of pre-reproductive ages, 4 of post-reproductive ages, while 20 birds have contributed to the population. The population of Long billed vulture includes 158 birds of pre-reproductive ages, 8 birds of reproductive age and 4 of post-reproductive ages, while 35 birds have contributed to the population. The population of Slender billed vulture includes 21 birds of pre-reproductive ages, 14 birds of reproductive age and 3 of post-reproductive ages, while 11 birds have contributed to the population.

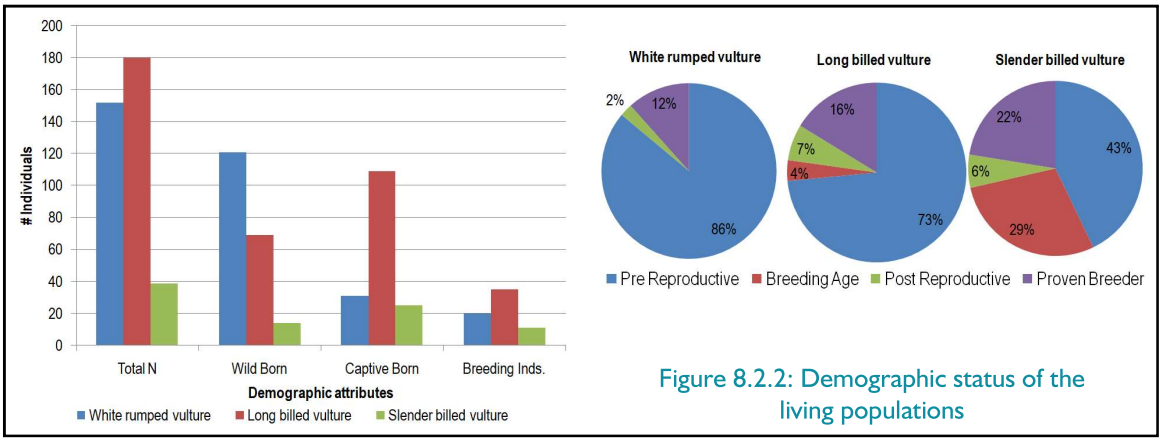


Figure 8.2.2: Demographic status of the living populations

Genetic Status

The current populations of White rumped vulture, Long billed vulture and Slender billed vulture originate from 20, 33 and 11 founders respectively and have 31, 110 and 24 living descendants that can be traced back to these founders. Pedigree records are available for 99%, 99.4% and 97% of the birds present in the populations of White rumped vulture, Long billed vulture and Slender billed vulture respectively with the populations retaining 95.73%, 97.98% and 92.93% respectively of the genetic diversity of the founders present in their populations.

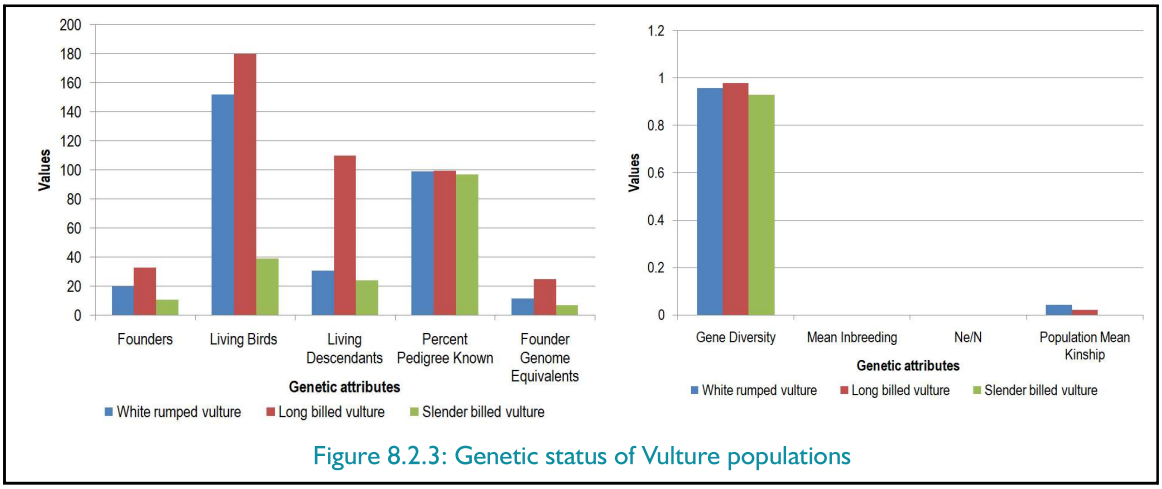


Figure 8.2.3: Genetic status of Vulture populations

Salient Features of the Populations of *Gyps* Vultures in Captivity

Analysis of the studbooks of the three species reveals the following:

1. A large proportion of the birds remain unsexed in the populations of all three species.

2. The populations of Long billed vulture and Slender billed vulture have a significant proportion of birds hatched in captivity; however, for White rumped vulture reproduction has been limited and wild origin birds continue to form a major portion of the population.

3. A majority of the birds are of wild origin; however, relatedness between individuals is not known.

Recommendations

1. The species are monomorphic and determination of gender is possible using molecular methods. All new wild origin birds should be suitably marked at the time of their entry into captivity and appropriate samples collected for determination of gender. Collection of samples and marking of birds already in captivity may be opportunistically carried out as and when they are handled.

2. The housing and husbandry practices adopted for White rumped vulture need review and shortcomings if any, need to be addressed appropriately.

3. Relatedness between individuals can be assessed by using appropriate molecular genetics analyses of biological samples collected for determination of gender.

8.3 Status of Nicobar Pigeon in Captivity

Taxonomy

Kingdom	Animalia
Phylum	Chordata
Class	Aves
Order	Columbiformes
Family	Columbidae

Species

Caloenas nicobarica
(Nicobar pigeon)

Distribution

The subspecies/ race *Caloenas nicobarica nicobarica* occurs from Nicobar islands in India, through Mergui archipelago (Myeik Kyunzu), Myanmar, islands off south-west peninsular Thailand, islands around Peninsular Malaysia, islands off southern Cambodia and Vietnam, islands around Sumatra, Wallacea and Papua (formerly Irian Jaya), Indonesia, possibly also Timor-Leste, many islands in the Philippines islands in Papua New Guinea to the Solomon Islands. The subspecies/ race *C. n. pelewensis* is reported from the Palau islands (BirdLife International 2001).

BirdLife International 2001

Distribution in India

The subspecies/ race *C. n. nicobarica* inhabits small islands in coastal regions in the Nicobar Islands, with few reports suggesting the presence of birds northwards upto Coco island in Andamans (Ali and Ripley 1969).

Threats

It is believed to be declining due to habitat destruction, trapping for food and as part of the pet trade as well as due to introduced predators (BirdLife International. 2016). The tsunami of 2004 is believed to have reduced available habitat due to destruction of coastal forests (Porwal et al. 2012).

Status and Conservation Actions

It is therefore placed in Schedule I Part III of the Wildlife Protection Act of India, while the IUCN Red List of Threatened Species classifies it as a Near Threatened species. The species is in extensive illicit trade of live birds and body parts for various uses and is included in appendix I of CITES.

Biological Attributes

Preferred Habitat

The species nests on small tropical islands with dense coastal forests in the Indo-Australian realm and move to larger islands with dense forest cover for feeding. The preferred area of occupancy is from sea level to 500 m (Gibbs et al. 2001). The smaller islands are used during the breeding season while the larger islands with presence of large number of fruiting trees are preferred during the non-breeding season (Gibbs et al. 2001).

Food Habits

Foraging activity is primarily limited to the ground where they forage on fallen fruit and any invertebrates that they encounter. The species is able to digest hard seeds and nuts due to the presence of a muscular thick walled gizzard, lined with horny plates.

Table 8.3.1: Reproductive attributes of Nicobar pigeon

Age at first reproduction	Gestation period	Clutch size
12 months	30 days	1

Table 8.3.2: Status of Nicobar pigeon in captivity

	Species360					CZA Inventory (2017 – 2018)					Studbook				
	Insts.	M	F	U	T	Insts.	M	F	U	T	Insts.	M	F	U	T
Nicobar pigeon	3	0	1	30	31	1	0	0	30	30	1	0	0	30	30

Demographic Status

Historical Population

Available records indicate the presence of the species in captivity for the first time in 1974, with the specimens being acquired from private dealers. The population was initiated with 6 birds and the current population includes their descendants. The population has continuously remained small (N < 50). Available records indicate the occurrence of 59 live hatches and 48 deaths since 1974.

A detailed demographic analysis of the population could however not be carried out due to lack of records on life-history events of individual specimens.

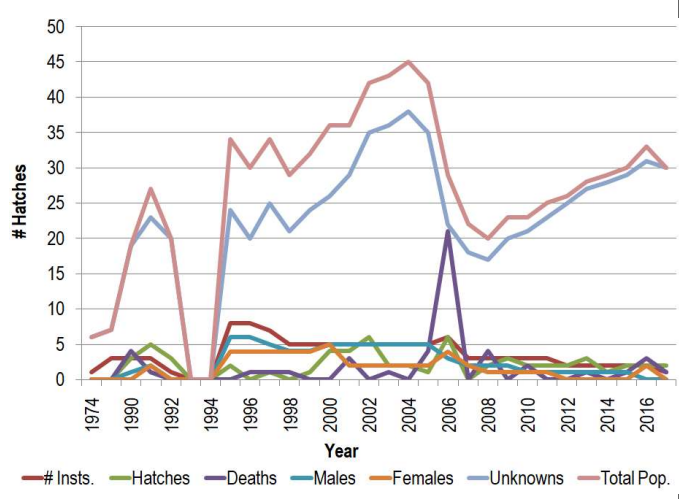


Figure 8.3.1: Status of Nicobar pigeon in Indian zoos

Living Population

The living population based on records made available indicates the presence of 30 birds of unidentified gender at a single location.

Genetic Status

Lack of information on parentage of birds constrains genetic analysis of the population. Records indicate that the population was established with 6 founder birds and the current population descends from these birds. This is suggestive of pairing between closely related individuals due to the lack of available mating choices with the population retaining limited genetic diversity available from the small founder base used to establish the population.

Salient Features of the Nicobar Pigeon Population in Captivity

The population has remained small throughout its history in captivity, with limited records available for analysis and development of a management plan for the species.

The population has contributions from only 6 individuals acquired from a dealer in 1974, this indicates the presence of limited genetic heterozygosity in the captive population.

Recommendations

Maintenance of detailed records of life-history events of individuals/ groups through tagging of birds.

Collection of biological samples at the time of tagging for molecular genetics studies for assessing:

- The sex of individual specimens.
- Relatedness between individuals and the heterozygosity retained by the existing population.

The information obtained from the molecular genetic studies can be used for developing pairing recommendations for the species in captivity and the level of supplementation required for maintaining desired levels of genetic heterozygosity.

References

1. Ahsan, M.F. (1994). Behavioural ecology of the hoolock gibbon (*Hylobates hoolock*) in Bangladesh. PhD dissertation, University of Cambridge, Cambridge (UK).
2. Ali, S. and Ripley, S.D. (1998). Handbook of the birds of India and Pakistan. Delhi: Oxford University Press.
3. Ali, S. and S. D. Ripley. (1969). Handbook of the birds of India and Pakistan, 3. Bombay: Oxford University Press.
4. Ali. S. and Ripley. S.D. (1978). Handbook of the Birds of India and Pakistan. Vol. 2. Oxford University Press. London.
5. Angom, S. A. (2012). Demographic Status and Genetic Variation of Sangai (*Cervus eldi eldi*) in Keibul Lamjao, PhD thesis, Saurashtra University, Rajkot.
6. Angom, S., Kumar, A., Gupta, S.K. and Hussain, S.A. (2017). Analysis of mtDNA control region of an isolated population of Eld's deer (*Rucervus eldii*) reveals its vulnerability to inbreeding. Mitochondrial DNA Part B: Resources, 2017 Vol. 2, No. 1, 277–280 https://doi.org/10.1080/23802359.2017.1325335.
7. Anon. (2016). International Studbooks for rare species of wild animals in captivity, Int. Zoo Yb. (2016) 50: 407–437. The Zoological Society of London.
8. Areendran, G. (2007). A Study on vegetation ecology in Pench Tiger Reserve, Madhya Pradesh with reference to Gaur (*Bos gaurus*), Ph.D. Thesis, Saurashtra University, India.
9. Aryal, A. (2008). Status and Conservation of Himalayan serow (*Capricornis sumatraensis thar*) in Annapurna Conservation Area of Nepal. BRTF Nepal: A Report Submitted to the Rufford Small Grant for Nature Conservation, UK and the People's Trust for Endangered Species, UK, 57 pp.
10. Aryal, A. (2009). Habitat ecology of Himalayan serow in Annapurna Conservation Area of Nepal. Tigerpaper, 36 (4): 12-20.
11. Ashokkumar, M., Swaminathan, S., Nagarajan, R. and Desai, A.A. (2011). Distribution, ecology and conservation of the Gaur (*Bos gaurus*, H. Smith, 1824). In: V.K. Gupta and A.K. Verma (eds), Animal diversity, natural history and conservation, pp. 77-94. Daya publishing house, New Delhi, India.
12. Aziz, M.A. and Feeroz, M.M. (2009). Utilization of forest flora by Phayre's Leaf-Monkey *Trachypithecus phayreii* (Primates: Cercopithecidae) in semi-evergreen forests of Bangladesh. Journal of Threatened Taxa. Vol. 1(5): 257-262.
13. Azlan, M. J. and Sharma D. S. (2006). The diversity and activity patterns of wild felids in a secondary forest in Peninsular Malaysia. Oryx 40, 36-41.
14. Bagchi, S. and Mishra, C. (2006). Living with large carnivores: predation on livestock by the snow leopard *Uncia uncia.* J. Zool. (Lond.) 268, 217–224.
15. Baillie, J., Challender, D., Kaspal, P., Khatiwada, A., Mohapatra, R. & Nash, H. (2014). *Manis crassicaudata*. The IUCN Red List of Threatened Species 2014: e.T12761A45221874.http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12761A45221874.en . Downloaded on 5 November 2015.
16. Baker, E.C.S. (1930). Game-birds of India, Burma and Ceylon. John Bale and Son, London.
17. Ballou, J.D., Lacy, R.C. and Pollak, J.P. (2011). PMx: software for demographic and genetic analysis and management of pedigreed populations (version 1.2). Chicago Zoological Society, Brookfield, IL, USA. Available from: http://www.vortex10.org/PMx.html.
18. Baral, H. S., Inskipp, C., Inskipp, T. P. and Regmi, U. R. (1996). Threatened birds of Nepal. Bird Conservation Nepal and Department of National Parks and Wildlife Conservation 13 pp.
19. Baskaran, N., Kannan, V., Thiyagesan, K. and Desai, A.A. (2011). Behavioural ecology of Four-horned antelope (*Tetracerus quadricornis* de Blainville, 1816) in the tropical forests of southern India. Mammalian Biology-Zeitschrift für Säugetierkunde 76 (6), 741-747.
20. Belsare, A. V, Vanak, A. T, and Gompper, M. E. (2014). Epidemiology of viral pathogens of free-ranging dogs and Indian foxes in a human-dominated landscape in central India. Transboundary and Emerging Diseases 61: 78-86.

21. Berwick, S. 1976. The Gir Forest: an endangered ecosystem. American Scientist 64: 28-40.

22. Bezbaruah, P. (2004). Habitat Status of the Golden Langur: *Presbytis geei* (Khajuria) with Special Reference to Availability of Specific Food Plants. Report to Primate Conservation, Inc., Charlestown, Rhode Island.

23. Bhattacharya, T. and Sathyakumar, S. (2010). Sighting of Tibetan wolf (*Canis lupus chanco*) in the Greater-Himalayan range of Nanda Devi Biosphere Reserve, Uttarakhand, India: a new record. Journal of Threatened Taxa 2(12): 1345-1348.

24. Bhattacharya, T., Bashir, T, Poudyal, K., Sathykumar, S. and Saha, G. K. (2012). Distribution, occupancy and activity patterns of goral (*Nemorhaedus goral*) and serow (*Capricornis thar*) in Khangchendzonga Biosphere Reserve, Sikkim, India. Mammal Study, 37: 173–181.

25. Bicknell, J. and Peres, C. A. (2010). Vertebrate population responses to reduced-impact logging in a neotropical forest. Forest Ecology and Management, 259: 2267–2275.

26. BirdLife International (2013). *Tragopan melanocephalus*. The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 7 July 2015.

27. BirdLife International. (2001). Threatened birds of Asia: the BirdLife International Red Data Book. BirdLife International, Cambridge, U.K.

28. BirdLife International. (2008). Drugs firms told to do more to prevent vulture extinctions. Available at: #http://www.birdlife.org/news/news/2008/08/indian_drug_announcemment.html#.

29. BirdLife International. (2012). Lophophorus impejanus. The IUCN Red List of Threatened Species2012:e. T22679182A40112162. http://dx.doi.org/10.2305/IUCN.UK.20121.RLTS.T22679182A40112162. en. Downloaded on 6 June 2016.

30. BirdLife International. (2013). *Polyplectron bicalcaratum*. The IUCN Red List of Threatened Species 2013: e.T22736199A50467064. http://dx.doi.org/10.2305/IUCN.UK.2013-2.RLTS.T22736199A50467064.en. Downloaded on 26 April 2016.

31. BirdLife International. (2014). *Catreus wallichii*. The IUCN Red List of Threatened Species 2014:e.T22679312A62707859. http://dx.doi.org/10.2305/IUCN.UK.20142.RLTS.T22679312A62707859.en. Downloaded on 22 May 2016.

32. BirdLife International. (2016). *Caloenas nicobarica*. The IUCN Red List of Threatened Species 2016: e.T22690974A93297507. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22690974A93297507.en.

33. BirdLife International. (2016a). *Gyps bengalensis*. The IUCN Red List of Threatened Species 2016: e.T22695194A93495642. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22695194A93495642.en. Downloaded on 18.01.2017.

34. BirdLife International. (2016b). *Gyps indicus*. The IUCN Red List of Threatened Species 2016: e.T22729731A95021258. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22729731A95021258.en. Downloaded on 18.01.2017.

35. BirdLife International. (2016c). *Gyps tenuirostris*. The IUCN Red List of Threatened Species 2016: e.T22729731A95021258. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22729731A95021258.en. Downloaded on 18.01.2017.

36. Biswas, J. (2005). Manas Biosphere Reserve, the last refuge of golden leaf monkey! In: Heritage Manas – The Manas Biosphere Celebration Commemorative Souvenir N.K. Dey (ed.), pp.23–25. Manas Biosphere Conservation Forum, Bongaigaon, Assam.

37. Bleisch, B., Brockelman, W., Timmins, R.J., Nadler, T., Thun, S., Das, J. and Yongcheng, L. (2008). *Trachypithecus phayrei*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 03 March 2014.

38. Boonratana, R., Das, J., Yongcheng, L., Htun, S. and Timmins, R.J. (2008). *Macaca leonina*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 03 March 2014.

39. Bose, J. (2003). Conservation Survey of Phayre's leaf Monkey. Wildlife Trust of India, 1: 1-36.

40. Bose, J. and Bhattacharjee, P.C. (2002). Behavioural profile of a troop of Phayre's leaf monkey (*Trachypithecus phayrei*) in a fragmented and disturbed habitat, northeast India. (abstract) XIX Congress of the International Primatological Society. Beijing, China, 0287.

41. Bose, J. and Bhattacharjee, P.C. (2004). Feeding behavior of a Phayre's leaf monkey (*Trachypithecus phayrei*) troop in Sepahijala Wildlife Sanctuary, Tripura, India. (abstract) XX Congress of the International Primatological Society. Beijing, China, 0272.

42. Breitenmoser, U., Mallon, D.P., Ahmad Khan, J. and Driscoll, C. (2008). *Panthera leo ssp. persica*. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on 04 July 2014.

43. Brockelman, W., Molur, S. and Geissmann, T. (2008). *Hoolock hoolock*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 24 October 2014.

44. Brown L. H. and Amadon, D. (1968). Eagles, Hawks and Falcons of the World. Country Life Books, Feltham.

45. Caldecott J.O. (1986). An ecological and behavioural study of the pig-tailed macaque. In: Szalay FS, editor. Contributions to primatology, Vol. 21. Basel (Switzerland): Karger. 259 p.

46. Chakrabarti, S., Jhala, Y.V., Dutta, S., Qureshi, Q., Kadivar, R.F. and Rana, V.J. (2016). Adding constraints to predation through allometric relation of scats to consumption. Journal of Animal Ecology, 85: 660–670, doi: 10.1111/1365-2656.12508.

47. Challender, D.W.S. (2011). Asian Pangolins: increasing affluence driving hunting pressure. TRAFFIC Bulletin, 23(3): 92–93.

48. Champion, H.G. and Seth, S.K. (1968). A revised survey of the forest types of India. Manager of Publication Government of India, New Delhi. 404 pp.

49. Chauhan, B.S. and Sharma, V. (1991). Status of Western tragopan in Himachal Pradesh, India. WPA News 34:25–28.

50. Chellam, R. (1993). Ecology of the Asiatic lion (*Panthera leo persica*). Ph.D. thesis, Saurashtra University, Rajkot.

51. Chellam, R. and Johnsingh, A.J.T. (1993). Management of Asiatic lions in the Gir Forest, India. Symposia of The Zoological Society of London 65: 409-424.

52. Chetry, D., Chetry, R. and Bhattacharjee, P.C. (2007). Hoolock: The Ape of India. Gibbon Conservation Centre, Gibbon Wildlife Sanctuary, Mariani, Assam, India. 133pp.

53. Chivers, D. J., (1984). Feeding and ranging in gibbons: A summary. In: The Lesser Apes: Evolutionary and Behavioural Biology, H. , Preuschoft, D. J. Chivers,W. Y. Brokelman, and N. Creel (eds.), Edinburgh Univ. Press, Edinburgh, pp. 267–281.

54. Choudhury A. U. (2003). The pig-tailed macaque *Macaca nemestrina* in India- status and conservation. Prim Cons 19: 91-8.

55. Choudhury, A. (1987). Notes on the distribution and conservation of Phayre's leaf monkey and hoolock gibbon in India. Tiger Paper. Vol. 14(2), 2-6.

56. Choudhury, A. (1994a). Phayre's leaf monkey (*Presbytis phayrei*) in northeastern India. Tiger paper 21(3): 1–4.

57. Choudhury, A. (1994b). Further observations of Phayre's leaf monkey (*Trachypithecus phayrei*) in Cachar, Assam. J. Bombay Nat. Hist. Soc. 91: 203–210.

58. Choudhury, A. (1996). Primates in Assam – Status and conservation. Tiger Paper. Vol. 23(3), 14-17.

59. Choudhury, A. (2001). New primate sanctuary in Assam, India. Asian Primates 7(3-4): 18-19.

60. Choudhury, A. (2002). Distribution and conservation of the Gaur *Bos gaurus* in the Indian Subcontinent. Mammal Review 32: 199-226.

61. Choudhury, A. (2002). Golden langur *Trachypithecus geei* threatened by habitat fragmentation. Zoo's Print Journal, 17(2): 699–703.

62. Choudhury, A. (2006). The distribution and status of hoolock gibbon, *Hoolock hoolock*, in Manipur, Meghalaya, Mizoram, and Nagaland in Northeast India. Primate Conservation 20: 79-87.

63. Choudhury, A. (2009). The Distribution, Status and Conservation of Hoolock Gibbon, *Hoolock hoolock*, in Karbi Anglong District, Assam, Northeast India. Primate Conservation 24: 117-126.

64. Chundawat, R. S. (1991). Habitat selection by Snow leopard in Hemis National Park, India. International Pedigree Book of Snow Leopards, 6: 85–92.

65. Chundawat, R. S. (1992). Ecological studies on Snow leopard and its associated species in Hemis National Park, Ladakh. University of Rajasthan, Jaipur. 166 pp.

66. Chundawat, R. S., and Qamar Qureshi. (1999). Planning wildlife conservation in Leh and Kargil districts of Ladakh, Jammu and Kashmir. Final Report. Wildlife Institute of India, Dehardun. 92 pp.

67. Chundawat, R.S. and Rawat, G.S. (1994). Food habits of Snow leopard in Ladakh. Proc. Int. Snow Leopard Symp. 7:127-132.

68. Chundawat, R.S., Khan, J.A. and Mallon, D.P. (2011). *Panthera tigris ssp. tigris.* The IUCN Red List of Threatened Species 2011: e.T136899A4348945. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T136899A4348945.en.

69. Chundawat, R.S., Khan, J.A. and Mallon, D.P. (2011). *Panthera tigris ssp. tigris*. The IUCN Red List of Threatened Species 2011: e.T136899A4348945. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T136899A4348945.en.

70. Corbet, G.B and Hill, J.E. (1992). The mammals of the Indo-Malayan Region: a systematic review. National History Museum Publications. Oxford Univ. Press.

71. Corbet, G.B. and Hill, J.E. (1992). The mammals of the Indomalayan region: a systematic review. Oxford University Press, Oxford, United Kingdom.

72. Crockett, C.M. and Wilson, W.L. (1980). The ecological separation of *Macaca nemestrina* and *M. fascicularis* in Sumatra. In: Lindburg DG, editor. The macaques: studies in ecology, behavior and evolution. New York: Van Nostrand Reinhold. p 148-81.

73. Cunningham, C. and Mootnick, A. (2009). Gibbons. Current Biology 19 (14): R543–R544.

74. Cuthbert, R. J., Dave, R., Chakraborty, S. S., Kumar, S., Prakash, S., Ranade, S. P. and Prakash, V. (2011). Assessing the ongoing threat from veterinary NSAIDs to critically endangered *Gyps* vultures in India. Oryx 45: 420-426.

75. Dar, S.A. and Khan, J.A. (2016). Food habits of dhole Cuon alpinus in tropical forests of southern India. CURRENT SCIENCE, VOL. 111, NO. 10, pp 1701 - 1705.

76. Das J, Bhattacharjee PC, Biswas J and Chetry D. (2005). Western Hoolock Gibbon: Socioecology, Threats and Conservation Action Plan. Department of Zoology, Gauhati University, and Primate Research Centre, Northeast Centre, Guwahati, India. 70p.

77. Das, J., Biswas, J., Bhattacharjee, P. C., and Mohnot, S. M. (2006). First distribution records of the eastern hoolock gibbon (*Hoolock hoolock leuconedys*) from India. Zoo's Print Journal 21 (7): 2316-2320.

78. Das, J., Medhi, R. and Molur, S. (2008). *Trachypithecus geei*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>.

79. Davidar, E.R.C. (1975). Ecology and behaviour of the dhole or Indian wild dog (*Cuon alpinus* Pallas). Pp. 109–119 in M.W. Fox, M.W. ed. The wild canids. Van Nostrand Reinhold, New York, NY, USA.

80. Davidar, E.R.C. (1997). Cheetal walk-living in the wilderness, Oxford University Press, Chennai.

81. Davidson, A.D., Detling, J.K. and Brown, J.H. (2012).Ecological roles and conservation challenges of social, burrowing, herbivorous mammals in the world's grasslands. The Ecological Society of America. 10(9): 477–486.

82. del Hoyo, J., Elliott, A and Sargatal, J. (1994). Handbook of the Birds of the World, vol. 2: New World Vultures to Guineafowl. Lynx Edicions, Barcelona, Spain.

83. Delacour, J. (1977). The Pheasants of the World. Spur Publications and the World Pheasant Association. 395 pp.

84. Din, J.U. and Nawaz, M.A. (2011). Status of Snow leopard and prey species in Torkhow valley, District Chitral, Pakistan. The Journal of Animal & Plant Sciences, 21(4): 836-840.

85. Dinerstein, E. and Mehta, J.N. (1989). The Clouded leopard in Nepal. Oryx 23, 199-201.

86. Dookia, S. (2002). Habitat preference, abundance and group size of Indian *Gazella gazella bennetti* in semi arid region of Rajasthan. Ph.D. thesis. J.N.V. University, Jodhpur, Rajasthan. Pp. 179.

87. Dookia, S. and Goyal, S. P. (2007). Chinkara or Indian Gazelle. In "Ungulates of Peninsular India" (Eds. K. Sankar and S. P. Goyal), ENVIS Bulletin, Wildlife Institute of India. 103-114 pp.

88. Dookia, S. and Jakher G.R. (2007).Food and feeding habit of Indian Gazelle (*Gazella bennettii*), in the Thar Desert of Rajasthan. Indian Forester 133(10): 1327–1340.

89. Duckworth, J.W. and MacKinnon, J. (2008). *Capricornis thar*. The IUCN Red List of Threatened Species2008:e.T3816A10096556.http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T3816A10096556.en.Downloaded on 22 June 2016.

90. Duckworth, J.W. and Timmins, R. (2015). *Moschiola indica*. The IUCN Red List of Threatened Species 2015: e.T136585A61979067. http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T136585A61979067 .en. Downloaded on 20 April 2017.

91. Duckworth, J.W., Samba Kumar, N., Chiranjibi Prasad Pokheral, Sagar Baral, H. and Timmins, R.J. (2013). *Rucervus duvaucelii*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 11 May 2015.

92. Duckworth, J.W., Steinmetz, R., Timmins, R.J., Pattanavibool, A., Than Zaw, Do Tuoc and Hedges, S. (2008). *Bos gaurus*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 21 March 2015.

93. Duke, G. (1989). The world's largest population of Western Tragopans. Report to BirdLife International, Cambridge

94. Durbin, L., Hedges, S., Duckworth, J., Tyson, M., Lyenga, A., & Venkataraman, A. (2004). *Cuon alpinus*. 2004 IUCN Red List of Threatened Species.

95. Easa, P.S. (1998). Habitat utilization of animals in Parambikulam Wildlife Sanctuary with special reference to Gaur. KFRI Research Report 155.

96. Fa JE. 1989. The genus *Macaca*: a review of taxonomy and evolution. Mammal Rev 19(2): 45-81.

97. Fliegl, G.M. (1973). Breeding the peacock pheasants. Avicultural Magazine, 79: 216-218.

98. Fooden, J. (1990). The bear macaque, *Macaca arctoides*: a systematic review. Journal of Human Evolution, 19: 607-686.

99. Fooden, J., Quan, G., Wang, Z. and Wang, Y. (1985). The stump tail macaques of China. Am. J. Primatol., 8: 11-30.

100. Fox, J. L., Sinha, S. P., Chundawat, R. S. and Das, P. K. (1986). A Survey of Snow Leopard and Associated Species in the Himalayas of North-Western India: A Report. Wildlife Institute of India, Dehardun.

101. Fox, J.L. (1994). Snow leopard conservation in the wild - A comprehensive perspective on a low density and highly fragmented population. Pages 3-15 In: J. L., Fox, Du Jizeng (Eds.). Proceedings of the Seventh International Snow Leopard Symposium. International Snow Leopard Trust, Seattle, Washington. 331 pages.

102. Frankham R. (2008). Genetic adaptation to captivity in species conservation programs. Mol. Ecol. 12:131–140.

103. Frankham, R., Ballou, J.D. and Briscoe, D.A. (2002). Introduction to Conservation Genetics. Cambridge University Press, Cambridge, UK.

104. Ganesh, T. and Davidar, P. (1999). Fruit biomass and relative abundance of frugivores in a rainforest of Southern Western Ghats, India. Journal of Tropical Ecology, 15, 399–414.

105. Garson, P.J., Young, L. and Kaul, R. (1992). Ecology and conservation of the Cheer pheasant *Catreus wallichi*: Studies in the wild and the progress of a reintroduction project. Biological Conservation, 59(1): 25-35.

106. Gaston, A.J., Garson, P.J. and Hunter, M.L. Jr. (1981). Present distribution and status of pheasants in Himachal Pradesh, Western Himalayas. Journal of World Pheasant Association, 6:10–30.

107. Gaston, A.J., Garson, P.J. and Hunter, M.L. Jr. (1983). The status and conservation of forest wildlife in Himachal Pradesh, Western Himalayas. Biological Conservation 27: 291 - 314.

108. Gee, E.P. (1963). The Indian Wild Ass: A survey. J. Bombay Natural History Society, 60 (3), 517–529.

109. Gibbs, D.; Barnes, E.; Cox, J. (2001). Pigeons and doves: a guide to the pigeons and doves of the world. Pica Press, Robertsbridge, U.K.

110. Gilbert, M., Watson, R.T., Virani, M.Z., Oaks, J.L., Ahmed, S., Chaudhry, M.J. I., Arshad, M., Mahmood, S., Ali, A. and Khan, A.A. (2006). Rapid population declines and mortality clusters in three Oriental White-backed Vulture Gyps bengalensis colonies in Pakistan due to diclofenac poisoning. Oryx 40(4): 388-399.

111. Giri, S., Aryal, A., Koirala, R. K., Adhikari, B. and Raubenheimer, D. (2011). Feeding ecology and distribution of Himalayan serow (*Capricornis thar*) in Annapurna Conservation Area, Nepal. World Journal of Zoology 6 (1): 80-85.

112. Glatston, A. R. (1994). Status survey and conservation action plan for Procyonids and Ailurids: the Red panda, Olingos, Coatis, Raccoons and their Relatives. Switzerland: IUCN, Gland.

113. Goodrich, J., Lynam, A., Miquelle, D., Wibisono, H., Kawanishi, K., Pattanavibool, A., Htun, S., Tempa, T., Karki, J., Jhala, Y. and Karanth, U. (2015). *Panthera tigris*. The IUCN Red List of Threatened Species 2015: e.T15955A50659951. http://dx.doi.org/10.2305/IUCN.UK.20152.RLTS.T15955A50-659951.en.

114. Gopi, G., Habib, B., Lyngdoh, S. and Selvan, K.M. (2012). Conservation of the endangered Asiatic wild dog *Cuon alpinus* in Western Arunachal Pradesh: linking ecology ethics and economics to foster better coexistence. Wildlife Institute of India Dehradun.

115. Goyal, S. P., Sinha, B., Shah, N. and Panwar, H. S. (1999). Sardar Sarovar Project – a conservation threat to the Indian wild ass (*Equus hemionus khur*). Biological Conservation 88: 277-284.

116. Grassman, L., Lynam, A., Mohamad, S., Duckworth, J.W., Bora, J., Wilcox, D., Ghimirey, Y., Reza, A. and Rahman, H. (2016). *Neofelis nebulosa*. The IUCN Red List of Threatened Species 2016: e.T14519A97215090. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T14519A97215090.en. Downloaded on 31 July 2018.

117. Grassman, L.I. Jr., Tewes, M.E., Silvy, N.J. and Kreetiyutanont K. (2005). Ecology of three sympatric felids in a mixed evergreen forest in North-Central Thailand. Journal of Mammalogy 86, 29-38.

118. Gray, T.N.E., Brook, S.M., McShea, W.J., Mahood, S., Ranjitsingh, M.K., Miyunt, A., Hussain, S.A. & Timmins, R. (2015). *Rucervus eldii*. The IUCN Red List of Threatened Species 2015: e.T4265A22166803. http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T4265A22166803.en

119. Green, R.E., Newton, I., Shultz, S., Cunningham, A.A., Gilbert, M., Pain, D.J. and Prakash, V. (2004). Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. Journal of Applied Ecology 41: 793-800.

120. Green, S. M. and Minkowski, K. (1977). The lion-tailed macaque and its south Indian rainforest habitat. In: Primate Conservation, Bourne, G. H. and Prince Rainier III, H.S.H. of Monaco (eds.), Academic Press, New York. pp.289–337.

121. Grimmet, R., Inskipp, C., and Inskipp. T. (1998). Birds of the Indian subcontinent. Oxford University Press, Delhi, India.

122. Groves, C. P. (2001). Primate taxonomy. Smithsonian Institution Press, Washington, DC, USA.

123. Grubb, P. (2005). Artiodactyla. In: D. E. Wilson and D. M. Reeder (eds), Mammal Species of the World. A Taxonomic and Geographic Reference (3rd ed), pp. 637-722. Johns Hopkins University Press, Baltimore, USA.

124. Gupta, A. and Chivers, D. (2000). Feeding ecology and conservation of the Golden langur. Journal of the Bombay Natural History Society, 97(3): 349-362.

125. Habib, B., (2007). Ecology of Indian Wolf, *Canis lupus pallipes* Sykes, 1831, and modeling its potential habitat in the great Indian bustard sanctuary, Maharashtra, India. PhD dissertation submitted to Aligarh Muslim University Aligarh-202 002, UP, India.

126. Habib, B., Shrotriya, S. and Jhala, Y. V. (2013). Ecology and Conservation of Himalayan wolf. Wildlife Institute of India – Technical Report No. TR – 2013/01, Pp 46.

127. Harris, R.B. (2014). *Pseudois nayaur*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 20 October 2014.

128. Hayssen VD, Van Tienhoven A (1993). Asdell's patterns of mammalian reproduction: a compendium of species-specific data. Cornell University Press, Ithaca, New York, 658–659.

129. Hayward, M. W., Lyngdoh, S. and Habib, B. (2014). Diet and prey preferences of dholes (*Cuon alpinus*): dietary competition within Asia's apex predator guild. Journal of Zoology doi:10.1111/jzo.12171.

130. Hearn, A., Sanderson, J., Ross, J., Wilting, A. and Sunarto, S. (2008). *Neofelis diardi*. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.2.<www.iucnredlist.org>. Downloaded on 24 September 2014.

131. Heath, M.E. (1995). *Manis crassicaudata*. Mammalian species, 513: 1–4.

132. Heptner, V. and Sludskii, A.A. (1992). Mammals of the Soviet Union. Volume II, Part 2 Carnivora (Hyaenas and Cats). Smithsonian Institution Libraries and National Science Foundation, Washington DC. 748 pages.

133. Horwich, R. H., Das, R. and Bose, A. (2013). Conservation and the Current Status of the Golden Langur in Assam, India, with Reference to Bhutan. Primate Conservation (27): 1-7.

134. Horwich, R.H. (1972). Home range and food habits of Nilgiri Langur *Presbytis johnii*. Journal of Bombay Natural History society, 69: 255-267.

135. Htun, A., Timmins, R. J., Boonratana, R., and Das, J. (2008). *Macaca arctoides*. In: IUCN 2008. 2008 IUCN Red List of Threatened Species URL: www.iucnredlist.org Accessed: 9-1-2014.

136. Hussain, S. (2003). The status of the snow leopard in Pakistan and its conflict with local farmers. Oryx 37(1):26-3.

137. Hussain, S.A., Singsit, S., Vaiphei, N., Angom, S. and Kipgen, K. (2004). Brow Antlered Deer or Sangai (*Cervus eldi* M'Clelland, 1842). In Sankar, K and Goyal, S.P. (Eds.) 2004. Ungulates of India. ENVIS Bulletin: Wildlife and Protected Areas, Vol. 07, No. 1. Wildlife Institute of India, Deheradun, India. Pp. 448.

138. ISIS (International Species Information System) (2004). SPARKS 1.54: Single population analysis and records keeping system. Eagan, MN: International Species Information System. Available from: www.isis.org.

139. Islam, K. and Crawford, J.A. (1987). Habitat use by western tragopans *Tragopan melanocephalus* (Gray) in Northeastern Pakistan. Biological Conservation 40: 101-115.

140. Israel, S., Sinclair, T., Grewal, B. and Hoefer, H.J. (1987). Indian wildlife. APA Productions (HK) Ltd., Hong Kong.

141. Ito, T. (1971). On the oestrous cycle and gestation period of the Japanese serow, *Capricornis crispus*. Journal of the Mammalogical Society of Japan 5:104–108 (in Japanese, English summary).

142. IUCN SSC Antelope Specialist Group (2017). *Gazella bennettii*. The IUCN Red List of Threatened Species 2017: e.T8978A50187762. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T8978A50187762.en (downloaded on 19 February 2018)

143. IUCN SSC Antelope Specialist Group. (2017). *Tetracerus quadricornis*. The IUCN Red List of Threatened Species 2017: e.T21661A50195368. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T21661A50195368.en.

144. Iyengar, A., Babu, V. N., Hedges, S., Venkataraman, A. B., Maclean, N. and P. A. Morin (2005). "Phylogeography, genetic structure, and diversity in the dhole (*Cuon alpinus*)". Molecular Ecology. 14 (8): 2281–2297. doi:10.1111/j.1365-294X.2005.02582.

145. Jackson, R. M. (1996). Home range, movements and habitat use of snow leopard (*Uncia uncia*) in Nepal (Doctoral dissertation, University of London).

146. Jandrotia, J.S., Sharma, V. and Katoch, S.S. (1995). A pheasant survey in the Ravi Catchment of Chamba District, Himachal Pradesh, India. Annual Review of the World Pheasant Association 1994/95:67–74.

147. Jhala, Y.V., (2013). Indian Wolf: *Canis lupus pallipes* in Johnsingh, A.J.T., and N., Manjrekar, eds. 2013. Mammals of South Asia. Vol. 1. Hyderabad: Universities Press (India) Pvt Ltd.

148. Jhala, Y.V., Mukherjee, S. Shah, N., Chauhan, K.S., Dave, C.V, Meena, V, and Banerjee, K. (2009). Home range and habitat preference of female lions (*Panthera leo persica*) in Gir forests, India. Biodivers. Conserv. 18:3383–3394

149. Johnsgard, P.A. (1986). The pheasants of the world. New York: Oxford University Press, 3–280.

150. Johnsingh, A. J. T. (1992). Prey selection in three sympatric carnivores in Bandipur. Mammalia 56:517–526.

151. Johnson, K. G., Schaller G. B. and Hu, J. (1988). Comparative behavior of Red and Giant pandas in the Wolong Reserve, China. J. Mammal. 69: 552±564.

152. Joshi, N.J. (1959). Afforestation work under the Cutch Desert Immobilization scheme, Banaskantha Division, Gujarat State; Dry Zone Afforestation Symposium-. F.R.I., Dehra Dun.

153. Kaczensky, P.; Lkhagvasuren, B.; Pereladova, O.; Hemami, M. and Bouskila, A. (2015). *Equus hemionus*. The IUCN Red List of Threatened Species 2015: e.T7951A45171204. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T7951A45171204.en downloaded on March 12 2016.

154. Kakati, K. (1997). Food selection and ranging in the hoolock gibbon in Borajan reserve forest, Assam. M.Sc. dissertation. Wildlife Institute of India, Dehra Dun.

155. Kalsi, R.S. (1998). Density index and habitat association of the Cheer pheasant *Catreus wallichii.* Final report submitted to OBC, UK and WPA South Asia Regional Office, New Delhi

156. Kamler, J.F., Songsasen, N., Jenks, K., Srivathsa, A., Sheng, L. and Kunkel, K. (2015). *Cuon alpinus*. The IUCN Red List of Threatened Species 2015: e.T5953A72477893. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T5953A72477893.en.

157. Karanth, K.U. and Sunquist, M.E. (1995). Prey selection by tiger, leopard and dhole in tropical forests. Journal of Animal Ecology 64(4): 439-450.

158. Karanth, K.U. and Sunquist, M.E. (2000). Behavioural correlates of predation by tiger (*Panthera tigris*), leopard (*Panthera pardus*) and dhole (*Cuon alpinus*) in Nagarahole, India. Journal of Zoology 250: 255-265.

159. Kaul, R. (1989). Ecology of the Cheer pheasant *Catreus wallichii* in Kumaon Himalaya. Unpublished Ph.D. dissertation, University of Kashmir, Srinagar.

160. Kaul, R.; Raza, R.; and Kalsi, R. (1995). Pheasant surveys in Arunachal Pradesh. Pp. 28–34 In: Jenkins, D. (ed.). Annual Review of the World Pheasant Association 1993/ 94. World Pheasant Association, Reading.

161. Kita, I., Sugimura, M., Suzuki, Y., Tiba, T. and Miura, S. (1987). Reproduction of female Japanese serow based on the morphology of ovaries and fetuses. Pp. 321–331 In: The biology and management of Capricornis and related mountain antelopes (H. Soma, ed.). Croom Helm, London, United Kingdom.

162. Krebs, E. and Kaumanns, W., (2001). European Studbook for the Lion Tailed Macaque (*Macaca silenus*), Zoo Köln, Köln.

163. Krishna, B.A. Singh, M. Singh, M. and Kaumanns, W. (2008). Infant development and weaning in *Macaca silenus* in the natural habitats of the Western Ghats, India; CURRENT SCIENCE, VOL. 94, NO. 3, 10, 347 – 355.

164. Krishnan, M. (1972). An ecological survey of the larger mammals of peninsular India. Part II. J. Bombay Nat. Hist. Soc. 69: 26-54.

165. Kumar, A. (1987). The ecology and population dynamics of the lion-tailed monkeys (*Macaca silenus*) in south India. Ph.D. thesis. Cambridge University.

166. Kumar, A. (1987). The ecology and population dynamics of the lion-tailed monkeys (*Macaca silenus*) in south India. Ph.D. thesis. Cambridge University.

167. Kumar, A., Singh, M. and Molur, S. (2008). *Macaca silenus*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 10 May 2015.

168. Kumar, A., Umapathy, G. and Prabhakar, A. (1995). A study on the management and conservation of small mammals in fragmented rainforests in the Western Ghats of south India: A preliminary report. Primate Conservation, 16: 53–58.

169. Kumar, V.P., Shrivastwa, A., Nigam, P., Kumar, D. and Goyal, S.P. (2016). Genetic characterization of wild Swamp deer populations: ex-situ conservation and forensics implications, Mitochondrial DNA Part A, DOI: 10.1080/24701394.2016.12257323.

170. Kumara, H. N. and Singh, V. R. (2008). Status of *Macaca silenus* in the Kudremukh Forest Complex, Karnataka, India. International Journal of Primatology, 29, 773–781.

171. Kumara, H. N., Singh, M., Sharma, A. K., Singh, M. and Kumar, M. A. (2000). Faunal component in the diet of lion-tailed macaques. Primate Rep., 58, 57–66.

172. Kumara, H.N. and Singh, M. (2004). Distribution and abundance of primates in rain forests of the Western Ghats, Karnataka, India and the conservation of *Macaca silenus*. International Journal of Primatology, 25 (5): 1001-1018.

173. Kurup, G.U. (1979). Conservation of lion tailed macaque (*Macaca silenus*) and nilgiri langur (*Presbytis johnii*). Tiger Paper. Vol. 6(4), 17-19.

174. Lackey, L.B. (2010). Records, Studbooks, Regional Zoo Associations, and ISIS. In: Wild mammals in captivity: principles and techniques for zoo management. 2nd edition. Eds.: Kleiman, D.G., Thompson, K.V., Baer, C.K.: Chicago: University of Chicago Press. p 303–313.

175. Lacy R.C. (1994). Managing genetic diversity in captive populations of animals. Eds: Bowles M.L., Whelan C.J.: Restoration and recovery of endangered plants and animals. Cambridge: Cambridge University Press. p 63–89.

176. Lacy R.C. (2009). Stopping evolution: genetic management of captive populations. Eds.: Amato G., DeSalle R., Ryder O.A., Rosenbaum H.C.: Conservation genetics in the age of genomics. New York: Columbia University Press. p 58–81

177. Lacy R.C. (2012). Achieving True Sustainability of Zoo Populations. Zoo Biology 00: 1–13, DOI 10.1002/zoo.21029.

178. Lalthanzara, H., Lalawmawia, S., Solanki, G.S. and Ramanujam, S.N. (2015). Density and relative abundance of Grey Peacock- Pheasant (*Polyplectron bicalcaratum*, Linnaeus, 1758) in montane broadleaved evergreen forest of Mizoram, North East India. International Journal of Innovative Science, Engineering & Technology, 2 (7): 654-661.

179. Laska, M. (2001). A comparison of food preferences and nutrient composition in captive squirrel monkeys, Saimiri sciureus, and pigtail macaques, Macacanemestrina. Physiology & Behavior, 73/1-2: 111-120.

180. Laurenson K, Sillero Zubiri C, Thompson H, Shiferaw F, Thirgood S, and Malcolm J. (1998). Disease threats to endangered species; Ethiopian wolves, domestic dogs and canine pathogens. Animal Conservation.;1:273–80.

181. Laurie, W. A. (1978). The ecology and behaviour of the greater one-horned rhinoceros. Ph.D. dissert., University of Cambridge, 450 pp.

182. Laurie, W. A.; Lang, E. M. and Groves C. P. (1983). *Rhinoceros unicornis*; Mammalian Species, No. 211 pp. 1-6.

183. Lelliott, A.D. (1981). Survey of Cheer pheasant near Dhorpatan west Nepal 1981 In: C.D.W. Savage and M.W. Ridley (eds.) Pheasants in Asia 1982. pp. 58-61. Reading UK: WPA.

184. Leslie, D.M.; Sharma, K. (2009). "*Tetracerus quadricornis* (Artiodactyla: Bovidae)". Mammalian Species. 843: 1–11. doi:10.1644/843.1. Downloaded on 10 April 2017.

185. Lindburg, D. G., Lyles, A. M. and Czekala, N. M. (1989). Status and reproductive potential of lion-tailed macaques in captivity. Zoo Biology Supplement, 1, 5–16.

186. Low, J. (1991). The smuggling of endangered wildlife across the Taiwan Strait. TRAFFIC International, Cambridge.

187. Madge, S. and McGowan, P. (2002). Pheasants, partridges and grouse. London: Christopher Helm.

188. Madhusudan, M. D. and Karanth, K. U. (2000). Hunting for an answer: is local hunting compatible with large mammal conservation in India. In: Robinson, J. G. and Bennett, E. L. (eds). Hunting for sustainability in tropical forests. – Columbia University Press, New York, USA: 339–355.

189. Madhusudan, M. D. and Karanth, K. U. (2002): Local hunting and the conservation of large mammals in India. Ambio, 31: 49–54.

190. Maheshwari, A., Takpa, J., Sandeep K. and Shawl, T. (2010). An investigation of carnivore-human conflicts in Kargil and Drass areas of Jammu and Kashmir. Report submitted to Rufford Small Grant.

191. Mahmood, T., Hussain, R., Irshad, N., Akrim, F. and Nadeem, M.S. (2012). Illegal mass killing of Indian Pangolin (*Manis crassicaudata*) on Potohar Region, Pakistan. Pakistan Journal of Zoology, 44 (5): 1457-1461.

192. Mahmood, T., Irshad, N. and Hussain, R. (2014). Habitat Preference and Population Estimates of Indian Pangolin (*Manis crassicaudata*) in District Chakwal of Potohar Plateau, Pakistan. Russian Journal of Ecology, 45(1): 70–75.

193. Mahmood, T., Jabeen, K., Hussain, I. and Kayani, A.R. (2013). Plant species association, burrow characteristics and the diet of the Indian pangolin, *Manis crassicaudata*, in the Potohar plateau, Pakistan. Pakistan Journal of Zoology, 45(6): 1533-1539.

194. Mallon, D. (1984). The snow leopard in Mongolia. International Pedigree Book of Snow Leopards 4:3-10.

195. Mallon, D. (1985). The mammals of the Mongolian People's Republic. Mammal Review 15:71-102.

196. Martin, C. (1977). Status and ecology of the barasingha *Cervus duvauceli branderi* in Kanha National Park, India. Journal of the Bombay Natural History Society, 74(1): 60-132.

197. McCarthy, T. M. and Chapron, G. (2003). Snow leopard survival strategy. ISLT and SLN, Seattle, USA.

198. McCarthy, T., Mallon, D., Jackson, R., Zahler, P. & McCarthy, K. (2017). *Panthera uncia*. The IUCN Red List of Threatened Species 2017: e.T22732A50664030. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T22732A50664030.en. Downloaded on 01 August 2018.

199. McCarthy, T.M. (2000). Ecology and conservation of snow leopards, Gobi brown bears and wild Bactrian camels in Mongolia. Ph.D. Dissertation, University of Massachusetts, Amherst. 133 pages.

200. McPhee, M.E. and Carlstead, K. (2010). The importance of maintaining natural behaviors in captive mammals. In: Wild mammals in captivity: principles and techniques for zoo management. 2nd edition. Eds.: Kleiman, D.G., Thompson, K.V., Baer, C.K.: Chicago: University of Chicago Press. p 303–313

201. Mech, L.D. and Boitani, L. (IUCN SSC Wolf Specialist Group). (2010). *Canis lupus*. The IUCN Red List of Threatened Species 2010: e.T3746A10049204. Downloaded on 16 September 2017.

202. Meena, V., Jhala, Y. V., Chellam, R. and Pathak, B. (2011). Implications of diet composition of Asiatic lions for their conservation. Journal of Zoology 284: 60–67

203. Mendelssohn, H. (1982). Wolves in Israel. [In: Wolves of the world. F. H. Harrington and P. C. Paquet, eds]. Noyes Publications, Park Ridge, New Jersey: 173 - 195.

204. Mishra, C., Madhusudan, M.D. and and A. Datta. (2006). Mammals of the high altitudes of western Arunachal Pradesh, Eastern Himalaya: an assessment of threats and conservation needs. Oryx. 40 (1): 29-35.

205. Misra, M. and Hanfee, N. (2000). Pangolin distribution and trade in East and Northeast India. TRAFFIC Dispatches, 14: 4-5.

206. Molur, S., Brandon-Jones, D., Dittus, W., Eudey, A., Kumar, A., Singh, M., Feeroz, M.M., Chalise, M., Priya, P.,Walker, S. (2003). Status of South Asian Primates: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report, 2003. Zoo Organisation/ CBSG-South Asia, Coimbatore, India.

207. Muzaffar SB, Islam MA, Feeroz MM, Kabir M, Begum S, Mahmud MS, Chakma S, Hasan MK. (2007). Habitat characteristics of the endangered hoolock gibbons of Bangladesh: the role of plant species richness. Biotropica 39(4):539-45.

208. Naoroji. R. (2006). Birds of Prey of the Indian Subcontinent. with illustrations by N. John Schmitt. Om Books International. New Delhi, India. 704 pp.

209. Natesh, N., Atla, G., Nigam, P., Jhala, Y.V., Zachariah, A., Borthakur, U. and Ramakrishnan, U. (2017). Conservation priorities for endangered Indian tigers through a genomic lens. Scientific Reports. 7: 9614 | DOI:10.1038/s41598-017-09748-3.

210. Nieuwenhuijsen, K., Lammers, A. J. J. C., de Neef, K. J., and Slob, A. K. (1985). Reproduction and social rank in female stumptail macaques (Macaca arctoides). Int. J. Primatol. 6: 77– 99.

211. Nowak, R.M. and Paradiso, J.L. (1983). Walker's mammals of the world. 4th ed. Baltimore: Johns Hopkins University Press. pp: 1362.

212. Nowell, K. and Jackson, P. (1996). Wild Cats. Status survey and conservation action plan. IUCN, Gland, Switzerland.

213. Oaks, J.L., Gilbert, M., Virani, M. Z., Watson, R. T., Meteyer, C. U., Rideout, B. A., Shivaprasad, H.L., Ahmed, S., Chaudhry, M.J.I., Arshad, M., Mahmood, S., Ali, A. and Khan, A. A. (2004). Diclofenac residues as the cause of vulture population decline in Pakistan. Nature 42: 630 – 633.

214. Oates, J.F., Waterman, P.G. and Choo, G.M. (1980). 'Food selection by the south Indian leaf monkey (*Presbytis johnii*) in relation to leaf chemistry.' Oecologia, 45: 45–56.

215. Oi, T. (1990a). Population organization of wild pig-tailed macaques (*Macaca nemestrina nemestrina*) in west Sumatra. Primates 31(1): 15-31.

216. Oi, T. (1990b). Patterns of dominance and affiliation in wild pig-tailed macaques (*Macaca nemestrina nemestrina*) in west Sumatra. Int J Primatol 11(4): 339-56.

217. Oli, M. K., Taylor, I. R., Rogers, D. M. E. (1993). Diet of the snow leopard (*Panthera uncia*) in the Annapurna Conservation Area, Nepal. Journal of Zoology, 231(3): 365–370.

218. Olney, P.J.S. (2001). Studbooks in Encyclopaedia of the World's Zoos. Vol. 3. Fitzroy Dearborn Publishers; Chicago. Pp 1180-1183

219. Panda, S., Mishra, S., Mishra, A.K. and Mohapatra, S.N. (2010). Nandankanan faunal diversity. Nandankanan Biological Park, Forest and Environment Department, Government of Odisha: 28.

220. Pandey, S. (1993). Pheasant surveys and the conservation of protected areas in the Upper Beas Valley, Himachal Pradesh, India. Pp. 58–61 In: Jenkins, D. (ed.). Pheasants in Asia 1992. World Pheasant Association, Reading, U.K.

221. Pasha, M. K. S., Sankar, K. Qureshi, Q. and Areendran, G. (2004). Indian bison or gaur (*Bos gaurus* Lambert, 1804). ENVIS Bulletin 7: 91–102.

222. Pimm SL, Jenkins CN, Abell R, Brooks TM, Gittleman JL, Joppa LN, Raven PH, Roberts CM, Sexton J. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. Science. 2014 May 30;344(6187):1246752. doi: 10.1126/science.1246752.

223. Poirier, F.E. (1970). The Nilgiri langur (*Presbytis johnii*) of South India, pp. 251–388. In: Primate Behaviour. L.A. Rosenblum (ed.). Academic Press, New York.

224. Porwal, M. C., Padalia, H. and Roy P.S. (2012). Impact of tsunami on the forest and biodiversity richness in Nicobar Islands (Andaman and Nicobar Islands), India. Biodivers. Conserv.21:1267–1287 DOI 10.1007/s10531-011-0214-x

225. Prakash, V. (1999). Status of vultures in Keoladeo J. Bombay Nat. Hist. Soc. 96: 365–378

226. Prakash, V., Bishwakarma, M.C., Chaudhary, A., Cuthbert, R., Dave, R., Kulkarni, M., Kumar, S., Paudel, K., Ranade, S., Shringarpure, R. and Green, R.E. (2012). The Population Decline of Gyps Vultures in India and Nepal Has Slowed since Veterinary Use of Diclofenac was Banned. PLoS One 7(11).

227. Prakash, V.; Pain, D. J.; Cunningham, A. A.; Donald, P. F.; Prakash, N.; Verma, A.; Gargi, R.; Sivakumar, S. and Rahmani, A. R. (2003). Catastrophic collapse of Indian white-backed *Gyps bengalensis* and long-billed *Gyps indicus* vulture populations. Biological Conservation 109: 381-390.

228. Prasad S, Pittet A, Sukumar R (2010). Who really ate the fruit? A novel approach to camera trapping for quantifying frugivory by ruminants. Ecol Res 25:225–231. doi:10.1007/s11284-009-0650-1.

229. Prater, H.S. (1980). The book of Indian animals. Oxford University Press, New Delhi.

230. Prater, S. 1971. The book of Indian Animals. Bombay Natural History Society, Bombay, India.

231. Prater, S.H. (1993). The book of Indian Animals. Bombay Natural History Society, India.

232. Pratt, R.M.; R.J. Putman; J.R. Ekins and Edwards, P.J. (1986). Use of habitat by free-ranging cattle and ponies in the new forest, Southern England. J. Appl. Ecol., 23 : 539-557.

233. Qureshi Q., Sawarkar, V.B. and Mathur, P.K. (1995). Ecology and management of Swamp deer (*Cervus duvauceli*) in Dudhwa Tiger Reserve, U.P (India). Project Report. Wildlife Institute of India, Dehradun.

234. Qureshi, Q., Sawarkar, V. B., Rahmani, A. R. and Mathur, P. K. (2004). Swamp deer or Barasingha (*Cervus duvauceli* Cuvier, 1823). ENVIS Bulletin 7: 181–192.

235. Rahmani, A.R. (1990). Distribution of the Indian Gazelle or Chinkara, *Gazella bennetti* (Sykes) in India. Mammalia 54(4): 605–619.

236. Ralls, K. and Ballou, J.D. (2013). Captive Breeding and Reintroduction. Ed.: Levin S.A. Encyclopedia of Biodiversity, second edition, Volume 1, pp. 662-667. Waltham, MA: Academic Press.

237. Ram, M.S., Marne, M., Gaur, A., Kumara, H.N., Singh, M., Kumar, A. and Umapathy, G. (2015) Pre-Historic and Recent Vicariance Events Shape Genetic Structure and Diversity in Endangered Lion-Tailed Macaque in the Western Ghats: Implications for Conservation. PLoS ONE 10(11): e0142597. doi:10.1371/journal. pone.0142597.

238. Ramachandran, K.K. (1995). Status survey of Primates in Shendurney Wildlife Sanctuary and adjacent areas. KFRI Research Report No. 106. 34p.

239. Raman, T.R.S., Mishra, C., and Johnsingh, A.J.T. (1995). Survey of primates in Mizoram, north-east India. Primate Conservation. Vol. 16, 59-62.

240. Ramesh, K. (2003). An ecological study on the pheasants of the Great Himalayan National Park, Western Himalaya. Forest Research Institute, Dehradun.

241. Ramesh, T., Kalle, R., Sankar, K. and Qureshi, Q. (2012). Dry season factors determining habitat use and distribution of mouse deer (*Moschiola indica*) in the Western Ghats. Eur. J. Wildl. Res. DOI 10.1007/s10344-012-0676-5.

242. Ranjitsinh, M. K. (1997). Beyond the Tiger: Portraits of Asian Wildlife. Birajbasi Printers, New Delhi, India.

243. Rawat G.S. (2008). Special habitats and threatened plants of Ladakh pp 1 – 7 In: Rawat, G.S. (Ed.). 2008. Special habitats and threatened plants of India. ENVIS Bulletin: Wildlife and protected areas, Vol. 11(1). Wildlife Institute of India, Dehradun, India.

244. Redford, K. H. (1987). Ants and termites as food: patterns of mammalian myrmecophagy. In Genoways, H. H. (Ed.). Current mammalogy, New York, Plenum Press.

245. Reid, D. G., Hu, J. and Huang, Y. (1991). Ecology of the Red panda in the Wolong Reserve, China. J. Zool. (Lond.) 225: 347±364.

246. Roberts, M. S. and Gittleman, J. L. (1984). *Ailurus fulgens*. Mammalian Species 222: 1-8.

247. Roberts, T.J. (1977). The Mammals of Pakistan. Ernest Benn, London, UK.

248. Roberts, T.J. (1991). The Birds of Pakistan. Vol. 1 Non-Passeriformes. Oxford University Press, Karachi.

249. Roberts, T.J. (1992). The Birds of Pakistan. Vol. 2 Passeriformes. Oxford University Press, Karachi

250. Rode, K. D., Chapman, C.A., McDowell, L. R. and Stickler, C. (2006). Nutritional correlates of population density across habitats and logging intensities in red tail monkeys (*Cercopithecus ascanius*). Biotropica, 38, 625–634.

251. Roonwal, M. and Mohnot, S. (1977). Primates of South Asia: Ecology, Sociobiology and Behavior. Cambridge.

252. Rowe N. (1996). The pictorial guide to the living primates. East Hampton (NY): Pogonias Pr. 263 p.

253. Roy, D., Ashokkumar, M. and Desai, A.A. (2012). Foraging ecology of Nilgiri Langur (*Trachypithecus johnii*) in Parimbikulam Tiger Reserve, Kerala, India. Asian Journal of Conservation Biology. Vol. 1 No. 2, pp. 92-102.

254. Salter, R.E. (1983). Summary of currently available information on internationally threatened wildlife species in Burma. FAO, Rangoon, Burma.

255. Sanjit, L., Bhatt, D and Sharma, R. K. (2005). Habitat heterogeneity of the Loktak lake, Manipur. Current Science, Vol. 88, NO. 7, 10.

256. Sankar, K., Qureshi, Q., Pasha, M. K. S. and Areendran, G. (2000). Ecology of gaur *Bos gaurus* in Pench Tiger Reserve, Madhya Pradesh. Final Report. Wildlife Institute of India, Dehra Dun. pp.27.

257. Sarker, S.U and M. Iqbal (1997). Hatching and rearing of the Indian White-backed Vulture *Gyps bengalensis* in captivity. Vulture News 37:21-2.

258. Sati. J.P. and Alfred, J.R.B. (2001). Hoolock gibbon (*Bunopithecus hoolock*). In ENVIS Bulletin: Wildlife & Protected Areas, Non-Human Primates of India, A.K. Gupta (editor), vol. 1, no. 1, 32–41: 60-7.

259. Schaaf, C.D. (1978). Population size and structure and habitat relation of the Swamp deer (*Cervus duvauceli duvauceli*) in Suklaphanta Wildlife Reserve, Nepal. Ph. D. Thesis. Michigan State University, USA, 111pp.

260. Schales, C. and Schales, K. (1994). Galliformes. avian medicine: principles and application. Florida: Wingers Publ. p: 1218-1236.

261. Schaller, G. B. (1967). The deer and the tiger. A study of wildlife in India. University of Chicago Press, Chicago, USA and London, UK.

262. Schaller, G. B. (1977). Mountain Monarchs: Wild Sheep and Goats of the Himalaya. University Chicago Press, Chicago. 426 pages.

263. Schaller, G.B. (1998). Wildlife of the Tibetan Steppe. University of Chicago Press, Chicago, USA

264. Schaller, G.B., Li Hong, Talipu, Junrang Ren, and Mingjiang Qiu. (1988). The Snow leopard in Xinjiang. Oryx 22(4):197-204.

265. Schlitter, D.A. (2005). Order Pholidota. In: Wilson D.E. and Reeder, D.M. (eds.). Mammal Species of the World: A Taxonomic and Geographic Reference, 530-531. Johns Hopkins University Press, Baltimore, MD, USA.

266. Selvan, K.M., Gokulakkannan, N. and Sridharan, N. (2013). Food habits of dhole *Cuon alpinus* in Kalakad-Mundanthurai Tiger Reserve in Tamil Nadu, India. Asian Journal of Conservation Biology, Vol. 2 No. 1, pp. 69 -72

267. Shah, N. V. (1993). Ecology of Wild Ass (*Equus hemionus khur*) in Little Rann of Kutch. Ph.D. Thesis, The Maharaja Sayajirao University of Baroda, Baroda 390 002, India.

268. Shah, N. V (2004). Indian wild ass or Khur in Sankar, K and Goyal, S.P. (Eds.) 2004. Ungulates of India. ENVIS Bulletin: Wildlife and Protected Areas, Vol. 07, No. 1. Wildlife Institute of India, Dehradun, India. Pp. 448.

269. Shahi, P.S. (1982). Status of gray wolf (*Canis lupus pallipes*) in India: a preliminary survey. J. Bomb. Nat. Hist. Soc. 79(3):493-50.

270. Sharma, A.K., M. Singh, W. Kaumanns, E. Krebs, M. Singh, M. A. Kumar and H.N. Kumara. (2006). Birth patterns in wild and captive Lion-tailed Macaques (*Macaca silenus*). International Journal of Primatology, 27(5): 1429–1439.

271. Sharma, I. K. (1970). "Breeding of the Indian white-backed vulture at Jodhpur". Ostrich. 41 (2): 205–207.

272. Sharma, K. (2006). Distribution, status, ecology, and behavior of the Four-horned antelope (*Tetracerus quadricornis*). Ph.D. dissertation, University of Mumbai, Mumbai, India.

273. Sharma, K., and Rahmani, A.R. (2004). Four horned antelope or Chowsingha (*Tetracerus quadricornis* Blainville). Pp. 53-60. In: K. Sankar and S.P. Goyal (Eds.) Ungulates of India. ENVIS Bulletin: Wildlife and Protected Areas, Vol. 07, No. 1. Wildlife Institute of India, Dehradun, India. Pp. 448.

274. Sharma, K., Rahmani, A. R.; and Chundawat' R. S. (2005). Ecology and distribution of Four-horned antelope *Tetracerus quadricornis* in India. Bombay Natural History Society, Mumbai, India.

275. Shultz, S., H.S. Baral, S. Charman, A.A. Cunningham, D. Das, D.R. Ghalsasi, M.S. Goudar, R.E. Green, A. Jones, P. Nighot, D.J. Pain, and V. Prakash (2004). Diclofenac poisoning is widespread in declining vulture populations across the Indian subcontinent. Proceedings of the Royal Society of London B (Supplement), 271: S458-S460. DOI: 10.1098/rsbl.2004.0223.

276. Singh H.S. (2001). Indian wild ass (*Equus hemionus khur*) in the Little Rann of Kutch, Gujarat, India. JBNHS Volume 98 Pages 327—334.

277. Singh T. (1991). Bioecology of the Seriously Endangered Brow Antlered Deer, *Cervus eldii eldii* in the Only Natural Habitat Keibul Lamjao of Manipur with Special Reference to its Conservation, Final technical report submitted to the Department of Environment, Government of India. pp127.

278. Singh, H. S. (2001). Antelopes and gazelles: distribution and population status in Gujarat, India. Indian Forester 127:1098–1106.

279. Singh, M., Kumar, A. and Molur, S. (2008). *Trachypithecus johnii*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 2 February 2015.

280. Singh, M., Kumara, H.N., Kumar, M.A. and Sharma, A.K. (2001). Behavioural responses of lion-tailed macaques (*Macaca silenus*) to a changing habitat in a tropical rainforest fragment in the Western Ghats, India. Folia Primatologica, 72, 278–291.

281. Singh, M., Sharma, A. K., Krebs, E. and Kaumanns, W. (2006). Reproductive biology of lion-tailed macaque (*Macaca silenus*): an important key to the conservation of an endangered species. Current Science, 90, 804–811.

282. Singh, M., Singh, M., Ananda Kumar, M., Kumara, H.N., Sharma, A.K. and Kaumanns, W. (2002). Distribution, Population Structure, and Conservation of Lion Tailed Macaques (*Macaca silenus*) in the Anaimalai Hills, Western Ghats, India. American Journal of Primatology, 57, 91-102.

283. Singh, M., Singh, M., Kumara, H.N., Kumar, M.A. and D`Souza, L. (1997). Inter-and intra-specific associations of non-human primates in Anaimalai hills, south India. Mammalia, 61, 17-28.

284. Singh, MR., Singh, ME., Ananda, K.M., Kumara, H.N., Sharma, A.K., and Sushma, H.S. (2000). Niche separation in sympatric lion-tailed macaque (*Macaca silenus*) and nilgiri langur (*Presbytis johnii*) in an Indian tropical rain forest. Primate Report. Vol. 58, 83-95.

285. Singh, R. (1985). Geographic variation in the Barasingha or Swamp deer (*Cervus duvauceli*). Journal of the Bombay Natural History Society, 82 (1):188-190.

286. Sinha, B.C. (1993). Impact of landuse of the eco-degradation of the wild ass habitat in Little Rann of Kutch , Gujarat. Report, Wildlife Institute of India, Dehra Dun, India.

287. Sinha, S.P. and Chandola, S.S. (2006). Swamp deer sighting in Uttaranchal State, India. Oryx, 40 (1):14-14.

288. Sirianni, J.E. and Swindler, D.R. (1985). Growth and development of the pigtailed macaque. Boca Raton (FL): CRC Pr. 168 p.

289. Smith, A.T., Xie, Y., Hoffmann, R.S., Lunde, D., MacKinnon, J., Wilson, D.E. and Chris Wozencraft, W. (2008). A Guide to the Mammals of China. Princeton University Press. 576 pp.

290. Solanki, G. S. and Naik, R. M. (1998). Grazing interactions between wild and domestic herbivores. Small Ruminant Research 27: 231–235.

291. Sridhar, S., Edgaonkar, A. and Kumar, A. (2013). Understorey structure and refuges from predators influences habitat-use by a small ungulate, the Indian chevrotain (*Moschiola indica*) Ecological Research DOI: 10.1007/s11284-013-1031-3.

292. Srinivasulu, C. and Srinivasulu, B. (2012). South Asian Mammals. Their Diversity, Distribution, and Status. Springer, New York.

293. Srivastava, A. (1999). Primates of northeast India, Megadiversity Press, Bikaner (Rajasthan), India, 208 pp.

294. Srivastava, A., Biswas, J. and Bujarbarua. P. (2001b). Status and distribution of Golden langurs (*Trachypithecus geei*) in Assam, India. American Journal of Primatology, 55(1):15-23.

295. Srivastava, A., Baruah, M. and S. M. Mohnot. (2001a). The population dynamics and conservation of Golden langurs. Journal of the Bombay Natural History Society, 98(1): 12–17.

296. Srivastava, K.K.; Zachavias, V.J., Bhardwaj, A.K.; Joseph, P. and Joseph, S. (1996). Some observations on troop structure, activity budget and food habits of the Nilgiri langur (*Presbytis johnii*) in Periyar during mansoon (June-August). Indian Forester, 122 (10): 946-950.

297. Sugimura, M., Suzuki, Y. Kamiya, S and Fujita, T. (1981). Reproduction and prenatal growth in the wild Japanese serow, *Capricornis crispus*. Japanese Journal of Veterinary Science 43:553–555.United Kingdom.

298. Sunquist, M.E. and Sunquist, F. (2002). Wild cats of the world. The University of Chicago Press, Chicago.

299. Sushma, H. S. and Singh, M. (2006). Resource partitioning and interspecific interaction among sympatric rain forest arboreal mammals of the Western Ghats, India. Behavioral Ecology, 17, 479–490.

300. Swarup, D.; Patra, R. C.; Prakash, V.; Cuthbert, R.; Das, D.; Avari, P.; Pain, D. J.; Green, R. E.; Sharma, A. K.; Saini, M.; Das, D. and Taggart, M. (2007). Safety of meloxicam to critically endangered Gyps vultures and other scavenging birds in India. Animal Conservation 10 (2): 192-198.

301. Talukdar, B.K., Emslie, R., Bist, S.S., Choudhury, A., Ellis, S., Bonal, B.S., Malakar, M.C., Talukdar, B.N. and Barua, M. (2008). *Rhinoceros unicornis*. The IUCN Red List of Threatened Species 2008: e.T19496A8928657. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T19496A8928657.en.

302. Tewari, R. and Rawat, G.S. (2013b). Factors influencing seasonal changes in the herd size and composition of Swamp deer in Jhilmil Jheel Conservation Reserve, Haridwar, Uttarakhand, India. Int. J. of Pharm. & Life Sci., 4 (8): 2870-2875.

303. Tikader, B.K. (1983). Threatened Animals of India. Zoological Survey of India, Calcutta, India.

304. Tilson, R. L. (1979). On the behaviour of the hoolock gibbons (*Hylobates hoolock*) during different seasons in Assam, India. Journal of the Bombay Natural History Society 76: 1-16.

305. Tuboi, C. and Hussain, S.A. (2014). Factors affecting forage selection by the endangered Eld's deer and hog deer in the floating meadows of Barak-Chindwin Basin of North-east India. Mammalian Biology. http://dx.doi.org/10.1016/j.mambio.2014.10.006.

306. Tuboi, C., Hussain, S. A., Badola, R., Leima, S. and Babu, M.M. (2015). Recent Changes in the Phumdis of Keibul Lamjao National Park, Manipur and Management Implications. In: ENVIS bulletin. Ecology and Management of Grassland Habitats in India. Eds. Rawat, G.S. and Adhikari, B.S. Wildlife Institute of India, Dehradun 248001, India Vol. 7 pp 240.

307. Wang, S. (1998). China Red Data Book of Endangered Animals. Beijing: Science Press, 132–135.

308. Wang, X., Choudhury, A., Yonzon, P., Wozencraft, C. and Than Z.(2008). Ailurus fulgens. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on 18 June 2014.

309. Wangchuk, T., Inouye, D., Hare, M. (2003). A new subspecies of Golden langur (*Trachypithecus geei*) from Bhutan. Folia Primatologica, 74(2): 104-108.

310. Wayre, P. (1968). The Golden langur and the Manas Sanctuary. Oryx 9: 337–339.

311. Wayre, P. (1969). A guide to the pheasants of the World. Country Life Ltd., London.

312. WAZA (2005). Building a Future for Wildlife – The World Zoo and Aquarium Conservation Strategy, WAZA, Berne, 2005.

313. Wei, F., Feng, Z., Wang, Z. and Hu, J. (1999). Current distribution, status and conservation of wild Red pandas Ailurus fulgens in China. Biological Conservation 89, 285-291.

314. Wharton, C. H. (1968). Man, Fire and Wild Cattle in Southeast Asia. Proceedings of the Annual Tall Timbers Fire Ecology Conference 8: 107–167.

315. Williams S.E. and Hoffman E.A. (2009). Minimizing genetic adaptation in captive breeding programs: a review. Biol. Conserv. 142:2388–2400.

316. Williams, B.H. (2003). Red panda in eastern Nepal: how do they fit into ecoregional conservation of the eastern Himalaya. Conservation Biology in Asia 16, 236-250.

317. Willis, K. and Wiese, R. J. (1993). Effect of new founders on retention of gene diversity in captive populations: a formalization of the nucleus population concept. Zoo Biol 12:535–548.

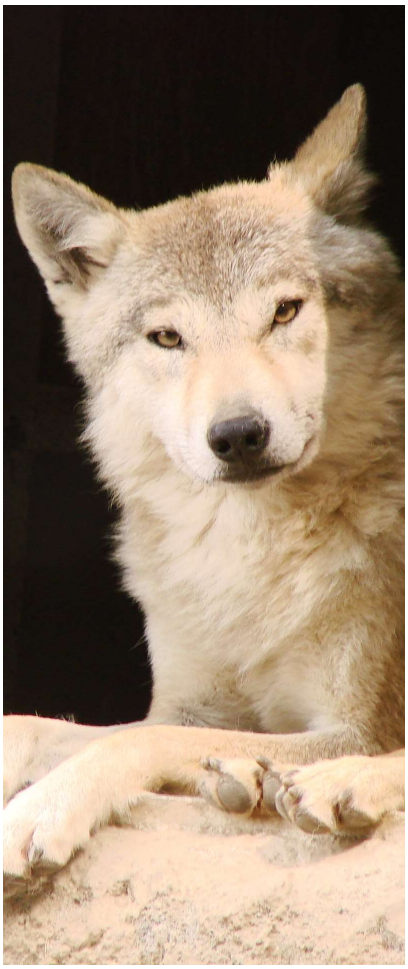
318. Wilting, A., Buckley-Beason, V.A., Feldhaar, H., Gadau, J., O'Brien, S.J. and Linsenmair, K.E. (2007). Clouded leopard phylogeny revisited: support for species recognition and population division between Borneo and Sumatra. Frontiers in Zoology 2007, 4:15, 1-10.

319. Yonzon, P. B. (1989). Ecology and conservation of Red panda in Nepal Himalayas. PhD thesis, University of Maine, Orono,U.S.A.

320. Yonzon, P.B. and Hunter, M.L. (1991). Conservation of the Red panda *Ailurus fulgens*. Biological conservation 5, 1-11.

321. Zoological Survey of India. (2002). Pangolins (Mammalia: Pholidota) of India. ENVIS Newsletter, Vol. 9 (No. 1 and 2).






भारतीय वन्यजीव संस्थान
Wildlife Institute of India

P. O. Box 18, Chandrabani
Dehradun - 248002
Uttarakhand, India
Phone: +91 135 2640111-115
Fax: +91 135 2640117
Email: wii@wii.gov.in
Website : http://www.wii.gov.in