
Ministry of Environment Forest and Climate Change
Central Zoo Authority
केन्द्रीय चिड़ियाघर प्राधिकरण
CARE IN CAPTIVITY
A Compendium to Showcase Best Practices of Zoos

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Suggested Citation: Central Zoo Authority (2026). CARE IN CAPTIVITY: A Compendium to Showcase Best Practices of Zoos. pp: 1-96

Credits: Cover (Back) Photo: Dr. Sanjay Kumar Shukla, IFS (Retd.)

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पर्यावरण, वन एवं जलवायु परिवर्तन
भारत सरकार

सत्यमेव जयते

भूपेन्द्र यादव
BHUPENDER YADAV

MINISTER
ENVIRONMENT, FOREST AND CLIMATE CHANGE
GOVERNMENT OF INDIA

MESSAGE

India's zoos occupy a vital place in our nation's collective commitment to wildlife conservation. Beyond their traditional role, they have emerged as dynamic institutions that support *ex situ* conservation, advance scientific research, inspire learning, and build capacity for the future. As custodians of some of our most threatened species, zoos carry a profound responsibility to uphold the highest standards of animal welfare, ethical care, and professional excellence. Robust systems of monitoring, evaluation, and continuous improvement are therefore essential to ensure that these institutions fulfill their conservation mandate with integrity and accountability.

The publication **"CARE IN CAPTIVITY: A Compendium to Showcase Best Practices of Zoos"** is a timely and commendable initiative that reflects the evolving vision of modern zoos as centres of conservation leadership. It brings to the fore exemplary practices that place animal welfare, science, and education at the heart of zoo management. The establishment of a Biobank of Endangered Wildlife in Indian zoos marks a significant milestone in harnessing modern science for conservation. Through the systematic collection and preservation of biological and genetic material, we can safeguard invaluable genetic diversity, strengthen population management, enhance disease surveillance, and support cutting-edge reproductive and genomic research for generations to come.

Conservation breeding programmes form a cornerstone of species recovery, particularly for those facing severe decline in the wild. When guided by scientific rigour, national priorities, and long-term vision, such programmes can prevent genetic erosion and demographic instability. Integrated with habitat conservation, ecological restoration, and carefully assessed reintroduction or reinforcement efforts, they offer renewed hope for the revival of endangered species in their natural landscapes.

The Ministry of Environment, Forest and Climate Change remains steadfast in its commitment to strengthening science-based policy frameworks, fostering collaboration across institutions, and promoting adaptive, forward-looking approaches to conservation. Through these collective efforts, Indian zoos will continue to evolve as centres of conservation excellence, inspiring stewardship, advancing knowledge, and contributing meaningfully to national and global biodiversity conservation goals.

(Bhupender Yadav)

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कीर्तवर्धन सिंह
KIRTI VARDHAN SINGH

Message

India is recognised globally for its rich biodiversity. Zoos have evolved beyond their traditional role and are now important institutions for conservation, research, education, and capacity building. The publication "CARE IN CAPTIVITY: A Compendium to Showcase Best Practices of Zoos" is a commendable initiative that brings together exemplary practices adopted by Indian zoos in the areas of animal housing, nutrition, veterinary care, environmental enrichment, behavioural management, conservation breeding, and visitor education.

The development of a Biobank of Endangered Wildlife in Indian zoos represents a strategic investment in conserving the genetic material of threatened species and provides an invaluable resource for future research, assisted reproduction, and species recovery efforts. The biobank complements in-situ conservation by offering an added layer of security against irreversible genetic loss.

Focused conservation breeding initiatives have shown encouraging results, particularly for critically endangered and highly threatened species. Species Recovery Programmes, supported by scientifically managed conservation breeding, play a vital role in restoring viable populations of threatened fauna. These programmes, when guided by sound science and coordinated with habitat protection and field-based conservation actions, provide a realistic pathway for reintroduction and long-term survival of species in the wild.

The success of these initiatives depends on close collaboration among zoos, research institutions, forest departments, veterinarians, conservation biologists, and policy makers. The dedicated efforts of all professionals and institutions involved in strengthening zoo management, advancing conservation breeding, and contributing to species recovery programmes across the country are very well appreciated.

Together, through sustained commitment and innovation, we can secure a resilient future for India's endangered wildlife and uphold our responsibility towards preserving the nation's natural heritage.

(Kirti Vardhan Singh)

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MESSAGE

Modern zoos have evolved from being mere centres of public display to becoming vital conservation institutions that play a significant role in supporting species survival through science-based management, research, and education. In the context of increasing anthropogenic pressures on wildlife and natural habitats, zoos today contribute meaningfully to conservation breeding, species recovery programmes, capacity building, and the generation of scientific knowledge essential for informed wildlife management and policy formulation. Ensuring high standards of animal welfare, grounded in biological, behavioural, and veterinary sciences, is fundamental to the effective functioning and credibility of such institutions.

The Compendium titled "CARE IN CAPTIVITY: A Compendium to Showcase Best Practices of Zoos", brought out by the Central Zoo Authority, represents a comprehensive and evidence-based documentation of successful practices adopted by zoos across the country. The compendium captures a wide range of scientifically validated approaches related to animal housing, nutrition, veterinary healthcare, behavioural enrichment, environmental management, and professional capacity development. By systematically consolidating these best practices, the publication provides valuable insights into the evolving standards of animal care and management in Indian zoos.

The documentation of conservation breeding and species recovery initiatives highlighted in this compendium underscores the importance of strategic population management, maintenance of genetic viability, and coordinated ex-situ interventions that effectively complement in-situ conservation efforts. Such integrated and scientifically guided approaches are critical for the long-term conservation of threatened and endangered species.

By bringing together standardised protocols and successful field-level practices, this compendium will serve as an important technical reference for zoo managers, veterinarians, biologists, researchers, and policymakers. It is expected to facilitate the uniform adoption of science-driven management practices, promote continuous monitoring and evaluation, and strengthen the role of Indian zoos in supporting national and global conservation priorities. I am confident that this publication will encourage excellence in zoo management and further reinforce India's commitment to animal welfare and biodiversity conservation.

(Tanmay Kumar)

New Delhi
March 09, 2026

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MESSAGE

Once primarily places of entertainment, zoos today stand at the forefront of conservation, education, and scientific research and the importance of zoos in preserving wildlife and fostering a connection between humans and the natural world has never been more critical.

The compendium offers invaluable insights into various aspects of zoo management, from habitat design and animal welfare to public education and sustainable practices. Each chapter encapsulates proven strategies and innovative approaches that have been successfully implemented in zoos across the globe. These best practices serve as a testament to our collective commitment to excellence and our unwavering dedication to the creatures in our care.

The case studies and detailed guidelines highlight the importance of creating enriching environments for animals, engaging educational programs for visitors, and fostering collaborations with local and international conservation organisations. The principles outlined here are not just theoretical ideals but practical solutions that can be adapted and implemented in diverse settings, ensuring that zoos remain vibrant centres of conservation and learning.

The success stories featured in this compendium are a source of inspiration and a call to action for zoo professionals everywhere. They remind us that, with dedication and innovation, we can make significant strides in our mission to protect and preserve our planet's precious biodiversity.

I extend my heartfelt gratitude to all the contributors whose expertise and passion have made this compendium possible. It is my hope that this guide will serve as a vital resource for zoo managers, staff, and all those involved in the care and conservation of wildlife. Together, we can continue to push the boundaries of what is possible in zoo management and ensure a brighter future for all species.

(Sushil Kumar Awasthi)

Place: New Delhi
Date: 24th February, 2026

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MESSAGE

Zoos today occupy a position extending far beyond their traditional role as facilities for exhibition. Modern zoos function as centres of conservation science, supporting ex-situ conservation, species recovery, research, education, and capacity building, while complementing in-situ conservation efforts.

This Compendium on Best Practices in Zoos is a significant initiative, as it documents and disseminates scientifically validated approaches adopted by Indian zoos in key thematic areas such as conservation breeding, species recovery programmes, artificial incubation techniques, and robust systems for monitoring and evaluation. Conservation breeding programmes, when guided by sound genetic and demographic management, play a pivotal role in securing assurance populations of threatened species and, where feasible, supporting reintroduction and population reinforcement in the wild. Similarly, species recovery initiatives undertaken in coordination with field conservation agencies demonstrate the growing integration of ex-situ and in-situ strategies.

The inclusion of best practices on artificial incubation reflects the application of technological and veterinary advancements in improving reproductive success, particularly for threatened avifauna and reptiles. Equally important is the emphasis on systematic monitoring and evaluation of zoos, which ensures compliance with prescribed standards, promotes evidence-based management, and fosters continual improvement in animal welfare, conservation outcomes, and institutional performance.

By compiling these best practices, the Compendium serves as a valuable knowledge resource for zoo professionals, researchers, policymakers, and other stakeholders. It is hoped that this publication will encourage replication of successful models, strengthen professional capacities, and reinforce India's commitment to science-driven zoo management aligned with national priorities and international conservation standards.

I commend the efforts of all contributing institutions and professionals involved in this endeavour and am confident that this Compendium will contribute meaningfully to enhancing the conservation role of zoos in India.

(Ramesh Pandey)

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Message

It is with great pleasure and a profound sense of responsibility that I introduce this "CARE IN CAPTIVITY: A Compendium to Showcase Best Practices of Zoos". The practices outlined in this compilation are a testament to the dedication and ingenuity of zoological professionals in Indian zoos in their tireless pursuit of excellence in animal care and conservation. This comprehensive compendium of best practices in zoo management is a compilation focusing on a wide array of innovative measures aimed at enhancing animal welfare, promoting conservation breeding, enriching the lives of captive animals, ensuring top-notch veterinary care, designing effective enclosures, and much more.

From the implementation of enrichment programs that mimic natural behaviours to successful reintroduction initiatives aimed at restoring populations in the wild, each practice detailed in this compilation represents a milestone in the ongoing journey towards better stewardship of our planet and its inhabitants.

Furthermore, this compilation goes beyond the confines of zoo walls, delving into the realm of community engagement through education programs, citizen science initiatives, and nature conservation activities. It emphasizes the vital role that zoos play as hubs of learning and encouragement, inspiring individuals of all ages to become stewards of the natural world. Moreover, this compilation recognizes the importance of sustainability in modern zoo management, with a focus on initiatives such as the reduction of single-use plastics and the adoption of alternative energy sources. By embracing these practices, zoos demonstrate their commitment to environmental responsibility and serve as catalysts for positive change in their communities and beyond.

I extend my heartfelt gratitude to all the Zoo Director, Curators, Officer-in charge of zoos, Biologists, Veterinarians, Researchers, Educators, and Conservationists who have contributed their expertise and insights to this compilation.

Let this compendium be a beacon of best practices, guiding us towards a more sustainable and harmonious relationship with the natural world.

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01 Best Practice in Monitoring and Evaluation of Zoos in India

- Praveen Chandra Tyagi, Former PCCF & CWLW (HOFF) TN

Introduction

Wild animals have been kept in captivity since time immemorial in India. Many rulers- maintained menageries keeping ferocious animals in captivity. In the Colonial Period, the British set up a small Zoo called Marble Palace Zoo in Kolkata in 1854, one of the first Zoos in the country. Subsequently many Zoos were set up in India where animals were kept in small enclosures designed to exhibit animals from close quarters. In course of time there was a mushrooming of Zoos, private menageries, circuses and animal collections. There was a growing realization that the Zoos should function based on regulations to be determined by the Government. In pursuance of this, the Central Zoo Authority (CZA) was created by the Government of India through an amendment of the Wildlife (Protection) Act, 1972 and the insertion of Chapter IVA (Sec 38A to 38J), on 2nd February, 1992. The function of CZA was to (a) specify the minimum standards for housing, upkeep and veterinary care of the animals kept in a zoo; (b) evaluate and assess the functioning of zoos with respect to the standards or the norms as may be prescribed; (c) recognise or derecognise zoos. The Zoo were statutorily required to obtain recognition and prior approval of CZA before commencing operations.

Evaluation of Zoos

The Ministry of Environment and Forest and climate change notified the Recognition of Zoo Rules 1992 which was amended in 2004, 2009,2013, 2019 and 2022 (Zoo Rules) to incorporate enhanced measures for Animal Welfare. . As per rule 9, Zoos are classified in the categories such as Large, Medium, Small and Mini Zoos based on qualifying criteria based on area, number of visitors, number of species and animals and number of endangered species and animals. It is incumbent on the operating Zoos to seek recognition and satisfy the standards and norms enumerated in the Zoo Rules. Zoo which have failed to maintain the prescribed standards and norms within a reasonable time frame were directed to close down and transfer animals to other Zoos.

The Central Zoo Authority evolved a evaluation criteria and began evaluation of the Zoos every year, third or fifth year depending upon category of the Zoo i.e. large, medium, small or mini Zoo for compliance of norms and standards to ensure the quality of upkeep and maintenance to provide better living conditions for the wild animals at the same time providing a satisfying and learning experience for the visiting public. This evaluation system is one of the best practices in Indian zoos as it reflects on the management of Zoos and maintenance of standards prescribed in Zoo Rules. Those Zoos which fail to comply with Zoo rules and do not improve within the time frame are derecognized and have to close down. There are 145 recognized Zoos in the country, 17 Large Zoos, 24 Medium Zoos, 32 Small Zoos, 58 Mini Zoos, 13 rescue centers and 1 circus managed by various authorities.

The Wildlife (Protection) Act, 1972 and Recognition of Zoo Rules, 1992 made it mandatory for the Zoo to provide animals housing, maintenance and upkeep that is congenial to the physical and behavioral health of the animals. The regular evaluation and recommendation for improvement have transformed Zoos from traditional animal displays to interactive, conservation centers that bridge and link captive collections (Ex-situ) to free-range wildlife (In-situ). In the strategic plan (master Plan) of the Zoos the main endeavor is to provide thematic and naturalistic display of animals housed in the Zoos. Zoos are now introducing innovative natural enclosure design with enrichments to reflect the immersion effect. The nutrition, health care, visitor management and record keeping has vastly improved in the Zoos across the country.

The evaluation framework for Zoos is very inclusive and exhaustive covering all aspects of Zoo management and has four parts.

Part I- describes the basic information of the Zoo, its name, location, year of establishment. management, number of species and animals displayed, visitor number, special facilities, budget etc.

Part II- describes the details on compliance of the conditions stipulated by the Central Zoo Authority during the grant of previous approval. Part III- covers information on Standards and Norms prescribed in the Recognition of Zoo Rules, 2009 ,subject to which recognition under section 38H of the Act shall be considered. This part covers the information on the General requirement of Zoos, Administrative & Staffing Pattern, Development and planning, Animal Housing, display of animals & animal enclosures, Enclosures and animal facilities, Nutrition and food hygiene (Carnivore food and hygiene , Food distribution, Removal of unused feed and excreta etc), Visual observation on daily activity pattern of animals and preventive healthcare , Veterinary and Infrastructure Facilities; Zoo hospital, Animal restraint, Veterinary Support staff, Wildlife veterinary medical education and training, Post-mortem and disposal of carcasses of animals, Euthanasia, Acquisition and breeding of animals, Research Activities, Education and Outreach Activities and Visitor facilities.

Part IV- is most important as it lists out the shortcoming and deficiencies in the Zoo management with respect to the norms and guidelines of the Zoo Rules. This part also contains the suggestions/recommendation of the Evaluator based on his observation during the Zoo visit and examination of all zoo records. This Evaluation is one of the most vigorous evaluations and covers all aspects of Zoo Management.

Management Effectiveness Evaluation of Zoos

The Central Zoo Authority in collaboration with Wildlife Institute of India has developed the framework for assessing the Management Effectiveness Evaluation of Zoos (MEE ZOO) in 2020. This framework is unique as it is one of the most comprehensive evaluation tools developed based on the IUCN –WCPA framework.

MEE-Zoo is an inclusive assessment based on information and documentation provided by the zoo and a detailed site visit. The exercise will generate baseline data for comparison and with repeated evaluations will generate performance trends that will provide in-sights for better decision-making and ex-situ conservation initiative planning. It can also focus on management efforts when resources are constrained.

The MEE of Zoos is a discrete, holistic and independent exercise, with adaptive management to improve efficiency and understanding and rationalizing resource allocation. It involves all stakeholders, communities and NGOs and promotes education and awareness. The baseline data generated is used for comparison and also helps in grading the Zoos using a Scoring system. The framework provides rapid assessment with minimum budgetary support with clear and specific focus and strategic guidance and action for improvement. Further the assessment will lead to grading of zoos in various categories.

The MEE framework for Zoological Parks has six distinct stages or elements:

A. Context will establish the mandate, role of Zoos for conservation of species (Context)
B. Planning will include all the efforts in conceiving, designing the ex-situ conservation and management strategy (Planning)
C. Availability of resources and infrastructure (Inputs)
D. Management actions and protocols (Process) and
E. Eventually produces goods and services (Outputs)
F. That results in impacts or (Outcomes)

In order to ensure credibility to the assessment process a committee of 15 independent experts was constituted. The Technical Manual 'Guidelines, Criteria and Indicators for Evaluation of Indian Zoological Park through Management Effectiveness Evaluation Process (MEE-ZOO) (Tyagi et al, 2020) was used for the MEE process.

Key focus of evaluation in six elements of MEE framework of Zoos

Elements of evaluation	Criteria Proposed
Context	Mission, Vision, objectives and Strategy of the Zoo Compliance with the essential requirements Zoo landscape and its environment Ethical standards and norms
Planning	Planning process: master plan Specific strategies and plans: Enrichment Plan, Education Plan, Visitor Management Plan, landscape management and Disaster Management strategy Captive/ Conservation Breeding Plan, norms and strategy
Input	Human and financial resource Training and Capacity Building Visitor and education infrastructure Healthcare, Nutrition and sanitation Protection infrastructure
Process	Sustainability of animal population and resources Stakeholders participation Health care Zoo enforcement Animal welfare Species specific enrichment Use relevant technologies for conservation, education, research Rescue and rehabilitation
Output	Research activities and collaboration Safety of animals, animal keepers and visitors Sanitation and hygiene regime Achieving animal welfare Maintaining database on animals Zoo Veterinarian and staff performance Responding to emergencies
Outcomes	Health of animals Rescue and rehabilitation of animals Contribution of Zoo Animal keepers, veterinarian and supporting staff Conservation breeding programme human resource development Visitor learning experience Research relevance Climate Change Innovative technology and best management practices

For assessment of six elements of the MEE framework, 42 criteria (headline indicators) have been developed (3 to 8 questions have been developed in each element). Explanatory notes, wherever needed, were provided to guide the assessment process. The scores, along with observations (remarks), provide a better understanding of the situation in the Zoo. The Evaluator will provide short note on (a) Management Strengths; (b) Management Weaknesses and (c) Actionable Points and Strategy

Scoring System

The scoring of the various indicators will be done using a scorecard which shall be marked in four categories viz., Poor, Fair, Good and Very Good. The evaluator shall have to fill a table for filling of marks of all 42 indicators. As each indicator has a maximum of 10 marks, 420 will be the maximum score and evaluator shall assign overall score and percentage as per scorecard.

MEE ZOO First Cycle Results:

The 15 expert evaluators and the coordinator/guide conducted the assessment of all 39 Zoos as per the prescribed criteria and completed the MEE Score Card. The scores obtained by Zoos for each element were tabulated for different categories of Zoo. A broad analysis of element wise performance indicates that there is definitive value in collective learning from institutions.

The Arignar Anna Zoological Park, Tamil Nadu secured the highest MEE Score of 82% among the large category zoos and rated "Very Good". The Kamla Nehru Zoological Garden, Gujarat scored 59% and rated "Fair", as the assessment revealed gaps that the zoo could proactively work towards. Among the medium category zoos, the Padmaja Naidu Himalayan Zoological Park, West Bengal secured the highest MEE Score of 83% and rated "Very Good". The MEE of the State Museum & Zoo, Kerala and Nagaland Zoological Park, Rangapahar, Nagaland indicated that they require substantial improvement.

The actionable points derived from the MEE-Zoo evaluation, along with the pillars of change indicated in the Vision Plan for Indian zoos (2021- 31) can become the catalyst for the transformation, build innovation and leadership and help zoos deliver experiences that inspire visitors to take conservation action and affirm deeper community connect.

Best innovative Practices in Zoos

1) At Nandankanan Biological Park, Odisha, research on conservation breeding of Indian pangolin is actively being conducted in the specially designed 'Indian pangolin conservation breeding center' which closely mimics natural habitat and nutritional needs as occurring in the wild. The pangolins are continuously monitored through infrared sensitive CCTV cameras and all physiological, behavioral and reproductive cycle data are collected and analyzed.
2) At Arignar Anna Zoological Park, Tamil Nadu, three biologists are contributing immensely in analyzing stud book data on animal heterozygosity, kinship value to bring new blood under animal exchange programme, have revitalized education, research, interpretation and outreach programme and assisted in maintain Zoo records.
3) Zoo Ambassadors Camp at Arignar Anna Zoological Park, Tamilnadu- The program is essentially an education- cum- entertainment camp for school students. It is mentored by Zoo Veterinarians, Zoo Biologists, and species specialists. Students are sensitized on animal management and the use of activity sheets. They are awarded a certificate for "Zoo Ambassador of Vandalur Zoo" along with a badge and Zoo passport. Students act as 'Zoo Ambassadors' and spread the message of conservation to their friends and family members. In 2020, due to the nationwide lockdown, the program was continued online. The live streaming feature available on the zoo website from 180 cameras installed in the zoo and animal enclosures also gained further momentum during the lockdown with approximately 60,000-80,000 daily views.
4) Nawab Wajid Ali Shah Zoological Gardens, Uttar Pradesh excelled in giving impetus to education, awareness, and outreach programmes primarily targeted at children and youth. The "Nature Interpretation Center" showcased the biodiversity rich forest of Uttar Pradesh exhibits on wildlife enriched the center. The Nature Interpretation has a gallery of signages which are in braille , catering to the visually impaired visitors thus taking a step towards universal accessibility. The zoo also facilitates free entry to Persons with Disability and conducts regular programs for school children with special needs.
5) The Sri Chamarajendra Zoological Gardens, Karnataka is one among the few self-sustainable zoos. In the past two decades, the zoo administration has introduced many interventions, innovations and programs; from waste management policy, to a flexible animal adoption program. After segregation of the waste, the biodegradable waste is used for making biogas, vermicompost, manure in the campus itself. Biogas is used in the zoo kitchen. The zoo has tie-ups with various NGOs for the recycling of plastic. The zoo is able to harvest around 79 crore liters of rain water through directed infrastructure changes. The surrounding areas of the zoo and the farmers have also benefited by this system as no borewells go out of water during the summers, The zoo also provides RO drinking water for free to the visitors. Seventy percent of the water that gets wasted from the RO units is re-used in the zoo gardens.
6) The Madras Crocodile Bank Trust, Tamil Nadu has set up a docent program to include wildlife enthusiasts from the city to get involved with zoo activities under supervision of the staff. The program has been set up in line with the guidelines put for by the CZA for volunteer engagement. The docents are volunteer educators and help engage the public in education activities and provide information about the animals displayed in the zoo.

Key weaknesses/ shortcomings

The shortcomings noticed from the MEE evaluations element wise are given below:

CONTEXT

The Zoos have to focus on strengthening mission, vision, objectives and strategy set by them in the Master Plan for steering the Zoo for achieving the NZP policy.

PLANNING

The development of the four sub-plans in the Mater Plan viz Conservation education, animal enclosure enrichment, Captive breeding of animals and landscape management plan must be prepared as per guidelines for scientific management of Zoos. The other section relating to Disaster Management Strategy and security plan needs more input.

INPUT

Many zoos do not have a society for management of funds and also lack advisory committees in place with specific TOR and meeting schedules. Zoo management must try to mobilize maximum additional resources from internal and external sources for sustainable management e.g.: CSR, animal adoption programs, and accepted revenue generation avenues within the zoo. Zoos have to strengthen Human Resource development by filling vacant positions and adhere to the staff requirements as per the zoo Rules. Zoo managements need to focus efforts on site specific, well-developed visitor facilities, universal accessibility across the zoo, transport services, catering, marketing, and promotional material (website, apps, brochures, branding of materials in the store etc). Zoos have a hospital but need to focus efforts on developing state of the art facilities for diagnostics and treatment with large and small animal operation theaters, separate quarantine areas, post-mortem and carcass disposal facilities with sufficient stock of medicine, and in-house laboratory. Additionally, zoos must have sufficient collaborations with State Veterinary Colleges or district veterinary hospitals, including a Health Advisory Committee having independent experts.

PROCESS

Zoos must plan their animal collection so that animals are in social and demographic groups, allow optimum breeding, adopt adequate population control mechanisms and raise self- sustained populations without any deviation from the collection plan. The concept of green zoos with environmentally sustainable operations should enable the zoos to develop a comprehensive garbage disposal system, a strategy for recycling of wastewater, energy conservation, explore renewable energy sources and regularize bio-hazardous/ veterinary waste disposal with the help of innovative technologies. Zoos need to develop novel and innovative approaches to locally source some of its food for animals (fodder, tree fodder, greens, rats and insects) and deal with the challenges of limited space to grow special feed. As developing modern zoos, it is pertinent to consider implementation of visitor friendly, smart applications for sharing information on maps & signage, keepers talk, visitor guidance and ticketing. Other technological innovations in

conservation education related to information kiosks, touch screens with event information, and feedback, web-based live streaming of animals, virtual reality, augmented reality, electronic bar- code-based entry gates, technology-based devices for animal welfare in the form of sprinklers, water blasters. The use of camera traps and CCTVs for monitoring animals and for security etc must be considered. Any technology for visually impaired, physically challenged and for visitors with special needs must be introduced.

OUTPUT

Most zoos are uncertain about research priorities for their house teams, which also lack capabilities. The best option is to collaborate with research bodies and organizations, sharing data to facilitate research, disseminates and publication of research in appropriate platforms. Most zoos appear to be lacking a comprehensive database (physical/ digital) for animals in its collection in standard formats as per CZA

norms, with permanent individual identification for animals for maintaining studbooks and records. Zoos are not actively pursuing genetic and demographic analyses for most animals which are great tools for developing Species Recovery Plans.

Outcomes

Zoo management must make efforts to provide opportunity for building leadership, capacity enhancement, specialised training, career progression and raising motivation levels of Staff and addressing welfare issues. The research priorities of the zoo have to be formulated in the form of a comprehensive research plan that can feed data into Zoo management and conservation.

Way Forward

- To inculcate the use of best practices in all aspects of management, there has to be an effective and all round amalgamation of science, applied research and technology grounded in evidence based conservation actions.
- The master plan has to be a strategic document envisioning the development and growth of the zoo over a 20-year period. This should include a detailed collection plan taking into account space availability, number of animals per species (including potential breeding), theme, and local climatic conditions. The masterplan must have a clearly stated mission, vision and objectives and include plans for education, enrichment, disaster management and landscape management.
- The existing conservation breeding programs have to be re-formulated with focus on genetic profiling of the species with clear indication of founder stock, animal marking, availability of skilled manpower, appropriate off exhibit location, the identification of founder stock, demographic and population management, behavioral management, nutrition, health care, record keeping, research, animal release after a feasibility assessment, plan for soft release, community engagement at place of release. The linkages with in-situ conservation initiatives must follow the One Plan approach for long term planning for species conservation.
- The animal housing has to be reviewed to include all aspects of species-specific biological requirements to augment the overall wellbeing of the animals along with developing a species-wise, dynamic environment enrichment plan. The design elements must effectively incorporate aspects of 'landscape immersion' (incorporating natural and cultural elements of animals' native land) and 'abstract ecology' (representing elements of animals' native habitat). The behavioral repertoire of animals should be studied and any indication of stress should be further examined by minimally invasive stress hormone estimation.
- Information/data management and recordkeeping is key to effective action in animal care. Zoos must use the mandated software(s) and for additional features and analysis, zoos may use globally recognised data recording systems or develop and manage programs independently to suit their needs.
- Research is an important initiative in a zoological institution. Zoos must recruit mandated technical and scientific personnel (as per Zoo Rules), encouraging research. Research at the zoo can strengthen management initiatives and address welfare concerns, ensuring better care for animals as well offer further insight into the behavioral and psychological trends in animals. Citizen science programs, usually addressing questions that require long- term, large-scale data collection, are a great way for people to build a positive relationship with the zoo and to contribute to science.
- Interpretative learning at the zoo relies heavily on immersive habitat experiences and creating memorable multi-sensory experiences. Various interpretative strategies may be included in the overall education strategy of the zoo including a dedicated interpretation center, interactive signage, developing relevant IEC material etc. Increasingly, the use of technology as a facilitator of inquiry and a tool for interpretation has gained popularity across the world.

- Visitor experience encompasses a visitor's emotions, beliefs, pReferences, perceptions, physical and psychological responses, that occur before, during, and after the visit. Continued visitor engagement surveys contribute to understanding visitor interaction with the zoo environment helps in better identifying people's needs, planning and designing of animal exhibits, providing adequate amenities, development of business and marketing strategies including the development of curated experiences, memberships and loyalty programs.
- There are continual advances in technology and digital interpretation applicable to zoo management. The use of digital technology can help zoos to expand outreach programmes, improve animal welfare, and achieve overall efficiency. Interactive technological systems (websites, zoo apps, virtual zoo tours etc) can offer opportunities to enhance visitor experience by expanding the dimensions of the encounter.
- Zoos need to garner a steady stream of revenue to effectively fund their operations. Gate revenue is the primary source of income for zoos, coupled with support from the government agencies and subsidiary sources such as bank interests, sale of items, leases, rents, and penalties.
- Zoos are complex institutions, requiring a wide range of skills and expertise for optimal functioning, including wildlife management, specialized veterinary care, administrative experience, communication skills and more. Zoos must thus invest in developing skilled and motivated teams and ensure appropriate career enhancement opportunities and skill enhancement training.
- Zoos must aim to become a part of the community that embodies the principles of sustainable functioning. The functions of the institution must aim to synergise the elements of soil, water, energy and waste and make this demonstrable by developing a comprehensive environmental sustainability strategy incorporating water reuse, filtration and recycling, thoughtful consumption and reduction of water pollution, and increase in recharge of the ground-water.

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02

Biobank of Endangered Wildlife in Indian Zoos

- B. Sambasiva Rao & Karthikeyan Vasudevan
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Extinctions of species are rapidly unfolding across taxonomic groups, and growing number of species are in need of immediate measures. Faced by this challenge, the International Union for Conservation of Nature (IUCN) has recently launched an Animal Biobanking for Conservation Specialist Group. It envisions a world by 2033, where biobanking is a powerful global force for conservation, a beacon of ethical and equitable practices, and an essential driver of biodiversity preservation.

Biobanks meet a wide range of requirements for conservation breeding, particularly for the use of assisted reproduction technologies (ART). Globally, successful examples of implementation of ARTs in wildlife are growing, and the overall efficiency of ARTs for wild animals has been enhanced. Therefore, the primary objective of biobank is the preservation of genetic material, germplasm, tissues, and live cells of endangered species. It involves the systematic collection of genetic material (DNA/RNA), gonads (ovaries/testis), gametes (spermatozoa/oocytes), tissues and cells, and preservation at sub-zero temperatures (-30° C to -196°C) without altering their integrity and viability. The biological samples preserved in the biobanks would serve as a biological repository for studies on genetics and even disease investigation. It will help develop cutting-edge technologies for *ex-situ* conservation and pave a way for development of new conservation strategies for endangered species. The germplasm preserved in the biobanks can be used to increase the genetic diversity of a population *in-situ* and enhance the viability of populations. These technologies are being made accessible to Indian zoos by the Central Zoo Authority (CZA). Since, biobanks are a repository of high-quality biological samples of wildlife that are an invaluable resource in matters of public health. These samples help us understand the mechanisms of disease, opening an avenue for accelerated diagnostics and treatment. Such collections can play a pivotal role in early detection of zoonotic diseases and preventing future pandemics.

To meet this requirement, the National Wildlife Genetic Resource Bank (NWGRB) was established with support from CZA at Laboratory for the Conservation of Endangered Species (LaCONES) a constituent lab of CSIR-Centre for Cellular and Molecular Biology in Hyderabad in 2018. This facility is listed among the globally recognized biobanks for wildlife by the IUCN. This facility constantly strives to perfect techniques for cryopreservation of gametes, tissues and primary cells of several species. So far, 27 wild animal species have been biobanked from Indian zoos in this facility. Wildlife veterinarians and biologists from various zoos in India have been trained on the protocols for sample collection and cryopreservation of tissues. Standard operation procedures and manuals for setting up biobanks at zoos have also been disseminated.

Wildlife species with primary cells biobanked at NWGRB from tissues collected postmortem from Indian zoos

Ungulates	Felids	Canids	Primates	Viverrids
Barasingha	Jungle Cat	Indian Wolf	Lion-tailed Macaque	Common Palm Civet
Barking Deer	Jaguar	Wild Dog		
Bison	Leopard	Hyena		
Blackbuck	Lion	Himalayan Black Bear		
Chousingha	Tiger	Sloth Bear		

Ungulates	Felids	Canids	Primates	Viverrids
Mouse Deer				
Swamp Deer				
Sambar				
Hog Deer				
Nilgai				
Spotted Deer				
Thamin Deer				
Wild Ass				
Wild Buffalo				

Recently, post-mortem tissues from Cheetah (*Acinonyx jubatus*) were collected and fibroblast cell lines developed and cryopreserved successfully. It has initiated biobanking of caecilians (tailless amphibians), an unrepresented group of vertebrates in global biobanks. India happens to be one of the global hotspots of caecilian diversity with 41 species belonging to three genera, and all of them are endemic. As part of this effort, tissues (skin, testis, ovary, liver, heart and lung) of two species: *Icthyophis beddomei* and *Gegeneophis sp*. were cryopreserved. Attempts have been made to collect spermatozoa and ovarian follicles (Fig 3), and develop cell cultures (Fig.4) of the two species.

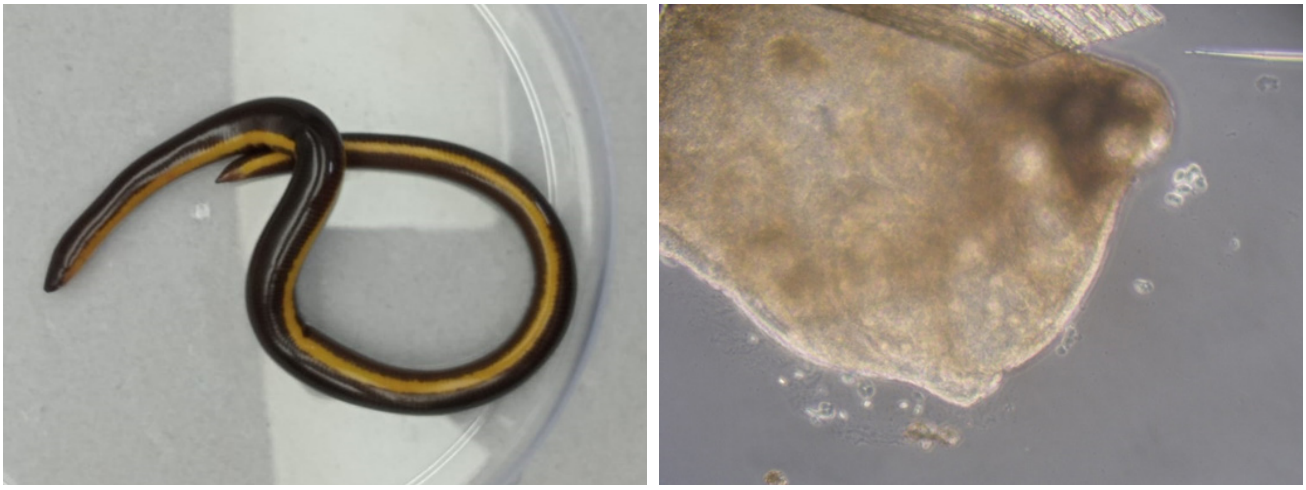

Fig.1: Ichthyophis beddomei (left) and culture of skin explant of I. beddomei (right)

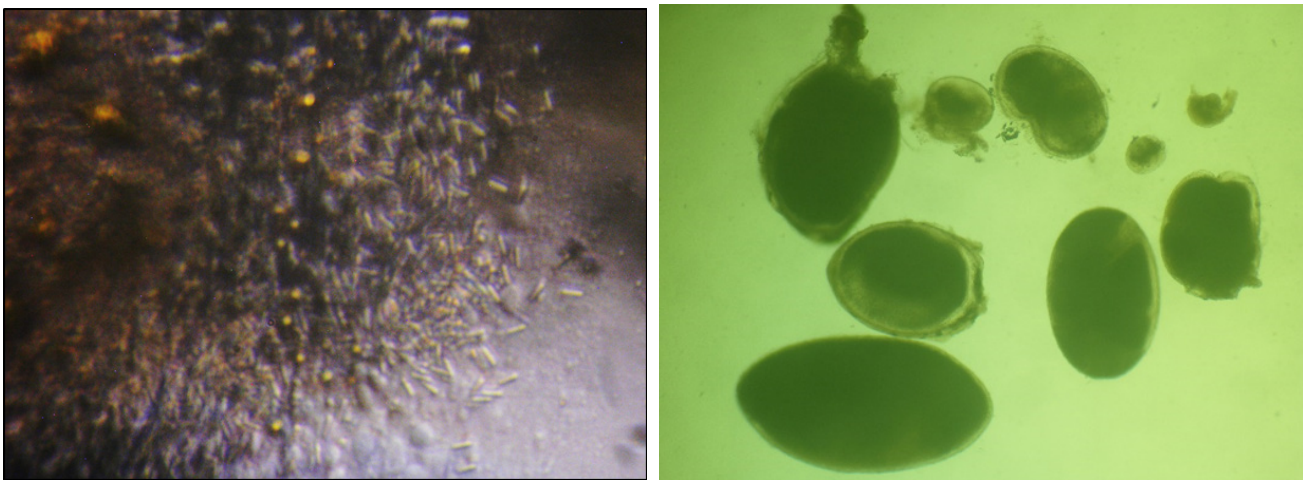

Fig. 2: Spermatozoa of I. beddomei (left) and ovarian follicles of Gegeneophis sp. stained with Hoechst3342

To promote biobanking in Indian zoos we have proposed setting up of a distributed network of biobanks in zoos in the country to promote this activity. Through this initiative, NWGRB and Padmaja Naidu Zoological Park (PNHZP), Darjeeling will soon be entering into a memorandum of understanding to promote biobanking of wildlife. As a step towards this initiative, hands-on training to PNHZP zoo veterinarian and biologist on the protocols for biobanking and setting up biobank facility within the zoo premises.

Fig. 3: Zoo veterinarian Dr Raj Sekhar Sarmah (left) and biologist Miss Subecha Rai (right) from PNHZP underwent hands-on training on biobanking at LaCONES-CCMB, Hyderabad.

03 Report on the First Record of Successful Hand Rearing of 2 Days Old Clouded Leopard *(Neofelis nebulosa)* Cubs in India at the Conservation Breeding Centre of Sepahijala Zoological Park

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Introduction

The Sepahijala Zoological Park started the conservation breeding program of the elusive Clouded Leopards in its Conservation Breeding Centre (CBC) in the year 2010 with complete financial support from the Central Zoo Authority (CZA). The Sepahijala Zoological Park is the Coordinating Zoo for the conservation breeding of Clouded Leopard in India. The main objective of this program is producing a stable self-sustaining population with genetically fit individuals to release in wild again. The breeding was started initially with 2 founder specimens. But to avoid the inbreeding more individuals have been introduced in this program at different times.

Why the hand rearing option was opted?

Hand rearing of wild animal baby should be always considered as a last option as nobody can take care of babies better than their parents. The Clouded Leopard cubs of Sepahijala Zoo (including CBC) were always raised by their mothers only since inception. But the survival rate of newborn Clouded leopard cubs was not satisfactory in this species as many cubs died within 1 to10 days of birth due to multiple reasons. In 2020, filial cannibalism was observed by the mother Clouded Leopard at CBC where she ate her 2 days & 6 days old newborn cubs. These are the experiences which triggered us to go for hand rearing & the basic hand rearing facility was developed thereafter.

Breeding

Though clouded leopards are not seasonal breeders and breeding may happen any time in a year. But peak breeding time is recorded between November to April.

- Here in the CBC of Sepahijala Zoological Park the breeding specimens were kept in naturalistic enclosure throughout the year to minimize the captive stress in this highly sensitive species which is very important for breeding. Simultaneously necessary arboreal pathways have been installed inside their enclosure to fulfil the arboreal needs of breeding specimens.
- Early acclimatization of male-female (Jiten & Jubeda) done by keeping them in close but segregated rooms for tactile, visual & olfactory acclimatization for successful pairing done from 14.05.2021 to 04.06.2021
- After considerable days of acclimatization period this season we have first released both Jiten & Jubeda in the same enclosure on 04/06/2021. But due to their aggressive nature of male towards female again we had to keep them separate for 20 days after 32 days of togetherness. In 4^{th} attempt of re-pairing they have mated on 02/01/22, 05/01/22 & 06/01/22.

Fig 1: Pair during acclimatization period. Fig 2: Pair after acclimatization period.

Fig 3: Allo-grooming; a sign of successful pairing. *Fig 4: Pair during mating.*

Hand rearing

Preparation for hand rearing:

a. After 90 (+/-6) days of gestation period the pregnant female gave birth of 2 cubs on 05/04/2022.

b. It was decided that both the cubs will be hand reared by me single handedly.

c. After 2 days of birth on 07/04/2022 both the cubs have been separated from mother for hand rearing.

d. CCTV monitoring facility has been installed in that cub rearing room to ensure maximum security.

e. Prohibited entry of outsiders in that cub rearing room to ensure maximum bio-security.

f. After separating the cubs for hand rearing they were gently washed by wet tissue to remove dirt & faecal materials from their body. Then both the cubs got weighed.

g. The temperature range inside the incubator was maintained 88° F - 95° F and the relative humidity was 55 – 65 percent for first week.

Fig 5: 2 days cubs with closed eyes *Fig 6: Cubs kept inside incubator*

Fig 7: Weighing 2 days old cubs

Fig 8: Cleaning newly collected cubs

Food & feeding procedure:

Formula: 1 cup low mineral content water ½ cup powdered KMR Probiotic

- Day 1: 1st feeding-Offered /Pedialyte or 5% dextrose only.
- Day 1-3: Offer mixture of water:KMR at a 3:1 ratio.
- Day 4-7: Gradually increase ratio to 2 parts distilled water to 1 part powdered KMR. In general cubs eat 10-20% of body weight per day.
- Days 1-14: Cubs eat every 3 hours/ 7 times per day. 7 gm to 15 gm per feeding. Let go 4-6 hours at night between feedings.
- Day 14-21: Cubs eat every 4 hours/ 6 times per day. 21 gm to 30 gm per feeding. Let go 6-8 hours at night.
- Week 3: Cubs eat every 4 hours/ 5 times per day. 28 gm to 45 gm per feeding.
- Week 4: Cubs eat every 5 hours/ 4 times per day. 48 gm to 52 gm per feeding.
- Week 5: Cubs eat every 5 hours. 48 gm to 52 gm per feeding.
- Week 6: Cubs eat every 5 hours. 48 gm to 52 gm per feeding.
- Week 7: Cubs eat every 6 hours. 45 gm to 50 gm per feeding. Started giving parboiled chicken 20 gm to 40 gm per feeding at this stage to stimulate chewing activity.
- Week 8: Cubs eat every 6 hours. 40 gm to 45 gm per feeding. Started giving parboiled chicken 45 gm to 70 gm per feeding.
- Cubs were entirely off bottle by 15th week & started feeding on meat based diet.

Fig 9: Syringe feeding

Fig 10: Bottle feeding

Fig 11: Feeding on parboiled chicken

Cub development:

- Weight of the male & female cubs were 374 gm & 287 gm respectively when separated from mother at the age of 2 days for hand rearing.
- Eyes were closed & ears were folded at that time.
- Eyes started opening at the age of 10-12 days.
- Ear folds started opening at the age of 2 weeks and competed at the age of 4 weeks.

- Started walking at the age of 20 days.
- Started climbing on objects at the age of 4th week.
- Canine started emerging at the age of 3rd weeks.
- Started chewing behaviour at the age of 6th week.

Photo plates of growing cubs (week wise) up to 2 months of age:

Fig 12: Week- 1

Fig 13: Week- 2

Fig 14: Week- 3

Fig 15: Week- 4

Fig 16: Week- 5

Fig 17: Week- 6

Fig 18: Week- 7

Fig 19: Week- 8

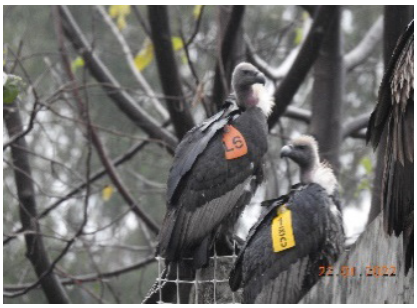
04 The Vulture Conservation Breeding Programme, Pinjore

- Nikita Prakash, In-charge JCBC, Vineet Kumar Garg, IFS, PCCF & CWLW, Haryana and Vibhu Prakash, Dy. Director (Retd), BNHS

Introduction

Asia's first Vulture Conservation Breeding Centre (VCBC) was established in 2004 at Jodhpur village, outside Bir Shikargah Wildlife Sanctuary near Pinjore in the Panchkula district of Haryana for three critically endangered Gyps species of vultures - White-rumped (*Gyps bengalensis)*, Long-billed (*Gyps indicus)* and Slender-billed (*Gyps tenuirostris).* This centre has also been a coordinating zoo of Central Zoo Authority for vulture conservation breeding in the country.

The Centre was established following the release of Vulture Recovery Plan 2004, as an insurance against the possible extinction of the three critically endangered Gyps species of vultures. The population of three resident Gyps species had crashed by over 99% between 1990 and 2000 due to the poisoning of their principal food -cattle carcasses- by veterinary pain killer-diclofenac. The vultures got exposed to the drug when they fed on the carcass of cattle that died shortly after the administration of the drug. This non-steroidal anti-inflammatory drug, considered a wonder drug for cattle, as it gave relief within fifteen minutes, was extremely toxic to vultures and caused renal failure even at very low concentrations. It was thought that unless a conservation breeding programme is established, the three critically endangered species of vulture may go extinct.



Slender-billed vultures

Long-billed vulture

White-rumped vultures

Consequently, these species had to be brought to the category of Critically Endangered in the year 2002 and these species were included in the list of Schedule-I of Wildlife (Protection) Act, 1972.

The Objective and Plan for Conservation Breeding Programme

Upon the establishment of the conservation breeding programme, it was empirically estimated that releasing 600 pairs of each of the three species in the wild would enable the formation of a self-sustaining and genetically viable population. To produce 600 pairs of each of the three species, it was decided to have six different Centres and produce a population of 100 pairs of each of the three species from every Centre - using 25 founder pairs of each of the three species at every Centre.

It was decided that 75% of the founder population would be collected either as nestlings or first year birds, 15% as sub-adults or 2-4 years old birds and rest as adults. It was also decided that the first release will not happen till about 16 years had elapsed after the capture of the founder stock.

Right from the onset, it was evident that Conservation Breeding and subsequent reIntroduction would be a long-term, expensive exercise.

Consequently, before initiating the programme, adequate facilities, expertise, and funding were ensured. It was also decided to establish several Centres in case individuals in one captive population were lost due to disease or other potential disasters. The BNHS has been leading vulture conservation efforts in India and

had gained experience in captive holding, husbandry and care of vultures by setting up the first Vulture Care Facility at Pinjore in 2001. The facility was fully equipped with hospital aviaries and veterinary labs. It had trained staff consisting of project managers, veterinarians and vulture keepers; as well as VP, who was trained in captive management and care of raptors and vultures at National Birds of Prey Centre, Newent (now called the International Centre for Birds of Prey) The Bird Life Partner in U.K., the Royal Society for the Protection of Birds promised technical and financial support for running the Conservation Breeding Programme.

Jatayu Conservation Breeding Centre (JCBC), Pinjore

(i) Location

Conservation breeding programmes need to be established in the natural distribution range of the species to be bred so that species get used to the area's climatic condition and are exposed to the area's natural pathogens. The JCBC, Pinjore is located within the normal distribution range of all the three species of vultures, as it lies at the edge of the Bir Shikargah Wildlife Sanctuary in Morni Hills of the Shivalik ranges of the Himalayan foothills and is close to Pinjore city. The Haryana Forest Department provided the land for establishment of the Centre.

(ii) Infrastructure for housing birds at JCBC

To accommodate at least 60 birds of each of the three species, the founder population and subsequently also the captive bred birds, within the budget constraints, the housing was constructed in a phased manner over 4-5 years. Number of aviaries were constructed for housing birds of different age classes and health conditions in a phased manner over 6-7 years. The Centre also required facilities for in house laboratories, clinical and critical care rooms, food processing room and administrative room. The aviaries had similarly designed but of different sizes; and had mud and sand floors as well as specialised perches to cause minimum harm to the birds' feet. The aviaries have double door protection and water troughs. In captivity, is it important to follow a routine to keep birds calm so they display normal behaviour.

There is a separate quarantine facility which is located at least 5 km from the Centre, with three quarantine aviaries. Any bird to be brought to the Centre is first kept in these aviaries and their health is monitored for 45 days. The aviaries are made up of iron poles and netlon. All in and all out policy is followed for quarantine. There are eight Nursery Aviaries (12x10x8'), six Colony Aviaries, eight Holding Aviaries (20x20x16') two Display Aviaries, four Hospital Aviaries, 8 Breeding Aviaries and one Green Aviary. The Colony Aviaries are the largest and the most important aviaries of the Centre. There are six Colony Aviaries (100x40x20') to house sub-adult and adult birds. These aviaries are large enough for the birds to do wing exercise by flying from one end to another and feed socially on carcasses, exactly as they do in the wild.

The vultures are social birds and have to be kept in flocks. A Colony Aviary accommodates 30-35 adult vultures and are designed to be spacious enough for the birds to carry out their routine activities and breed. A very important aspect of aviary design is the position of perches. Most of the perches are above human height and have uneven surfaces. Coconut rope is wound around the perches to give them a rough surface.

Juveniles and sub-adult birds up to the age of 2 years are housed in 9 Holding Aviaries, with capacity to hold 10 pairs in one big aviary (60x40x20') and 2 pairs each in the other smaller ones (20x20x20'). The birds which get injured or fall sick are shifted to Hospital Aviaries (12x10x8') for treatment and care.

The Centre is an off-display facility but 2 Display Aviaries (25x17x14') are constructed for curious visitors, where birds which are not releasable in wild are kept for display. Interpretation room (36x16x10') is also equipped with CCTV camera monitor which enables the visitors to watch the vultures housed in Display Aviaries.

Apart from the housing for birds, the conservation breeding Centre has other facilities like a small molecular biology laboratory, a laboratory to study the gut microbiology, a haematology laboratory, and a clinical room equipped with gas anaesthesia machine and basic surgical instruments and medicines.

(iii) Collection of Founder Populations of vultures at JCBC

The founder stock of vultures was collected from different parts of the country (primarily Haryana, Rajasthan, Madhya Pradesh, Maharashtra and Gujarat) to ensure good genetic diversity. A few WRVs were birds rescued by animal charities in Gujarat, after they were injured by kite strings. LBVs were collected largely from Madhya Pradesh, Rajasthan, Maharashtra, Haryana and Gujarat. The SBVs could be collected only from Assam. Most of the founder stock were collected till 2007.

The Long-billed Vultures nest on cliffs and quite often in protected areas. The help of professional rock climbers and honey collectors were taken to get the nestlings from the nests.

(iv) Transport of Vultures from collection sites to JCBC

The birds were transported in top open rectangular wooden boxes either via air or in air-conditioned vehicles. The vultures are big but are very nervous and their body temperature is known to increase by 5°C when captured and could collapse suddenly so the transport needs to be done quickly. The box has small holes all over except for the lid and the bottom for air circulation. The birds are not fed or offered water during transport.

(v) Introduction of Birds in JCBC

When birds arrive at any JCBC, they are first taken to a quarantine facility. At the end of 45 days of quarantine, the birds are given a final health check, post which they are moved to the JCBC. All birds introduced in the JCBC are ringed and micro-chipped for identification.

(vi) Provisioning of Food to Vultures

The vultures are offered freshly slaughtered goats that have been in the care of the Centre for at least ten days, to ensure they are free of toxic NSAIDs. The entire goat carcass is given after removing the skin as these 3 species do not feed on skin. As vultures are scavengers, they feed only when they come across a dead animal and not every day. So, we try to mimic the wild condition by offering meat only on Mondays and Fridays. One vulture is fed 4 kilos of meat in a week which is equivalent to 5% of its body weight per day.

All aviaries have water troughs which can be filled and emptied from outside, without entering the aviary.

(vii) Nesting and Breeding Behaviour of vultures

a. Courtship and pair formation

The Gyps vultures start pairing up when they are 3-4 years old. Usually, the male offers a twig to the female and if she accepts it, they become a pair for life. They select a nesting cot and are usually seen together. They may make a nest during the breeding season and lay eggs. However, fertile eggs are laid only when they are over 5 years old.

The WRV was the first to start breeding at the Centre in 2005. The first successful breeding however happened in 2008. The first successful breeding of SBV happened in 2009, while that of LBV happened in 2011.

b. Commencement of Breeding Season and nest building

The breeding season commences every year from October for the three species. They start defending the nest cot and may start nest building. Both sexes take an equal part in all the nesting activities. Some pairs make huge nests but some only with a few sticks. The WRV are first to start nesting in October, the LBV commence nesting in November and Slender-billed in December. Nest building is by both the partners. The nesting material, sticks and green branches from the major tree species around the Centre, is provided in bulk every week after September. The birds themselves pick the nest material and make nests on the nest cots. It could take up to two months.

c. Incubation and nestling periods of vultures

Vulture pairs lay one egg per year and lay usually in December. Both parents share almost equal responsibility in incubation. The egg is never left alone. There are 2-3 change overs every day. Incubation shifts could be very long of 6-7 hrs. The vultures sometimes get up and systematically stretch themselves.The eggs become vocal when they are about 50 days old, and it is called internal pip when the embryo starts pulmonary respiration. The eggs crack or external pip happens when they are about 53 days old and hatch by 55 days. On an average, the eggs hatch after an incubation period of about 55 days i.e. by the end of January.

Since day one, nestlings are fed on meat regurgitated by parents from their crop onto the nest. Nestlings pick up food from the nest or grab it from the parent's beak.

d. Artificial Incubation and chick swapping

Many a time, the vultures lay eggs but do not incubate. Sometimes they lay eggs on the ground and do not take care of it. Such eggs are rescued by the staff and are incubated artificially in incubators. To increase productivity, the Centre removes all the first clutch eggs and incubates them artificially. Although the vultures lay only one egg every year, but if their egg is lost within a month of laying, then they tend to lay again. The Centre exploits this and removes the first clutch to encourage them to lay again. The Incubator Room (12x10x10') is thermo-controlled and has table top hot air incubators for artificial incubation. The eggs are incubated at 36.3 to 36.9°C. These incubators are equipped with efficient temperature and humidity controls which are critical for hatching eggs. The vulture eggs usually hatch in about 55 days. The internal pip or the embryo starts calling at 50 days and at 52 days the shell cracks which is also called external pip. The egg is shifted to a hatcher kept in the brooder room after external pip occurs. The Brooder Room (12x10x10') is thermo-controlled and consists of hatchers and wooden brooder boxes of dimensions (1.5x1.5x2.0') with heat lamp for rearing newly hatched nestlings. The nestlings are hand reared in groups to make sure that they do not get imprinted on humans. After 3 days of hatching the chicks are exposed to sunlight for a few minutes to get vitamin D3 for calcium assimilation and then the duration is increased every day.

Chick swapping is also done at the Centre to increase productivity. The chicks are hand-reared for 10 days and are then given back to the parents on the nest and the second clutch egg is removed which is laid by then. This is called double clutching and chick swapping. It is possible to foster rear the chick by giving it to some other pair as vultures have no olfactory sense and do not recognise their nestling. The second egg is incubated artificially. This is how we attempt to get at least one chick per pair.

The Conservation Breeding Centres in the Country

The Central Zoo Authority (CZA) designated JCBC, Pinjore as a Coordinating Zoo for its Vulture Conservation Breeding Programme. The CZA decided to set up five more VCBCs in different Zoos with technical support from JCBC, Pinjore. The VCBCs at Van Vihar Zoo, Bhopal; Nandankanan Zoo; Odisha, Nehru Zoological Park, Telangana and Sakkarbaugh Zoo, Junagarh were sanctioned in 2007 whereas the VCBC at Muta, Jharkhand was sanctioned in 2009. CZA with the help of JCBC, Pinjore published a Working Manual for Vulture Conservation Breeding Programme in 2012, which provides the guidelines and protocols for establishing and running the Vulture Conservation Breeding Programme.

The Status of Conservation Breeding Programme

The Conservation Breeding Programme has been very successful. There are 817 vultures of three species housed at various Centres. The Pinjore, Rajabhatkhawa, Rani and Bhopal Centres have most of the captive population of vultures. The highest number of all the three species are housed at JCBC, Pinjore.

Table 1. Vultures at JCBC, Pinjore in 2024

Sr .No	Species	Total
1.	White-rumped Vulture	99
2.	Long-billed Vulture	224
3.	Slender-billed Vulture	66
Total		**389**

Table 2. Total Number of Nestlings fledged over the years at the JCBC till March 2024

Sr .No	Species	Total
1.	White-rumped Vulture	136
2.	Long-billed Vulture	209
3.	Slender-billed Vulture	52
Total		**397**

The need for Conservation breeding of vultures

The Conservation Breeding Programme was established to provide an insurance against possible extinction of the three species of vultures, after a 90% decline in the populations of these slow breeding and long living birds. It was known that in such birds, if the rate of annual adult mortality becomes more that 5% than extinction becomes a possibility. In case of WRV the annual rate of adult mortality had gone upto more that 40% and in case of Long-billed vulture and Slender-billed it was over 16%. With such high adult mortality rates, it was feared that the three species could get extinct in near future and it was important to have a conservation breeding programme as a safety net against losing these species.

In-situ linkage of the Vulture Conservation Breeding Programme. Preparation for ReIntroduction of captive bred vultures into the wild

The primary aim of the Vulture Conservation Breeding Programme - besides having captive populations as a safeguard against total extinction – is the reIntroduction of the captive-bred populations of vultures into the wild to augment the existing wild vulture population. The programme has been successful in breeding

a good number of vultures every year and reducing the usage of vulture toxic drug, diclofenac in cattle carcasses. Steps for reIntroduction of vultures in the wild have been initiated. The following steps are being undertaken by the JCBC and supporting agencies to ensure the survival of the released birds:

(i) Ban and restriction on use of vulture -toxic NSAIDs:

Under the Vulture Conservation Breeding Programme, the Centre has taken steps to make the environment safe for release of vultures. The Centre successfully persuaded the Government of India to ban the veterinary use of diclofenac in 2006, the notification for banning this drug was issued in 2008. In 2015, the Government also restricted the use of vial size of human formulations to just 3 ml to prevent its misuse in treating cattle. These measures brought down the usage of diclofenac.

The Centre, in collaboration with the Indian Veterinary Research Institute and the Royal Society for the Protection of Birds, U.K, also succeeded in safety testing of the drug, meloxicam on vultures in 2006 and found it to be safe. Similarly, the safety testing of another NSAID, tolfenamic acid on vultures was done recently and was found to be safe. Unfortunately, three more veterinary NSAIDs – aceclofenac, nimesulide and ketoprofen - have been found to be toxic and have caused mortality to vultures. The pharmacy surveys carried out in different parts of the country over the years indicate that the use of diclofenac is going down and vulture-safe drug, meloxicam, is becoming popular. However, both aceclofenac and nimesulide are also prominently used in veterinary care. Fortunately, these drugs were banned by Government of India for veterinary use in July 2023.

(ii) Testing of the safety of environment by releasing captive-bred vultures near the Conservation Breeding Centres

We have done test release of vultures from Pinjore and Rajabhatkhawa Centres. Eight birds were released from Pinjore Centre with tracking devices on 8th October 2020. None of the birds died of NSAIDs poisoning. However, three birds died of other causes. Ten birds each were released from Rajabhatkhawa in February 2021 and July 2022. So far, the birds are doing fine and are seen within a 100 km radius from the Centre. If there are no drug related mortalities for another year, more birds will be released. Monitoring of prevalence of vulture-toxic drugs in the 100 km area from release aviaries will continue.

Conclusion

Considerable progress has been made towards vulture conservation since 2004. Objectives of the Action Plan for Vulture Conservation 2006 have been achieved – veterinary use of diclofenac and two other toxic drugs have been banned and the conservation breeding program has been successful in breeding all the three vulture species in captivity. As a result, today, the probability of the three species going extinct is quite low, even if a catastrophe strikes the wild populations.

But we are only halfway in the conservation journey. The next phase is the release of captive vultures in the wild, which has its own set of challenges, most important being the new NSAID threats that have emerged. Like diclofenac, banning these drugs and removing them from veterinary use may take decades as well.

It is likely that until the environment becomes safe for vultures, we will see a combination of release of captive vultures along with strengthening of the conservation breeding programme – The Action Plan for Vulture Conservation 2020–2025 rightly recognizes this and makes appropriate recommendations.

05 Hand–Rearing of Sloth Bear (*Melursus ursinus*) in Nehru Zoological Park, Hyderabad – A Case Study

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The Sloth Bear (*Melursus ursinus*) is a widespread species in the Indian subcontinent (Puri, 2015) and can be found in a wide range of habitats such as moist and dry deciduous forests, grasslands, scrub and savannas (Dharaiya et al. 2017). This species was once highly abundant throughout its distribution range until the 18th century, but in recent decades its population has decreased by 50% and it was listed as vulnerable in the IUCN Red List and Schedule-I under the Indian Wildlife Conservation Act (IWPA) 1972, Dharaiya, 2020). Habitat degradation, destruction and hunting are the biggest threats to its population decline. Despite its commonality, the current distribution status, threats and survival rates of this species are largely unknown.

Geographically Telangana is located in the Deccan Plateau, has diverse habitat types, and supports a good number of Sloth Bear population. On February 4, 2021, a Forest Divisional Officer (FDO) found and rescued an abandoned Sloth Bear cub in the jungles of Jannaram Forest Division in Mancherial District. On February 5, it was handed over to the Wildlife Hospital and Rescue Centre, Nehru Zoological Park, Hyderabad for proper care and welfare. Upon arrival at the zoo, the cub was identified as male; from further physical examination it was noticed that the individual was weak and suffering from dehydration and diarrhea. To control dehydration and diarrhea Electral Powder 2 grams/50 ml water and Norflox-TZ tablets were given. The electrolyte solution contains a sufficient amount of liquids, electrolytes and minerals that are necessary for the normal functioning of the body. To save the cub it was decided to hand-rear and shifted to cub rearing centre.

Cub rearing centre and habitat enrichment

Cub rearing centre specially designed and built to rear animals when the parents are unable to incubate or rear the chick/calf/cub/puppies. The cub rearing centre has four night houses (6 x 6 feet) and these are connected with two day kraals (10 x 8 x 12 feet). Day kraals were built with a chain link fence and the bedding was filled with fine sand to a height of about 1 meter. The cub was released every day in to the day kraal in the morning (8:30 hr) and taken back to the night house in the evening (18:00 hr). All necessary arrangements were made in the night house to reduce the thermal and cold stress of the individual. A 60-watt light bulb was placed in the night house at a height of 3 meters to keep the room warm. In addition, night cages were provided with plenty of drinking water to prevent dehydration. Since the cub was raised in the summer, coolers were also arranged to avoid heat stress. To stimulate the physical and cognitive behavior of the cub, the day kraal provided with enrichment items such as climbing structures, bamboo honey feeders, wooden balls, wooden logs, and a water bowl (Plate 1). The use of enrichment items and the other activities of the cub were regularly monitored.

Feeding

The cub's daily feeding schedule was prepared based on its body condition and weight. The cub was estimated to be approximately 6 weeks old and weighed 4.18 kg at the arrival in the zoo. Sloth Bear cubs stay with their mother till the age of 2-3 years and mainly fed by mother's milk. Therefore we decided to offer milk four times a day according to the Royal Canine formula. A detailed feeding plan for hand-reared Sloth Bear cub in captivity is provided in (Table 1 and 2). Furthermore, we assessed the daily health status of the cub by monitoring stool consistency (daily) and body weight at regular intervals (once every 10 days). If we found any parasitic load in the feces, our veterinarians treated him according to the diagnosis. We observed a weight gain of cub 200-300 grams every 10 days (average monthly gain 0.900-1.74 kg Figure 1).

Therefore, the amount of the diet was increased every three weeks (i.e. 10 ml of milk and 10 grams of fruit) according to the cub's weight (Figure 2 and Plate 2). The same diet was followed until the cub reached 24 weeks old. After attaining an age of 24 weeks we fed the individual with adult diet i.e., 1 kg banana, 500 ml milk, 100 gram tomato, 250 gram carrot/sweet, 1 sweet lime, 1 kg watermelon/muskmelon, 100 gram honey, 100 gram sugar cane, 100 gram guava, and 2 sweet maize cobs.

Conclusion

Successful hand-rearing of a species depends on several factors, such as the type of species involved, age and health status of the species. Several authors have reported the successful incidents of hand rearing of various species. A successful hand rearing experience serves as guide to solve such situations that arise in the future and gives confidence to the keepers. The current hand rearing experience serve as a future guide for zoo staff.

Table 1. Daily timings and diet schedule followed for Sloth Bear cub during hand rearing

Time	Quantity of diet given every day
06:00 AM	40 ml milk
10:00 AM	40 ml milk
12:00 PM	60 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)
16:00 PM	60 gram of Fruit Juice Mix (Banana + Watermelon +Grapes)
18:00 PM	40 ml milk
22:00 PM	40 ml milk

Table 2. Daily diet schedule of Sloth Bear cub up to 24 weeks during hand rearing

Age		Quantity of diet given at a time in a day	Frequency
In days	Weeks		
1 - 10	1	40 ml milk	4
		60 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
11 - 20	2	40 ml milk	4
		60 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
21 - 30	3	40 ml milk	4
		60 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
31 - 40	4	50 ml milk	4
		70 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
41 - 50	5	50 ml milk	4
		70 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
51 - 60	6	50 ml milk	4
		70 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
61 - 70	7	60 ml milk	4
		80 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
71 - 80	8	60 ml milk	4
		80 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2

Age		Quantity of diet given at a time in a day	Frequency
In days	Weeks		
81 - 90	9	60 ml milk	4
		80 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
91- 100	10	70 ml milk	4
		90 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
101 - 110	11	70 ml milk	4
		90 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
111 - 120	12	70 ml milk	4
		90 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
121 - 130	13	80 ml milk	4
		100 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
131 - 140	14	80 ml milk	4
		100 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
141 - 150	15	80 ml milk	4
		100 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
151 - 160	16	90 ml milk	4
		110 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
161 - 170	17	90 ml milk	4
		110 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
171 - 180	18	90 ml milk	4
		110 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
181 - 190	19	100 ml milk	4
		120 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
191 - 200	20	100 ml milk	4
		120 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
201 - 210	21	100 ml milk	4
		120 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
211 - 220	22	110 ml milk	4
		130 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
221 - 230	23	110 ml milk	4
		130 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2
231 - 240	24	110 ml milk	4
		130 gram of Fruit Juice Mix (Banana + Watermelon + Grapes)	2

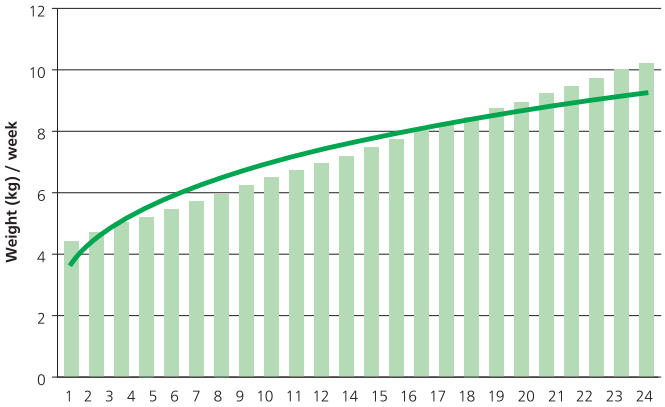

Figure 1. Growth rate of Sloth Bear cub in 24 weeks

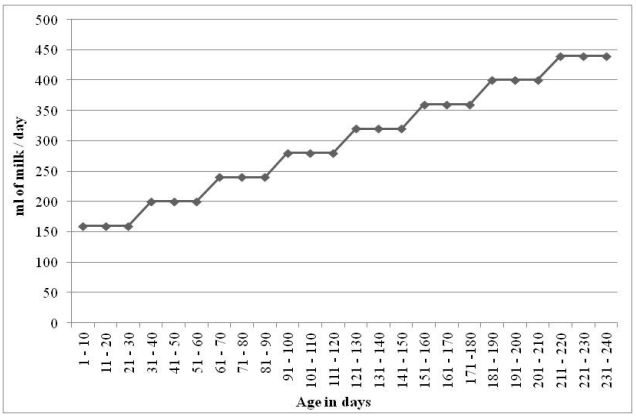

Figure 2. Quantity of milk provided at every 10 days interval

Plate 1. Use of enrichment items by Sloth Bear (Melursus ursinus) cub in day kraal

Plate 2. Sloth Bear cub drinking milk from the bowl

Acknowledgements

We thank the Principal Chief Conservator of Forests and Head of Forest Force, Principal Chief Conservator of Forests & Chief Wildlife Warden and Assistant Curator-I, Nehru Zoological Park, Hyderabad, Telangana State Forest Department, for their continuous support and encouragement.

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06

Conservation Breeding of Indian Pangolin *(Manis crassicaudata)*

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Pangolins are toothless, nocturnal, fossorial (living in burrows) and myrmecophagous (feeds on ants at termites) mammals belonging to the family Manidae of order Pholidota. By consuming vast numbers of insects, especially ant and termites, and providing shelter through their burrows, pangolins play a crucial role in controlling insect pests and maintaining the ecological balance of forest ecosystems. Indian pangolins are the largest among the eight known species of pangolins. All pangolin species have been subject to exploitation historically, which continues today. Of the eight extant species of pangolin, the Indian pangolin (*Manis crassicaudata*) and Chinese pangolin (*M. pentadactyla*) occur in India. The Indian pangolin is widely distributed across the country, occurring in Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Gujarat, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Odisha, Rajasthan, Tamil Nadu, Uttaranchal, Uttar Pradesh and West Bengal. It also occurs in Bangladesh, Pakistan, Nepal and Sri Lanka. The Chinese pangolin is native only to the north and north-eastern states including Arunachal Pradesh, Assam, Meghalaya, Nagaland and Sikkim of India, as well as Bangladesh, Bhutan, Nepal, Myanmar, China, Lao PDR, Taiwan (P.R. China), Thailand and Viet Nam. Although the two species are morphologically similar, the scales of the Indian pangolin are relatively larger than those of the Chinese pangolin and have 11–13 rows of scales across the back compared to 15–18 rows in the Chinese pangolin. A terminal scale is also present on the ventral side of the tail of the Indian pangolin, but absent in the Chinese pangolin.

Pangolins are the most illegally traded mammals of the world and their population is increasingly under threat throughout the range due to the domestic and international demand for live pangolins and their skin, scales and meat. Considering the above, Nandankanan Zoological Park, Odisha, has been identified by Central Zoo Authority, New Delhi (CZA) as the coordinating zoo for conservation breeding of Indian pangolins (*Manis crassicaudata*) based on the past husbandry and breeding records of the species. Indian pangolin conservation breeding programme at Nandankanan has been established in 2008 with financial assistance from CZA. The conservation breeding programme of Indian pangolin started in April, 2009 with 6 founders. Details of enclosure was described elsewhere (Mohapatra and Panda, 2014 and Mohapatra et al, 2022)(Fig, 1-2).

The pangolins are very difficult to keep and breed in captivity due to their unique biology and specialized behaviour. Over the past 160 years, more than 100 zoos or organizations have attempted to maintain pangolins. Most captive pangolins died within six months, although some were held for two to three years, in very few cases lived for 12–19 years (Hua et al, 2015). Besides, for the reason that Indian pangolins have a unique reproductive biology (long gestation [9 months], small litter size [1 offspring at a time], long inter-birth interval [2.5 years] and long generation length [8-9 years]), limited zoo born Indian pangolins, no participating zoo for the conservation breeding programme and no Indian and/or foreign zoo to contribute to the founders, these seized/rescued pangolins are important to establish a sustainable founder population. Studies on Sunda pangolin (*Manis javanica*) found that there is a need of minimum 30 founder individuals to start a conservation breeding programme.

Nandankanan Zoological Park has the only Conservation Breeding Centre for Indian pangolins in the world. Monitoring through the infrared sensitive CCTV cameras unfolds the secrets of the life of the pangolins. Research at the centre has helped to develop proper housing, husbandry and conservation breeding protocols for this endangered species. The centre has successfully bred 14 Indian pangolins in captivity (Fig. 3). Presently there are 23 (11M:12F) pangolins. Besides, studies in the centre have helped us to understand the behaviour, reproductive biology, haematology, husbandry and healthcare practices including identification of parasites and bacteria associated with Indian pangolins, contributing maximum research work on the lesser-known aspects of biology of Indian pangolins. In addition, the centre has been able to develop protocols for successful rearing and recorded the maximum longevity for any pangolin species in the world. Nandankanan Zoological Park has been helping various organizations viz. State Forest Department of Odisha and other states to deal with conservation and rehabilitation of this endangered species (Mohapatra et al, 2022). Initiatives are taken for collaboration with other pangolin facilities of South East Asia for mutual learning of best management practices including development of artificial diet, health care management, breeding and release protocols through Central Zoo Authority, New Delhi.

Six new naturalistic enclosures and 3 isolation cells were added in the centre facilitating proper housing

and preventing spread of infections respectively. All these new enclosures have moveable roofs facilitating sun exposure when needed. Further pangolins are provided with artificial mounds in addition to the existing burrows in soil substrate and hollow wooden logs, which are also being used as shelter. As feeding enrichment, feed was provided in feeding platform at different height along with provision of puzzle feeder (Fig. 4) to increase time spend in feeding behaviour. As the pangolins feed only on ants and termites, its very difficult to maintain in the centre, especially during the days of heavy rain and forest fire in summer, alternative feed supply chain were established though community participation. In addition, commercially available feed formula Granovit insectivore meal was procured with support from Zoo Zlin, Czech Republic. The feed could able to replace 50% of the feed when given mixed with the ant feed, but was not accepted when given separately.

Nandankanan Zoological Park is among the few zoos of the world that is successfully keeping and breeding these unique animals in captivity. With our research at Pangolin Conservation Breeding Centre, we have standardized housing and husbandry protocols of Indian pangolins and able to successfully breed them in captivity to get F1 generation, which is unique for the species in the world. It is noteworthy that, maximum longevity for Indian pangolin of 23 years has also been recorded at Nandankanan Zoological Park which is also one of the longest among 8 pangolin species. The earlier reported longevity of pangolin in captivity is 19 years. It may be kindly noted that the generation length of Indian pangolin is about 8-9 years. The surviving F1 Indian pangolin offspring of PCBC are being allowed for breeding now and may produce F2 generation in near future.

A study to estimate the genetic diversity among Indian pangolins at Pangolin Conservation Breeding Centre, Nandankanan Zoological Park, estimated effective population size, representing individuals capable of contributing genetically to future generations, was estimated as 18.6 individuals (11.4-35.1at 95% CI). Among the 29 individuals studied (Fig 1), we find out seventeen unrelated pangolins i.e., 11 females and 06 males were genetically more suitable for enhanced breeding considering the genetic composition and allelic diversity in view (Wangmo et al., 2024). Study at the centre has identified eight bacteria genus(*Bacillus, Brachybacterium, Enterococcus, Jeotgalicoccus, Lysinibacillus, Micrococcus, Proteus, Staphylococcus*) from the Indian Pangolin faecal and burrow soil samples, strongyles and strongyloides as gastrointestinal parasites and the tick *Amblyomma javanense* as ectoparasites (Mohapatra et al. 2020). Further microbiological studies from oral, nasal and vaginal swabs are collected from the sick captive Indian Pangolins to aid in disease diagnosis followed by immediate interventions. Recent molecular studies at Zoo Laboratory, Nandankanan Zoological Park using RT-PCR has diagnosed babesiosis in Indian pangolin, a first report Indian pangolin. Babesis spp. has been earlier reported in Sunda pangolin (Yodsheewan et.al., 2021).

On a pilot study we have released 1 transmitter tagged pangolin on 29.12.2021 (Fig 5). But within a week of tracking, it went to nearby village at Barang, so the individual was captured and brought back to the zoo. Prior to further release a detailed study on habitat characterization, current status of Indian pangolin will be assessed for selection of suitable release site/ Pangolin Safe Zone along with community awareness programmes on the said sites to ensure their protection and survival. We have an aim to release 20 Indian pangolins in next 12 years (1 zoo born Indian pangolin per year during initial five-year period, 2 each during next 6 years and 3 in the last year of the project) keeping a sustainable multigenerational breeding population in hand for continuing Pangolin CBP.

Fig-1. Pangolin Conservation Breeding Centre, Nandankanan Zoological Park

Fig. 2. Inside of an Indian pangolin enclosure at Pangolin Conservation Breeding Centre

Fig. 3. Captive bred Indian pangolin with its mother.

Fig. 4. Puzzle feeder for Indian pangolin

Fig. 5. Release of transmitter tagged Indian pangolin.

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07

Conservation Breeding of *Manouria emys* at Nagaland Zoological Park

- Nagaland Zoological Park

Introduction

The Asian Giant Tortoise a.k.a. Burmese Brown Mountain Tortoise is Critically Endangered species under IUCN 3.1 and falls under the Schedule II species of the Wildlife (Protection) Act, 1972. This species has a limited geographical distribution in the North- eastern part of the Indian sub-continent and extending into Burma (Myanmar) and parts of South-east Asia upto Thailand. This species thrives in the mountainous regions where the climate is sub-temperate with moderate to high humidity. They are basically forest-dwellers and hence also called Asian Forest Tortoise. They are also being artificially bred in countries as far as in the United States and other European countries by creating similar climatic conditions for breeding.

The decrease in the wild population of this species has prompted the Forest Department of Nagaland to take this initiative and with Nagaland Zoological Park at the helm, conservation breeding programme was started in the year 2013 in collaboration with the Turtle Survival Alliance (TSA-India) for technical expertise. However, with lesser expertise in handling this species, innovative methods were structured independently by Nagaland Zoological Park and the program took off. After many Trial & Error subjugation the *first* ever success was recorded only in the year 2018. Since then, this program has been directed positively towards the achievement of the ultimate goal of the program. In partial fulfillment of the goal, a batch has been already released into the wild on 19th December 2022 at Intanki National Park.

Aim and Objective

The main aim and objective of this conservation breeding program is to achieve a sizeable wild population of this species. To re-populate the wild species in the areas where they once thrived. Furthermore, their study will help in determining the geo- climatic conditions of the region and also future population expansion of the species so that their wild population is replenished.

Methodology

The method used for the incubation of eggs is basically indigenous method with varying degree of process for such species. The use of Artificial Incubators has not yielded any success till date and most likely the use of such machines is not favourable for the eggs of this species. The method followed from mating to the hatching time is briefly described below;

i. *Mating*: The mating pairs are identified and monitored for eggs. Selection of mating pairs are done by natural selection only. Once identified, they are confined to an enclosed space and released into the nesting area when

it is about time for laying eggs. In a group of more than one (1) mating pair, females are marked and likewise their eggs when laid are given specific identification numbers to keep track of hatchlings parental history. After mating ends, the females are kept separately, away from males and allowed to lay eggs at their own chosen sites within the enclosure facility.

ii. *Collection*: After the eggs are laid in the naturally selected site by the female, eggs are collected carefully within 24 hours, weighed and placed in the already prepared Styrofoam boxes with proper markings. However, if the collection is due past 24 hours, then we have to wait for upto 10 days before collecting the eggs. This is to ensure that the eggs are not shaken/ moved during this early stage of development.

iii. *Preparation*: The Styrofoam boxes are filled with vermiculite dust upto 1/3rd the height of box. Water is sprayed gently on top to ensure moist condition replicating the forest ground condition. Making small depth holes in rows and column on the vermiculite, the eggs are carefully placed and covered with the same. Another box is also prepared by replacing the vermiculite dust with forest soil (mulch) consisting of forest soil(moist) and leaf litter (dead and decaying). This mulch is the natural strata used by this species to lay their eggs in the wild. However, water is regularly sprayed to keep the fillings from drying away due to heat.

iv. *Egg Monitoring*: The average number of eggs during the mating season varies between 100 – 150 eggs from all the females. The clutch size of which may contain about 50-60 eggs. The eggs are kept in the same orientation in the Styrofoam boxes until hatching because these eggs do not require rotation. Incubation lasts upto 60-90 days during which probes are kept to monitor temperature and humidity inside the box. The Temperature- Dependent Sex Determination (TSD) in *Manouria emys* has given an estimated pivotal temperature is 29.29°C and humidity level of 60 – 80%. The temperature below 29.29 ^{O}C will result in male hatchlings and above this temperature results in females. During the entire incubation time, eggs are confirmed of development by doing *candling* of a very few random eggs from each batch. This gives the visual confirmation of the development of embryo inside the eggs. The eggs are constantly monitored and the temperature and humidity readings are logged so that there is minimal deviation from the optimal temperature of 29.29°C. Any deviation from this temperature beyond ±5.0°C will result in non-development of the embryo inside the eggs.

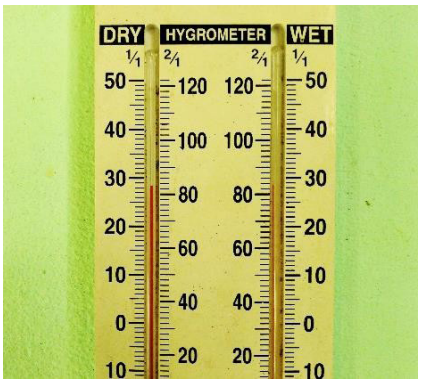
v. *Hatching*: Hatching takes place naturally, however at times some eggs do require assisted hatching due to the baby inability to breakthrough the shell. After hatching, the young ones are constantly monitored in every aspect of their upkeep. This is to ensure their development and survivability.

Equipment used

Some of the equipment used during the incubation process and also tools and instruments used for monitoring during upkeep and post release are given below:

(i) Styrofoam Box (As an incubating box)

(ii) Vermiculite Dust (As bed/strata for placing the eggs)



(iii) Temperature & Humidity probe (For logging the temp & humidity data)

(iv) UV Lamp (For maintaining stable heat)

(v) Water Sprayer (For maintaining stable humidity)

(vi) Weight Machine (For checking weight)

(vii) Radio Tag/tracker and receiver (For post-release monitoring)

Monitoring

Post release in the pre-selected sites in nature, the released individuals are radio tagged and monitored continuously to study their adaptive behaviour in the wild. This provides important data for scientific study and research. In the first few months of their release, they are confined to a limited site bounded by artificial fence to give them chance to adapt. This protection also wards off predators and other unwanted elements that will pose threat to their life. Staffs are constantly being sent to the release site to keep track of the individuals from time to time. This ensures the chances of survival of these species when re-introduced back into the wild.

Technical Aspect

The Turtle Survival Alliance, an international organization with its branch in India based in Lucknow (UP) by the name TSA-India oversees the technical aspects of this breeding program. They also provide manpower,

equipment and other scientific devices for the program. Officially an MoU was signed between the TSA-India and Nagaland Zoological Park in 2013 with extensions after every three (3) years thereon for this conservation breeding program.

Important Factors

This is a hardy terrestrial species with lifespan of upto 80 years in the wild. The adult can reach upto body weight of 30 kgs. There are two sub-species of *Manouria*. The species in consideration here is *Manouria emys* while the other sub-species is *Manouria phyrie.* The distinctive feature between the two is the presence of *fused* hinge-line (*in case of emys*) and *separated* hinge-line (*in case of phyrie*) on their underbody called plastron.

Result

The *first* successful batch of hatchling came in 2018 with a total of 28 eggs hatching out from 75 eggs kept in incubation. 10 (Ten) individuals survived into the Fourth (4) year where they were radio tagged and released into the Intanki National Park. They have now spread into a wider area of the national park based on the survey conducted. The release of this species into the wild habitat is attained after they attain the age of sub-adult i.e., to about 4-5 years. At present, the Nagaland Zoological Park have the batches ranging from 1-3 years old hatchlings depending on the time they were born. And these batches are also being monitored and likely to be released back into the wild to increase their wild population once a new release site is located and prepared for their release.

Present Status

With the founder stock of 14 individuals (6M:6F:2J) in the year 2018, hatching of eggs has seen as positive trend over the last 6 years. The present stock of this species in the inventory as of December 2023 stands at 103 individuals (10M:9F:84J) with 10 individuals (5M:5F) released inside the national park.

Fig: Release of First Batch at Intanki National Park

Conclusion

The conservation breeding program jointly carried out by Nagaland Zoological Park and Turtle Survival Alliance (TSA-India) is likely to boost the population of this threatened species in the region in the near future. The radiotelemetry exercises for survival and dispersal data of the released tortoises will help to ascertain the ecological and behavioral patterns, abiotic factors influencing the seasonality of the animals and survivorship of the juveniles from predation. This shall aid in development of effective long-term conservation and recovery strategy for the species and an eventual release strategy for supplementation with support of government and other stakeholders in the region.

08 Conservation Breeding of Blyths' Tragopan at Blyths' Tragopan Conservation & Breeding Centre, Kohima under Nagaland Zoological Park

- Nagaland Zoological Park

Introduction

The Blyth's tragopan, *Tragopan blythii* is a brilliantly-coloured pheasant, largest of all tragopan, and is easily recognized by its bright yellow bare facial skin. It is listed in schedule I, part III of wildlife protection Act 1972 and classified as Vulnerable (VU) on the IUCN Red list 2006. It is also listed on Appendix I of CITES (Conservation on International Trade on Endangered Species). They are found in the mountains of North-east India and Bhutan to extreme South-eastern Tibet and North-West Myanmar, distributed in Barial, Patkai and Naga Hill ranges Into Manipur, Mizoram, areas south of river Brahmaputra (Ali & Riply,1983). Within India, the sub- species blythii is known mainly from the state of Nagaland generally found between altitudes of 1600-2500m although in certain parts it may be found as high as 3200m.

Aims and Objective

The general objective of the program will be ex-situ conservation of Blyth's tragopan for the purpose of conserving the gene pool with the possibility of reintroducing back to its home range to strengthen its wild population. The other objectives are to carry out model research on their habitat, behavior and breeding biology in captivity to ensure their survival and to induce natural breeding. The main objective of the centre is as follows:

i. To strengthen the necessary infrastructure for management of breeding centre.

ii. To act as a rescue and rehabilitation centre for injured/abandoned Tragopan rescued from the wild to complement conservation pheasantry.

iii. To train and orient staff in the conservation breeding techniques and pheasantry management through capacity building.

Housing Facilities offered

The breeding facility comprise of 4 off-exhibit enclosure. Perches are placed within each enclosure at variable height. The branches used as perches are carefully selected, based on their rough texture and appropriate diameter (≥4-5"). A sheltered indoor section is provided in each enclosure for the bird to retreat during inclement weather. Plants species such as Musa, Cherry, Rhaphidophora, Dwarf lilyturf, mulberry tree is grown inside the enclosure.

Food and Feeding

The diet offered to the captive birds basically contains vegetative matters in the form of mixture of fruits, vegetable, greens and sprouts. The greens offered to the birds are readily found in the peasantry premises.

Seasonal fruits are also included in the diet. Grains and a small quantity of hard -boiled egg are also offered to birds. The food is offered at early morning (*between* 06:00-07:00h). The additional diets for the chicks include termites, finisher and starter feeds.

Management of birds

All the enclosures are spot-cleaned every day, food plates are cleaned and clean water is changed regularly. A footbath at the entrance of each enclosure to keep check of infections from entering the enclosure. Deworming is done after every three months to check for endoparasites. The health of the birds is closely monitored prior to the breeding season by providing additional supplements prescribed by the Veterinary doctor.

Reproductive Management

The incubation of eggs is purely natural and dependent on the mother. There is no human involvement as the entire process is left to the mother to incubate the eggs naturally. In order to facilitate the proper development of eggs and provide maximum *in the wild condition* for the sitting birds certain measures are followed which can be summarized as below;

i. Proper setup of the nesting platforms at variable heights for selection by the bird.
ii. Use of good nesting materials from their natural habitats.
iii. Maintaining a good diet throughout.
iv. Use of trained and well-equipped staff for monitoring.
v. Total restriction of movement in the nesting area during the period.
vi. Use of 24x7 surveillance for the safety of the birds from predators and other external disturbances.
vii. Maintaining a *Silence Zone* in and near the nesting area of the birds.

Each breeding enclosure had a minimum of 3 different nest sites to provide multiple nesting options to choose from. The nest is made of cane baskets with a diameter of about 30-40 cm and a depth of about 20 cm. These baskets were mounted at different locations at heights of about 4-5ft inside the enclosure using wood perches. Dry leaves, ferns and dried moss are used as nesting material. The nest is camouflaged using bamboo leaves and some green leaves. Outdoor nest is covered using water-proof plastic sheets from the top, to prevent rain water from entering the nest. All the nests had perches placed closely to facilitate the movement to and from the nesting platforms. Disturbance near the nesting platform is kept to a minimum following the installation of the nesting platform.

Nesting platforms are provided by the third week of February and the birds start exhibiting breeding behaviors by 2st week of March and continues well into may. During this season the male advertise themselves with flamboyant displays to attract females. Breeding calls are emitted as advertisement calls to signal their presence. As part of the display, the male engages in a dance with plumage spread to provide full effect while engorging its two fleshy horns above the eyes. Fanning and erecting to tail and dancing in front of the female are observed. The mating season starts in the month of March and takes about a month or so. The matting call produced by the male is "**MAO, MAO, MAO**" with a deep base sound and the sound produced

by the female is a sharp quacking sound forming into musical tune. Egg laying starts by last week of March followed by incubation in April and hatching during May- June. The clutch size ranges from 3-5 eggs per female and incubates from upto 28-36 days until hatching. The chicks are reared naturally by the mother. The chicks are kept along with their mother till the next breeding season.

Progress of breeding from 2013-2023

The Centre started with 7 Founder stock (4M:3F) and over the years chicks were successfully hatched out but only few were able to developed into mature birds. Below is a summarized breeding record.

YEAR	CHICKS
2016	1
2017	NIL
2018	NIL
2019	NIL
2020	2
2021	3
2022	4
2023	5
Total	15

Out of the total 15 chicks hatched out 11 offspring are surviving at present. At present the captive population at the breeding centre comprised of 20 individuals with 9 males, 6 females and 5 juveniles. An extract from the Blyths' Tragopan Studbook *436456/2021/CZA 3 2nd Edition 2023* gives the latest data at the centre as **22.16.8(46)** since 2010.

Conclusion

The conservation breeding program jointly carried by BTCBC under Nagaland Zoological Park and the Central Zoo Authority of India (CZA) is likely to boost the population of this threatened species in the region. The ex-situ conservation helps to maintain healthy gene pole as the birds are rescued from different region. Once the population reaches certain favorable numbers, they are to release in their natural habitat which will helps to ascertain their behavior and the ecological pattern. This shall aid in development of effective long-term conservation and recovery strategy for the species.

09 Conservation Breeding of Red Panda (*Ailurus Fulgens*) and Snow Leopard (*Uncia Uncia*) at Padmaja Naidu Himalayan Zoological Park, Darjeeling

- Padmaja Naidu Himalayan Zoological Park, Darjeeling.

Introduction

Red Panda is a small, elusive, and endangered mammalian species of the eastern Himalayas. It is distributed in the Himalayas from Central Nepal through northern Burma in the mountains of South-Western China at an altitude ranging between 900-13,000 feet. In India, Red Panda is distributed in Sikkim, Darjeeling Hills, and Arunachal Pradesh. In West Bengal, they are distributed in Singalila National Park and Neora Valley National Park. The species is listed as "Endangered" by the IUCN (2015) with a declining population in its distribution range. In India, the species receive protection under the Indian Wildlife Protection Act (1972). The species is also under the CITES Appendix I. Red Panda is threatened by habitat loss and fragmentation. Red Panda was also hunted and trapped in large numbers to be kept as pets and for supply to zoos worldwide. The red panda conservation breeding of PNHZ Park is the most successful breeding program of the species. The purpose of this conservation program is to make efforts at planned conservation breeding of the species and their multiplication for a demographically stable and genetically healthy population with the ultimate aim of being released into the wild to augment the wild population when the need arises. The Park is also the only captive facility in the world that has augmented captive red pandas into the wild.

Snow Leopard is an extremely beautiful animal distributed along the habitat scattered throughout a vast region surrounding the Central Asian deserts and plateaus ranging from Afghanistan to Uzbekistan. The species is generally found at an elevation between 3000m-4600m, although they are known to go above 5,500 m asl. in the Himalayas. In India, the snow leopard is distributed in the Himalayan chain from Kashmir to Sikkim. Snow Leopard is listed as "Vulnerable" on the IUCN Red List, with an estimated population of between 4,000 and 7,500 individuals remaining in the wild. In India, the species receive protection under the Indian Wildlife Protection Act (1972). The main threats the species face include hunting, habitat destruction, and fragmentation. The Snow Leopard Breeding Programme at PNHZ Park, is one of the most successful and only breeding programme of the species in Southeast Asia. The Park in 2003 had 18 Snow Leopards (9:9), one of the largest captive populations, in a single zoo, in the world. Presently, the Park also has the largest captive population of the species in the world.

Red Panda Conservation Breeding Program

History: In 1986, a planned conservation Breeding Program as a part of the Global Captive Breeding Master Plan was initiated in Darjeeling Zoo in response to International Conservation efforts, through the initiation of the conservation breeding program and improvement/modification of the existing housing facility. In 2007, the Park was designated as the coordinating zoo for the conservation breeding of the species by the Central Zoo Authority.

Currently, the Park has 16 (5:11) Red Pandas

Founder population: At the beginning of the project in 1990, the Park had one male (Basant) and three female red pandas (Amita, Chanda & Divya) of wild origin in stock. One male 'Oscar' was brought from Rotterdam Zoo on 1st April 1993 to augment the existing populations of 4 Red Pandas in the Park. The first successful (planned) breeding of the Red Panda occurred on 20.06.1994 when two cubs "Ekta" and "Friend" were born to 'Basant' and 'Amita'.

Acquisition of Red Panda

Sl No	Name	Studbook no.#	Date of birth	Sex	Place of Birth	Date of Acquisition
1	Oscar		09.06.1992	M	Rotterdam Zoo	1993
2	Gora		25.06.1993	F	Cologne Zoo, Germany	8.11.1994
3	Indira		26.06.1993	M	Madrid Zoo, Spain	8.11.1994
4	Hari		30.06.1993	M	Rotterdam Zoo	10.11.1994
5	Preety		26.06.1994	F	Holand	25.12.1996
6	Omin		17.07.1994	M	Belgium	25.12.1996
7	John	0561		M	Wild rescued	Sikkim on 03.04.2007
8	Kaijalay	0885		M	Wild rescued	08.03.2008
9	Durga	02115	18.12.2002	F	Auckland	09.10.2010
10	Rahul	02111	20.06.2002	M	Sikkim	31.10.2011
11	Rigsel	0789	28.05.2007	F	Sikkim	31.10.2011
12	Smile	2123	19.06.2012	F	Wild rescued	18.03.2013
13	Shobha	11116	07.06.2011	F	Sikkim	22.02.2014
14	Karma	10118	03.06.2010	F	Sikkim	23.11.2015

Transfer of Red Panda

Sl No	Name	Studbook no.#	Date of birth	Sex	Place of Birth	Transferred to	Date of Transfer
1	Preety		26.06.1994	F	Holland	Sikkim Zoo	14.03.1997
2	Jugul		21.06.1995	M	PNHZ Park	Sikkim Zoo on	14.03.1997
3	Nakul	0359	22.06.2003	M	PNHZ Park	Sikkim Zoo on	03.04.2007
4	Sagar	00121	26.06.2000	M	PNHZ Park	Auckland Zoo on	30.10.2010
5	Sonam	13177	28.06.2013	F	PNHZP	Nainital Zoo on	24.11.2014
6	Rahul	02111	20.06.2002	M	Sikkim	Nainital Zoo on	24.11.2014
7	Joel	15120	14.07.2015	M	PNHZ Park	Tier Park, Berlin	04.02.2020
8	Shine	14174	04.07.2014	F	PNHZ Park	Tier Park, Berlin	04.02.2020
9	Saki	223017	06.07.2021	F	PNHZ Park	Pafos Zoo	08.12.2023
10	Pabu	1796	16.07.2017	M	PNHZ Park	Pafos Zoo	08.12.2023
11	Janaki	1089	220.6.2010	F	PNHZ Park	Green's Resue and Rehabilitation Centre	26.02.2024

Birth Record of Red Panda

From 1994 to 2022, a total of 76 Red Panda births have been recorded in the Park.

Feeding

Species	Feed items	Quantity		Day of fasting
		Winter	Summer	
Red Panda *(Ailurus fulgens)*	i. Egg ii. Banana iii. Apple iv. Honey v. Milk vi. Bamboo leaves vii. other seasonal fruits like watermelon orange, grapes, cucumber viii. wild fruits, green leaves	01 pc 300 gms 200 gms 50 ml 400 ml 05 kgs 200 gms Upon availability	1 pc 200 gms 500 gms 50 ml 500 ml 4kgs 200 gms Upon availability	No fasting day observed

Veterinary Care

Captive red pandas are usually free from diseases except for parasitic infections at times. Red pandas have been known to be prone to canine distemper, canine parvovirus, Tyzzer's disease, and dental problems. To prevent infections in captive pandas, the enclosures are regularly cleaned and disinfected. The stool is collected and tested for parasites monthly, deworming is done every 3 months or when a parasite is detected during stool tests. Behavioral observation is done regularly to check for any symptoms of diseases.

Genotyping and Hormonal Study of Red Panda

In 2013, hormonal and genetic analysis of the captive red pandas was conducted in association with LaCONES, CCMB. The results showed that the captive population was genetically diverse and all females exhibited hormonal cyclicity. In 2019 & 2022, Fecal samples and Hair samples & in 2023 blood samples of red panda were analysed in LaCONES, CCMB for genetic profiling.

Research Studies

Completed

a) Study of Red Panda (*Ailurus fulgens fulgens*) in ex-situ facilities in co-relation with the in-situ facilities for conservation breeding. 2012

b) Red Panda Nutrition: an approach towards integration. 2015

c) Studies on population and behavioural ecology of Red Panda (*Ailurus fulgens fulgens*) in Singalila National Park & Neora Valley National Park with reference to conservation. 2016

d) Analysis of Scat/Dung/Pellets/Excreta of various animals and birds in Padmaja Naidu Himalayan Zoological, Darjeeling; CBC, Dowhill; and CBC, Topkeydara for the presence of various parasites. 2020

e) Population and species survival assessment of Red panda (*Ailurus fulgens*) in Singalila National Park, West Bengal: Potential trajectory following re-stocking of the population under the captive breeding programme. 2021

f) Haematological and bio-chemical values of captive animals at PNHZ Park. 2021

g) Studies on population and behavioural ecology of Red Panda (*Ailurus fulgens fulgens*) in Neora Valley National Park, West Bengal: with special reference to conservation. 2021

Ongoing

a. Red Panda Augmentation programme in Singalila National Park and Neora Valley National Park.

b. Gut microbiome study of Red Panda.

c. Determination of Diet of Red Panda *(Ailurus fulgens)* in the wild through scat analysis.

d. Assessment of genetic variation and reproductive hormone profiles in selected endangered species of conservation interest at the Padmaja Naidu Himalayan Zoological Park, West Bengal.

Enclosures & Enrichment

The red panda is a crepuscular, arboreal, and solitary animal. The enclosures for red pandas at PNHZ Park have been designed with careful consideration so that the enclosures meet the physical, social, behavioural, and psychological needs keeping in mind their natural ecology. The enclosures are designed and enriched to accommodate all behaviours. The structural enrichment is changed regularly to prevent boredom in animals and to stimulate their natural behaviours.

All enclosures are open with undulating topography, natural vegetation, and edible grasses. The enclosures are provided with complicated aerial walkways, nesting boxes at varying heights, and resting platforms. Visual barriers made from bamboo are present between all enclosures to reduce stress.

Fig: A.& B. Feeding Platforms, C. Cubbing Box, D. Ariel Walkways, E. Visual Barrier

Red Panda Augmentation Program

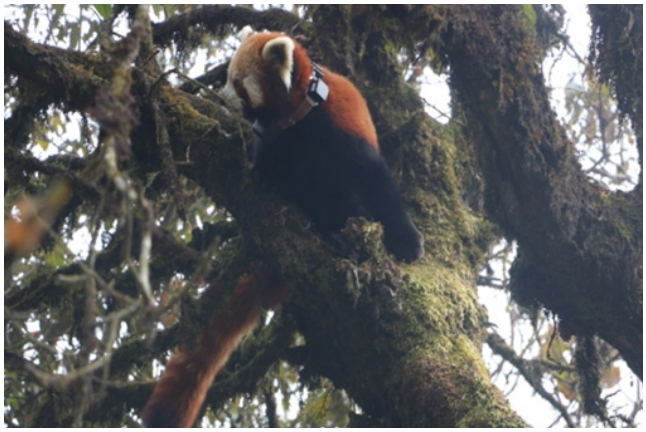
Augmentation or Population restoration is any conservation translocation within the indigenous range and aims to enhance population viability by increasing population size, increasing genetic diversity, or increasing the representation of specific demographic groups or stages. The first Red Panda Augmentation was carried out by PNHZ Park, in 2003-2004. The Park released 2 female pandas in Singalila National Park, out of which one female mated with a wild male and gave birth to a cub.

A population census for red pandas was carried out in 2018 and 2019 in Singalila National Park and Neora Valley National Park (NVNP) respectively. Genetic analysis of the scat samples was done in LaCONES CCMB, Hyderabad, and the Indian Institute of Science Education and Research (IISER), Kolkata. CCMB reported 38 Red Pandas in Singalila National Park and 32 Red Pandas in Neora Valley National Park & IISER reported Singalila 40 Red Pandas in SNP. Based on the census, the Second augmentation program was initiated. Genetically and behaviourally competent individuals from the conservation breeding centre following the proper rewilding process were selected for augmentation in Singalila National Park.

9 (2:7) red pandas to be released were selected based on DNA heterozygosity and relatedness in collaboration with CCMB, Hyderabad, and in consultation with the International Stud Bookkeeper for Red Panda.

In 2022, four red pandas (2:2) were released into Singalila National Park, out of which two survived. In 2023, three female red pandas were released and all 3 mated with their wild counterparts and gave birth to a total 5 cubs. This marks the success of the Red Panda augmentation program. In 2024, two female red pandas were again released in Sigalila National Park. The released red pandas were fitted with radio collars and were tracked and monitored for researchers, collecting valuable data on the behavior, movement and habitat pReferences of the species.

The park plans to release more individuals in Singalila National Park until the population of red panda is sufficiently augmented. Following that the park will release red pandas in Neora Valley National Park to augment the wild population there.






Snow Leopard Conservation Breeding Program

History: The park started work on the captive breeding of this rare species in the year 1983 as a part of a global captive breeding program. In 2007, the Park was designated as the coordinating zoo for the conservation breeding of the species by the Central Zoo Authority. **Currently, the Park has 10 (4:6) snow leopards.**

The current stock of Snow Leopard at PNHZ Park is 10 (4:6)

Founder Population: A pair of unrelated snow leopards was acquired from Zurich Zoo in 1986. Another pair was acquired from the U.S. Zoo in 1989. The first planned breeding occurred in 1989 with the birth of two female cubs. Another male was acquired from Hubstand, Sweden, and 2 wild rescued females were acquired from Leh Ladakh in 2000 to continue the breeding program.

Acquisition of Snow Leopard

SL. No	Name	Stud #	Sex	Birth Date	Place of Birth	Date of Acquisition
1.	Unnamed		M		Zurich Zoo, Switzerland	1986
2.	Unnamed		F		Zurich Zoo, Switzerland	1986
3.	Unnamed		M		U.S	1989
4.	Unnamed		F		U.S	1989
5.	Tyson	1850	M	08.08.1995	Nordic Ark Zoo, Sweden	28.01.2000
6.	Neeta	2228	F	1997	Ladakh	17.05.2000
7.	Meeta		F		Srinagar	17.05.2000
8.	Lavani	2862	F	16.05.2010	Lepzig Zoo, Germany	16.10.2013

SL. No	Name	Stud #	Sex	Birth Date	Place of Birth	Date of Acquisition
9.	Kim	2846	F	29.04.2010	Nuremberg Zoo, Germany	11.10.2012
10.	Sici	2935	M	22.05.2011	Jihlava Zoo, Czech Republic	19.04.2014
11.	Makalu	3140	M	17.04.2014	Dudley Zoo, UK	25.06.2016
12.	Zima	2861	F	06.05.2010	Leipzig Zoo, Germany	16.10.2013
13.	Namkha	3141	M	16.06.2016	Mulhouse Zoo, France	01.09.2016

Transfer of Snow leopards

SL. No	Name	Stud#	Sex	Birth Date	Transferred to	Date of Transfer	Comments
1	Subash	2402	M	08.07.2002	Simla Zoo	23.12.2004	On Breeding loan, Brought back on 30.03.2013
2	Sapana	2229	F	18.04.2000	Simla Zoo	23.12.2004	
3	Dev		M	19.06.2002	Nainital Zoo	23.12.2004	
4	Rani		F	18.04.2000	Nainital Zoo	23.12.2004	
5	Urvashi		F	23.10.1995	Sikkim Zoo	11.03.2005	
6	Kush	1972	M	31.10.1996	Sikkim Zoo	11.03.2005	On Breeding loan, Brought back on 03.04.2007
7	Ravi		M	25.05.2004	Sikkim Zoo	03.04.2007	
8	Malika	2541	F	25.05.2004	Sikkim Zoo	24.06.2010	
9	Mayur	3335	M	04.03.2018	Green's Rescue and Rehabilitation Centre	26.02.2024	

Birth Record of Snow Leopard

From 1986 to 2023, A total of 78 Snow leopard births have been recorded in the Park, the highest number of captive births of the species in the world.

Feeding

Proper feeding management of wild animals in captivity incorporates both husbandry skills and applied nutritional sciences. As a basic foundation of animal management nutrition is integral to longevity, disease prevention, growth, and reproduction**.** The snow leopards are fed with freshly slaughtered meat after quality inspection by the Veterinarian. Thursday is observed as a fasting day for all carnivores and no feed is given.

Species	Feed item	Quantity		Day of fasting
		Winter	Summer	
Snow Leopard *(Uncia uncia)*	i. Beef	2.5 kgs	2.5 kgs	Thursdays
	ii. Chicken	2.5 kgs	2.5 kgs	
	iii. Mutton	2.5 kgs	2.5 kgs	

Veterinary Care

To prevent infections the enclosures are regularly cleaned and disinfected. The stool is collected and tested for parasites monthly, deworming is done every 3 months or when a parasite is detected during stool tests. Behavioral observation is done regularly to check for any symptoms of diseases. Vaccination against Panleukopenia, Calicivirus, Herpesvirus, and Rabies is done annually.

Genotyping and Hormonal Study of Snow Leopards

In 2014, Blood samples of Snow leopards to assess the genetic health of the snow leopards, and fecal samples from females to assess the hormonal cyclicity based on fecal estrogen and progestogen analysis were sent to LaCONES, Hyderabad.

Research Studies

Short-term research on the "*Study of snow leopards*" funded by the Central Zoo Authority in 2013. The study looked into developing ex-situ husbandry aspects particularly to look into cub mortality and brittle bone diseases. It provided recommendations for creating appropriate facilities for breeding, cub care, and survivability. The research work gave inputs during the establishment of the new breeding center for the snow leopards where the night shelters, breeding dens, enclosures, and veterinary facilities have been developed based on the recommendations of the findings.

In 2024, PNHZ Park initiated a project titled "Assessment of genetic variation and reproductive hormone profiles in selected endangered species of conservation interest at the Padmaja Naidu Himalayan Zoological Park, West Bengal" in collaboration with the Wildlife Institute of India (WII) to study the genetic variation and reproductive hormones of various animals including Snow leopard and Red panda to aid the conservation breeding of both species.

Enclosures and Enrichment

Snow leopards have a shy, solitary, and elusive nature and a reputation for aggression between individuals of the same sex. The enclosures and enrichments are therefore designed keeping in mind the animal's natural habitat and behaviour. The enclosures are terraced and sloped. Weather considerations such as rain cover, shade structures are also provided. The enclosures are furnished with rocky substrates, resting platforms, and dens/ caves to provide shades from the sun. Logs are also provided for scratching to help reduce ingrown nails and natural substrates (mulch, turf, sod, etc) are provided for digging and making scrapes. Small and poorly furnished enclosures can lead to problems such as agitation, boredom, self-mutilation, weight fluctuation, and lethargy. The night shelters are equipped with dehumidifiers, heaters, wooden platforms, and squeeze cages. All enclosures and night shelters are equipped with CCTV cameras.

A.

B.

Fig: A. Snow leopard enclosure at Topkeydara, B. Crawl Area, C. Night Shelter, D. Resting Platform, E. Resting Shade, F. Cave, G. Dehumidifier & H. Squeeze Cage

Conservation Breeding Centre for Snow leopard and Red Panda, Topkeydara

In the park, breeding of the Snow Leopard and Red Panda is done at Conservation Breeding centre for Snow leopards and Red pandas, 3rd Mile, Topkeydara, Darjeeling. 5 hectares of land in Topkeydara block under Senchal Wildlife Sanctuary was handed over to Padmaja Naidu Himalayan Zoological Park for the construction of the off-display Conservation Breeding Centre for Snow leopard and Red Panda. The centre currently has 6 open-top enclosures for red pandas and 5 (2 chain-linked and 3 open-top) enclosures for snow leopards.

Arial View of Conservation Breeding Centre for Snow leopard and Red Panda, Topkeydara

10

Species Recovery of Gharial in the River Mahanadi

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Gharial has been on earth for over 80 million years and is now on the verge of extinction. The long snouted gharial has more than 100 razor-sharp interlocking teeth to catch its prey. It is currently found in 14 different habitats in the Himalayan fed river systems of Nepal, northern India and in the river Mahanadi of Odisha and meets the status of critically endangered in IUCN Red List. Odisha is unique in being the only state in India that is home to all three species of crocodilians: the gharial *(Gavialis gangeticus)*, the mugger crocodile *(Crocodylus palustris)*, and the saltwater crocodile *(Crocodylus porosus)*.

Mahanadi is one of the major rivers of India, and the southernmost distribution limit of the gharial. The river originates from the Bastar Plateau in Chhattisgarh and flows through 11 districts of Odisha, forming a large composite delta before emptying into the Bay of Bengal through numerous distributaries. Conservation efforts for the critically endangered gharial began in 1975. As part of this initiative, a captive breeding center was established at Nandankanan Zoological Park in Bhubaneswar, Odisha, along with a rearing center at the Gharial Research and Conservation Unit in Tikarpara, Odisha. These centers aim to rehabilitate captive-bred and reared gharials into the Mahanadi River. As per the available records, in 1980, first captive breeding of gharials happened in Nandankanan Zoological Park. Despite all conservation efforts, including release of 860 gharials mostly of 1m size into the river Mahanadi in between 1977 to 2016, inclusion of gharial guard, and declaring gorge sanctuary, the gharial population did not significantly improve. The 2018-2019 census reported only eight gharials in the area.

The Forest Department of Odisha has been implementing a project "Species recovery of Gharial in river Mahanadi" since 2019 to rehabilitate gharials in the river Mahanadi following strict monitoring protocols. Under the project, it was proposed to release 35 gharials (12M:23F) bred and reared at the Nandankanan Zoological Park, Bhubaneswar into the river Mahanadi in a phase wise manner to build a sustainable population in the wild. Prior to release, a pre-release survey was conducted to find out suitable release site(s) by evaluating river geo physiography and anthropogenic activities. It also includes tagging all the released gharials with transmitters to track their dispersal and survival using technology as well as technical field staff, implementation of a 10km 'NO FISHING ZONE' in Satkosia gorge, involvement of 14 forest divisions on both sides of the river Mahanadi, community participation and awareness, compensation for damaged fishing net and a reward of Rs. 1000 for reporting a live gharial if caught in a net.

Accordingly, from 2019 till August 2022 a total of 19 gharials consisting of 7 males and 12 female gharials were released in different batches in the river measuring 1.5m to 3.85m in length and aged between 5 to 16 years. All released Gharials were tagged with transmitters; 13 with radio transmitters and 6 with satellite transmitters for post-release monitoring. Three postgraduate research scholars were engaged for post-release monitoring. The transmitters helped the technical team to track gharials individually, their daily activity, habitat use, seasonal dispersal pattern, breeding biology and threats. One of the adult female gharials moved downstream about 120km and passed through a nylon fishing net and got its jaws wrapped up in a torn net. She was rescued successfully with the cooperation of the rescue team from Nandankanan, local forest staff and fishermen using cast net and encirclement net. At present 3 adult individuals are being tracked. The other 9 gharials have reported dead and for the remaining 7 numbers of gharials presence/ absence could not be ascertained due to loss of signal. Out of the 9 recorded deaths, 2 died due to blasting, 5 by entanglement in nylon nets, 1 killed by mugger, and 1 died from Clostridium haemolyticum infection, indicating major threats to survival as deleterious fishing activities, disturbed habitat, perceived interspecific conflict between gharial and mugger in the habitat.

Due to stringent protection efforts, research studies, the implementation of the 'NO FISHING ZONE,' and community awareness initiatives, the Satkosia Gorge Sanctuary has witnessed the natural breeding of

gharials for the first time in 40 years. This resulted in the hatching of 28 gharial hatchlings in May 2021, 32 hatchlings in May 2022, and 35 hatchlings in both May 2023 and 2024. Provision of reward resulted in seven gharial hatchlings/yearlings caught in the fishing net being handed over by local fisherman to local field staff/technical team. The tenure of the first phase of the project was completed on 30th June, 2023. The second phase of the project got approved by the Principal Chief Conservator of Forests (Wildlife) and Chief Wildlife Warden, Odisha on 08/08/2023. The activities undertaken included recruitment of three research scholars, survey of Mahanadi and Churasimal for reassessment of gharial habitat, anthropogenic threats, monitoring of released and wild gharials for tracking their movement, habitat use and documentation of breeding biology, awareness discussion in villages on both sides of River Mahanadi in preferred gharial habitats, engagement of Kumbhira Bandhu, awareness competitions in five schools near important gharial habitats, including an award for top performers, improvement of field camp at Sunakhania, procurement of telemetry and field equipment to facilitate the project activities and future release programme of gharials in winter, 2024.

The implementation of the Species recovery of Gharial in river Mahanadi project helped in identifying the factors affecting non-survival of gharial in the river Mahanadi and improved the understanding on their ecology and behaviour which aid in shaping implementation of future conservation measures to save this species in its southernmost habitat.

Figure 1- Release site at Satkosia gorge

11 Notes on False Nesting and Inter-relations Between Crow and Travancore Tortoise (*Indotestudo travancorica*) in Captivity at the Madras Crocodile Bank Trust/Centre for Herpetology

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The Madras Crocodile Bank Trust/Centre for Herpetology (MCBT) has the only known captive breeding group of the Travancore tortoise. Several authors have discussed this captive population concerning husbandry (Andrews & Whitaker, 1993), behavior (Ramesh, 2002; Whitaker, 2012), and reproductive biology (Ramesh, 2007; Whitaker & Andrews, 1997; Whitaker, 2012).

While many nests produced by females are laid in hidden undergrowth, eggs are routinely removed and consumed by both the jungle crow (*Corvus culminatus*) and house crow (*Corvus slendons*), both of which are residents of the MCBT campus. Not all nests were observed by Staff when the female tortoise was laying them, and crows were a significant predator of eggs while they were being laid (Plate 1). Eggs were also dug up by the same species 2 -3 days following egg laying. In some instances, a method that allowed for successful egg laying was placing a cage over the nest-digging female, although at other times, it caused the female tortoise to abort excavation and attempt to escape from the cage (Plate 2). Interestingly, Travancore tortoise females have been observed to extend oviposition post-1800 hrs until 1940, while they were previously described as crepuscular (Vijaya, 1983). Data from 2022 and 2023 revealed that predation of eggs coincided with the peak egg-laying periods, understandably. In 2022, four nests were observed in August and November and two in December. In 2023, seven nests were observed being predated: two in January, one in October, and two in December (Plate 3).

The intelligent nature of crows has been reported by Auddey *et al*. (2012), amongst others. These visually oriented birds are part of the urban and sub-urban landscape of India, including the environs of MCBT. To remove this risk of predation on eggs, Carl Stahl™ mesh is proposed to be installed in the enclosure, so eggs can be taken to the incubation lab once laid. Another reason to collect intact eggs is that unfavourable temperature regimes appear not be favourable for development to hatching in the enclosure.

Plate 1. *Crows are on the lookout for Travancore females excavating nests, mainly post 1600 hrs.*

Plate 2. *Female Travancore tortoise excavating nest within the protection of a mesh cover.*

Plate 3. *Predated Travancore tortoise eggs were found outside their enclosure. Literature cited.*

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12 Conservation Breeding Programme of Lion-tailed Macaque (*Macaca silenus*), Nilgiri Langur (*Trachypithecus johnii*), Ostrich (*Struthio camelus*) at Arignar Anna Zoological Park

- Arignar Anna Zoological Park

AAZP is the conservation breeding centre, and co-ordinating zoo for Lion-tailed Macaque and Nilgiri Langur and Participating Zoo in the breeding programme of Bengal Tigers, Indian Gaur, Indian Giant Squirrel & Wild dogs. It is also a captive breeding centre of Indigenous animals (Grey wolf, Gharial, Mouse deer, Nilgai, Swamp deer, Sambhar deer etc.) Exotic animals (Hippopotamus, Ostrich, Blue & Gold Macaw, Chimpanzee).

Lion tailed Macaque (*Macaca silenus*)

Arignar Anna Zoological Park in Vandalur has been identified as a key center for the conservation breeding of Lion-tailed macaques (*Macaca silenus*) since 1983. Initially, one male and three females were procured from the wild in the Anamalais region and placed in spacious off-exhibit enclosures spanning 3394 sq.m which is away from human intervention and disturbance. These enclosures were carefully designed to minimize human intervention and disturbance, offering a natural environment with a variety of edible tree species including *Anona squamosa, Bambusa bambus, Ficus religiosa, Azadirachta indica, Pithecellobium dulcis, Psidium guajava, Terminalia catappa, Tamarindus indicus, Syzygium cumini, Artocarpus heterophyllus, Phyllanthus emblica*, and other herbs and shrubs. Since its inception, a total of 80 births and 54 deaths have been recorded, of which ten males and six females have been exchanged with the following zoos, namely, Mysore, Trivandrum, Hyderabad, Guindy Childrens' Park, Patna and National Zoological Park, New Delhi. Currently a total of 2:7:0:9 LTMs are being maintained in the off-exhibit breeding enclosure and 3:8:0:11 are being maintained in the enclosure meant for public display. Thus, a total of 6:14:0:20 are being maintained at the zoo. Apart from the off-exhibit enclosure, the macaques in the display enclosure have also been breeding well and currently have one juvenile. However, a sizeable population fit enough for being released in the wild has not been achieved yet. Steps are being taken to improve the conditions in the breeding enclosure. LTM individuals are identified and marked with microchips. Through pedigree analysis, comparable pairs are chosen for breeding to ensure compatibility and genetic diversity.

However, in the scientific realm, it is observed that the present stock of LTM, in all zoos including participating zoos are the progeny group of the founder population. 1:3:0:4. To enhance the conservation effort, AAZP has initiated the proposal for acquiring founder population from wild in the ratio of 2:8:0:10 through proper channel for LTM and Nilgiri langur. This initiative aims to conduct a pilot study in Anamalai Tiger Reserve (ATR) and Kalakkad Mundanthurai Tiger Reserve (KMTR) to identify the healthy population for acquisition of potential individuals. The goal is to ensure the future survival and sustainability of the species by maintaining genetic

variability through Introduction of new blood line and thereby avoiding inbreeding. Periodic meetings and expert visits are being conducted.

Nilgiri Langur (*Trachypithecus johnii*)

A similar off-exhibit enclosure for Nilgiri Langurs (*Trachypithecus johnii*) has been proposed in the current masterplan of the zoo charted for the next two decades (2023-2043). The funds procured from the CZA for Nilgiri Langurs is currently being utilized for feeding, maintenance and keepers' salary. Upon the approval by the CZA, the construction of a new enclosure would be initiated in the due course. Permission has been sought for capturing viable individuals of Nilgiri Langurs from the wild for captive breeding programme. 50 new birth has been recorded so far while the death of 20 individual and 10 nos has been exchanged to other zoos 5:5:0:10. The present stock of Nilgiri langur is 9:11:0:20.The animals were exchanged to Sakkarbaurg zoo, Mysore zoo, Hyderabad zoo and Nandakannan zoo.

Ostrich (*Struthio camelus*)

Arignar Anna Zoological Park is known for good breeding of ostriches. In 2009, the park acquired a pair of ostriches from the Animal Research Centre in Kattupakkam, and since then, it has diligently cared for these birds. The zoo has designed a specialized enclosure tailored to ostrich breeding this includes separate cabins for breeding pairs, ample space for sub-adult ostriches to roam freely, and dedicated cabins for raising chicks along with special feed for ostriches, seasonal enrichment and ample of sand pit for dust bath.

The ostriches in the zoo are fed with ostrich specific feed charted and produced by TANUVAS, which differs from typical broiler feed in that it contains higher concentrations of essential amino acids like methionine and lysine. Additionally, it is supplemented with high concentration of protein and calcium in comparison to regular poultry feed.

Ostriches naturally inhabit arid environments where sand is abundant, and providing them with a sand pit in captivity mimics their natural habitat. The park has installed sand pits in all four partition enclosures, which greatly enhance the activity levels and well-being of the ostriches. These sand pits facilitate dust bathing, thermal regulation, foot care, and behavioural enrichment for the birds. By ensuring the provision of these amenities, we prioritize the physical and mental well-being of our ostriches.

The park's meticulous attention to the ostriches' welfare has created ideal conditions for breeding. As a result, the population has seen remarkable growth, with 78 births and 41 deaths recorded under the zoo's care. Additionally, the Arignar Anna Zoological Park has actively participated in exchange programs with various Indian zoos, including Sakkarbarg Zoo, Mysore Zoo, Guindy Children's Park, Lucknow Zoo, Pilikula Zoo, Gadag Zoo, and Kanpur Zoo.

Currently, the zoo maintains a healthy stock of ostriches, with a ratio of 2:5:10:17

13 Standardization of Artificial Incubation Technique for Indian Rock Python Eggs at Indroda Nature Park Zoo

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Indroda Nature Park has a snake house in which various reptilian animals falling under the order squamata are housed for display of visitors. In the year 2015, the Indian Rock Python started breeding at the green valley enclosure of the zoo. Before starting of the breeding period in spring season, the potential animals were paired in the enclosure. It resulted in successful mating between a male and a female python. After mating, the female animal laid eggs in the month of May-2015. The animal started incubating the eggs naturally. The female had selected a den for laying the eggs. Wherein, she kept spending days for incubation. The incubation was completed nearly half and she left the clutch of eggs abandoned in the month of June,2015. All necessary efforts were put in place to restart the natural incubation of the egg. But unfortunately due to some internal discomfort, the animal didn't incubate the eggs again. The clutch was healthy otherwise, hence, immediately it was considered to take the clutch into artificial incubation. Then, there was no set protocol for artificial incubation at the zoo, hence various scientific literature was referred for creating artificial chamber and methods of incubation of reptilian eggs. The veterinary Officer - Dr. Aniket Patel and then technical assistant- Shri Irshad Theba developed a unique chamber for incubation of the eggs. Material used to create the incubation chamber were: Glass aquarium (large size), acrylic chamber with openable lid (which fits inside the glass aquarium), solarized soil and sand, hygrometer with temperature meter, unused dark room. By using all said materials, the artificial incubation of 30 remaining days were carried out and the zoo received 10 younglings of Indian Rock Python in July, 2015.

The young python babies were well taken care of. They grew to full extent in 5-6 years. Python babies obtained sexual maturity at the age of 7-8 years. Again in the year 2023, before starting of breeding season, potential male and female pythons were kept together for breeding. Successful mating of python resulted in laying of eggs by a female python on 18/05/2023. This time the female had laid two different clutches of eggs, both had 07 eggs. Out of two clutches, the female started incubating clutch—comprising of seven eggs. The remaining clutch-2 comprising of seven more eggs was abandoned.

The clutch-2 was taken in to artificial incubation wherein, the incubation chamber was made as protocol set in the year 2015. Humidity and temperature was maintained regularly and it was monitored by the HTC HD-303 temperature and humidity meter. After completion of 45 days of incubation period, the clutch kept under artificial incubation was checked for viability of foetus through egg candling. All eggs were showing development of blood vessels and two eggs were showing foetal movements inside.

On other side, the female python was provided all comfort and care during natural incubation of the eggs of clutch-1. After 50 days, the female left out the eggs after completing more than 80% of incubation. The clutch-1 was also taken in to artificial chamber for incubation and hatching. All eggs of clutch were examined and appeared healthy and viable. No dead egg with saprophytic organism (fungus, mould) growth was observed.

The clutch-1 (natural + artificial) hatched out on 20/07/2023. Total 7 python babies were born in the batch-1. The clutch-2 (completely artificial) hatched out 22/07/2023. In this batch-2, total 7 more younglings of python were born. All 14 babies were provided neonatal care and kept in the veterinary hospital for

observation and further care for initial days. The body length and weight of the new born were noted. The batch wise data of the same is as under:

Sr. no.	Batch	No. of animals	Date of birth	Mean value of body weight in gram at the time of birth	Mean value of body length in centimeter at the time of birth
1.	I	07	20/07/2023	149.5 (in range of 120 gram-164 gram)	63.1 (in range of 60 cm – 67 cm)
2.	II	07	22/07/2023	149.2 (in range of 134 gram-161 gram)	60.9 (in range of 58 cm – 64.5 cm)

The babies have started ecdysis from day 8 of their birth. On 28/07/2023, two babies died soon after their first ecdysis. Immediately both were taken in to panel post-mortem examination. It revealed acute respiratory distress syndrome as the cause of death. All 12 alive babies were under suspicion range for having same disease, although the clinical manifestation of the disease was zero. Looking in to the nature of disease- peracute, the prophylactic measures were immediately applied. All alive babies were taken in to intensive treatment of nebulization and parenteral antibiotic treatment. The babies were shifted in to larger enclosures with provision of rice husk bedding and in-house moulting accessories and hiding places inside it. After completion of treatment of these 12 babies for a week, all were out of danger. Meanwhile all have completely moulted their skin except one, which was born weak and finding difficulty in shedding the skin. 11 babies have started taking feed. Python neonates chose mice for their initial feed and then they were shifted on to day old chicks after few weeks. The gaining of weight and rapid continuous ecdysis were observed in both the batches. During incubation, one egg was infested with maggots and underdeveloped baby was expelled to check the internal death due to maggot infestation. One weak neonate was born from that affected egg. It did not consumed feed inspite of providing several offerings. Coiling instinct around the mice was lacking in the neonate, hence, It was being manually fed three times in the span of three weeks, but soon after feeding, the neonate vomited out everytime. The animal became debilitated on account of prolong anorexia. It died on 16/09/2023. Upon post-mortem examination, it was found that, it had congenital anomaly of lungs. It was born with pulmonary hypoplasia.

The new born animals were observed for four months from their birth and neonatal and post natal care was provided. All 11 neonates were found fit for release in to nature. Therefore, a proposal was sent to the Principal Chief Conservator of the Forest (WL) and the Chief wildlife Warden of Gujarat State to release them in the natural habitat. The order of young python release was obtained on 03/10/2023 at two different places. After careful consideration, 04 young pythons were translocated to Sabarkantha Forest division and released in forest of Dholwani range on 20/11/2023. 07 young pythons were translocated to Shoolpaneshwar Sanctuary and released in to forest of Gora range on 20/11/2023. The data of their bodyweight and body length are as under:

Sr. no.	Date of recording the data	No. of animals	Mean value of body weight in gram	Mean value of body length in centimeter
1.	19/11/2023	11	423.4 (In range of 717 gram-171 gram)	76.6 (in range of 95 cm- 62.5 cm)

All the python young ones were observed for a while after their release in to nature till their disappearance and hiding in their habitat.

The photographs showing various procedures are on next page.

Photo Plate: 1

Oviposition, natural incubation and abandoning of eggs

Artificial Incubation Process and egg candling for checking viability of eggs

Hatching of python eggs

Photo Plate: 2

Neonatal care of hatched out python hatchlings

Data recording at the time of birth

Ecdysis process and feeding

14 Identification and Control of Pentastomids in Saw-Scaled Vipers (*Echis Carinatus*) Housed in Captivity

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Abstract

Pentastomids (Tongue worms) are endoparasitic arthropods causing pentastomiasis. It is a highly invasive disease that poses a threat to wild animals as well as humans. Animals acquire infection via the intermediate host. In reptiles, the parasite is present in the respiratory tract causing serious pathological complications. Usually, the infestation is asymptomatic, but nonspecific symptoms may occur at high parasitic concentrations. Due to the wide range of harmful effects of many antiparasitic substances, treating tongue worm invasion in reptiles remains a challenge. This case study revolves around the infestation that was diagnosed during the necropsy of a saw-scaled viper. Further, faecal examinations of the co-inhabitants revealed the same parasites. Therefore, a safer approach of treating with fenbendazole at a dose of 100 mg/kg b.w. p.o, was shown to be effective.

Keywords: Pentastomids, intermediate host, saw-scaled viper, zoonosis, fenbendazole

Introduction

Pentastomes (phylum Pentastomida), are wormlike parasitic arthropods (presence of chitinous exoskeleton) that are found mainly in the respiratory tracts of carnivorous mammals, reptiles, and birds. Tongue worms affect a variety of reptiles, including snakes, lizards, turtles, and crocodilians (Flach *et al.*, 2000; Junker *et al.*, 2006; Rataj, 2011; Kelehear *et al.*, 2011). They are dioecious and fertilization is internal. Females are larger than males; females lay ova that are coughed up, sneezed, or ingested and passed in faeces. Adults and larvae are hematophagous and feed from capillary beds through a sucking mouth. The mouth is attached to the mucosa via their hooks which are five in number from where they derive their name.

Although most infections remain unnoticed, an exceptional parasitic population can usually lead to occlusion of the trachea and airways causing respiratory distress and mortality. Some authors also suggest that stress can play an important factor in reactivating dormant nymphs in intermediate hosts and adult pentastomes in definitive hosts. The presence of existing adult pentastomes in the trachea of debilitated hosts may lead to suffocation. It is essential to diagnose and treat such infections to prevent widespread mortality of reptiles housed in captivity. These parasites also carry a high zoonotic risk therefore effective control of parasites in animals is necessary to have a safe one-health approach.

This paper aims to control the parasitic load with a safer alternative approach in treating pentastomids due to the established harmful effects of many anti-parasitic substances in reptiles.

Case presentation

A saw-scaled viper (*Echis carinatus*) was observed to have sudden mortality with no pre-existing comorbidities. The snake was said to be housed in coco peat substrate with co-inhabitants. The animal was feeding well and no abnormalities were observed apparently. On necropsy, the snake was observed to have an abundance of live worms attached to the trachea. All of the worms were extracted carefully and later microscopic analysis revealed the presence of dioecious worms with five hook-like structures thus confirming the pentastomids. Mucopurulent discharge was present in the oral cavity extending into the lungs and mixed with blood.

To prevent infection to other housed individuals strict biosecurity protocols were followed in handling the snakes and disinfection of equipment. Substrates in the enclosures were modified from coco-peat to sand; routine sterilization protocols were put in place. Further, the reptiles were provided with an additional UV B heat lamp system. A co-inhabitant faecal sample was tested by direct smear and faecal floatation technique. It was observed that pentastomids eggs were present in the fecal sample. Therefore, treatment of the co-inhabitant was done using Fenbendazole @100mg/kg p.o via feed; after 7 days, the treatment was repeated with the same dose (R. Gatêcki *et al.*, 2016). Further faecal examinations did not reveal the presence of any ova after the treatment.

Discussion

Pentastomids (tongue worms) are known to have ~140 species (Christoffersen *et al*., 2013). Their life cycle typically involves larval development in an intermediate host followed by maturation in the respiratory tract of a definitive terrestrial host (Siveter, *et al*., 2015). Reptiles are potential hosts of tongue worms due to their varied feeding habits, ranging from fishes to mammals, that act as potential intermediate hosts for pentastomids. Treatments against pentastomids vary along a wide range of drugs with different and questionable efficacies. Ivermectin has been quoted as the drug of choice in pentastomid cases but the results are variable. This variability in results can be accounted for by the variations in the margin of safety while determining doses in different species. Death of adult worms in the lungs or larvae/nymphs in tissue could result in massive antigenic release with serious and potentially lethal complications. Although such a reaction has not yet been reported, treatment risk must be understood and acknowledged (Paré *et al*., 2008). Therefore, working out with different drugs in different combinations is essential to eradicate such infections in safer ways.

In four Boelen's pythons (*Python boeleni*), a combination of ivermectin and fenbendazole at 200 mcg/kg and 100 mg/kg respectively was used as a treatment protocol which resolved the infection by cessation of ova shedding and non-visualization of the parasites in the radiographs (Baier J *et al*., 2008). In addition to this, two ball pythons were also successfully treated against pentastomids with fenbendazole @100mg/kg (R. Gatêcki *et al*., 2016). We chose to use this treatment regimen as a safer alternative to other parasitic drugs due to the nephrotoxicity concerns around the use of ivermectin (Klingenberg, Roger J., 1992; Rajesh *et al*., 2014). Future treatment regimens should focus on treating the pentastomids with insect growth regulators since they are anecdotally effective against copepods in fish (pentastomids are closely related to copepods). Both diflubenzuron and lufenuron have shown efficacy in eradicating these parasites in fish, but their potential to treat pentastome infections in reptiles needs to be researched (Paré *et al*., 2008; Bouboulis *et al*., 2004).

Acknowledgment

We sincerely thank the Trustees of the Madras Crocodile Bank Trust for their continued support and encouragement. We thank all the animal keepers for being the first responders in case of emergency/ incident and especially for their tireless efforts and commitment to animals and our environment. Further, we express our gratitude towards Coromandel International Ltd. for funding us with the equipment used for this study.

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15 Reproduction in Water Monitor, *Varanus Salvator*, With Notes on Treatment of External Yolk Sac in Juvenile

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Abstract

The present short note explores the husbandry aspects of adult Asian water monitors during and after egg laying in captivity, treating a retained yolk sac in a neonate and the aftercare of the juvenile. Though housed together for the past 7 years, this particular pair of adults bred and laid eggs for the first time in May 2023. The eggs laid were photographed at the time of laying in an attempt to document variations in egg structures and associated viability. A singular egg was hatched in December 2023, the neonate having an externally protruding yolk sac, which was treated successfully.

Introduction

The water monitor, *Varanus salvator,* is the second largest living lizard with the most extensive distribution in the Varanidae family. It is reported to have colonized both freshwater and marine habitats (Traeholt, 1993). In the wild, water monitors are observed to be primarily foragers, feeding on carrion and occasionally live prey such as mice and fish. Unlike other members of their family, they are not entirely dependent on burrows, using temporary burrows for thermoregulation to escape predation and nesting (Traeholt, 1993 and 1995).

In observations made by Shine *et al.*, 1998 on wild-caught lizards, it was reported that males mature at a smaller size than females, but males grow larger. Their findings showed that females reproduce year-round, less frequently in drier months, and the clutch size was directly proportional to the maternal body size.

Studies on these lizards in captivity have led to the following Conclusions- like most other reptiles, these lizards require UV exposure and high humidity levels, and housing of same-sex conspecifics with significant differences in sizes causes territorial fights leading to death. Mating was reported to be mildly injurious to the female, with the male grasping the neck of the female during the process (Hairston and Burchfield, 1992).

Andrews (1995) summarised previous reports of *Varanus salvator* reproduction at the Madras Crocodile Bank Trust- April and July were mating and nesting seasons, respectively, with hatching in March and April of the following year. Reproductive maturity was postulated to be reached at two years in male and female *V.salvator.* The size and age of the females did not influence the size and weight of the eggs laid; clutch size was larger in the older, bigger females.

Water monitors at MCBT

Two individuals are currently housed at MCBT: the two can be differentiated based on their size, the male larger than the female.

Enclosure: The enclosure is 112 sq. mt. of loose soil, short trees, wild grass, and a meandering water body (cement pond) that encourages free swimming. Large trees within the enclosure allow for climbing; tin sheets are affixed to branches before they extend out of the enclosure to prevent the escape of the lizards. Fell logs provide basking perches and good burrow spots beneath.

Diet: Fish and chicken, segregated and cut according to size. The animals are fed on two different sides of the enclosure to avoid competitive fights for food.

Cleaning: The pond is completely emptied and scrubbed at least twice a month, the frequency increasing or decreasing based on factors such as rains and cyclones. Leaf litter and routine water overflow maintain the feel of a natural shore habitat for the lizards.

Enrichment: Chicken pieces in closed cardboard boxes to enable foraging behavior is done throughout the year. Another activity is the Introduction of "blood popsicles" during summer months that intrigue their hunting senses.

Reproduction and Oviposition

While the actual mating process was not visually seen or recorded, the female was often seen with neck injuries, which can be correlated to the reports in earlier papers as a sign of mating. Typical nesting behavior of digging a burrow was seen only an hour before oviposition. The first egg was laid on the surface near the shallow nesting burrow; the female appeared restless and continued to move around the enclosure, laying four eggs till mid-afternoon, all at different spots. The female rested near the water body after the initial laying, periodically moving back to the nesting site.

A check on the animal at around 1900hrs showed her sprawled sideways at the nesting site, appearing weak (Plate 1). The animal was gently sprayed with water; the egg-laying process continued till 2300hrs (Table 1). During this time, the female was sprayed with water at 15-minute intervals and under observation till daybreak.

Post-laying Care for Female

The female was under observation for two weeks post oviposition- she fed immediately on day 1, active and foraging. In subsequent feeds, the female was given calcium supplement along with tilapia fish. Based on her approximate weight (≈3kg), she was given two doses two weeks apart of the supplement.

Egg Incubation and Hatching

All 12 eggs collected on May 24, 2023, were subjected to the same conditions- during collection, they were placed in exact orientation and laid in a tray containing sand from the nesting site. Subsequently, the eggs were transferred to damp cocopeat to maintain a humidity of 90% and placed in ventilated boxes at ambient temperature (28-30°C). The eggs were left undisturbed except for periodic dampening of the cocopeat with a manual mister.

Concerning general appearance, "healthy" eggs were properly white and elliptical, the eggshell thick, leathery, and opaque on candling. In the process of laying, the mother trampled two eggs. On laying, about five eggs were improperly formed with decalcified, deformed eggshells; the yolk hardened within two days, showing infertility (Plates 2a and 2b). By September, of all the eggs that were incubated, one egg appeared healthy- candling of the egg showed movement within

On day 215 of incubation, December 25, 2023, the hatchling pipped and fully exited the egg within 20 minutes (Plate 3). The animal was observed to have a large amount of yolk attached via the umbilical cord externally (Plate 4). The lizard was placed in a ventilated box in an incubator at 32 C, the umbilical area cleaned with a dilute solution of Betadine.

Treatment of external yolk sac in juvenile *V. salvator:*

The juvenile was left undisturbed for two days; in this period, the initial bright yellow of the yolk changed to a bruised brown, an indication of the onset of necrosis (Plates 4 and 5). In order to prevent further spread of infection, the yolk was ligated using vicryl 5-0 suture and surgically removed under topical application of local anaesthetic by the vets in an aseptic environment (Plate 6 and Plate 7). The animal was then placed in a sterile ventilated box- cleaned within an incubator for 24 hours, set at 32 C.

The remnant cord tissue was allowed to dry and slough off naturally, yet monitored regularly; the juvenile was shifted to a sterile plastic crate with a mesh lid provided with bark for hiding and basking and a

large water bowl. The artificial UV source, Exo terra UVB200 25W, was placed at an optimal distance. A photoperiod of about 9 hours light: 14 hours dark was maintained. The cord tissue was seen to be dry and had fallen off within 48 hours, and the scar tissue on the animal healed in less than one week after the procedure (Plate 8).

Juvenile Care

The juvenile was kept in seclusion and fed small bits of fish and rat pinkies. The animal's weight after consumption of the first feed, post-defection, was 51 grams. The diet was modified to chicken, organ meat, and pinkies, one meal of about 5-10grams every alternate day. The box was spot-cleaned of feces daily and completely cleaned twice a week. For any feed placed, the leftovers were removed at the end of the photoperiod (when the light was turned off) to prevent ant infestation.

Once the animal fed and passed feces routinely, an aquarium was set up with sturdy perches under the UV bulb floating logs for resting and was filled to 5 inches with water. Live fish were introduced in the water body. Feed was placed in a bowl near the perch branches for consumption. Keeping in mind the animal's agility, any gaps in the aquarium were closed with mesh. The aquarium was externally covered with paper to prevent animal agitation by constant movement in the surroundings. Routine cleaning was done after gently capturing and shifting the animal to a secure box.

Conclusion

The reported successful reproduction of *V. salvator* was the first attempt of this pair at MCBT. The mating and nesting time in 2023 at MCBT coincides with the initial reports of the breeding stock acquired by MCBT from North-East India in 1987, the pair mating and laying eggs in May and August during the first year. From consecutive mating history, it can be concluded that the onset of monsoon (May-July) might trigger oviposition (Andrews, 1995). A comparison of behavioral aspects seen in female *V.salvator* during this period is tabulated in Table 2.

Table 1. The oviposition activity correlated with temperature and humidity.

Time (24 Hrs)	Temperature (°C)	Humidity (%)	Number of Eggs Laid
0950	32.1	78	2
1100	33.3	74	1
1400	34.4	70	1
2005	29.9	86	2
2100	29.7	86	3
2200	29.7	87	2
2315	29.4	87	1

Data was collected through wireless Davis Weather station Vantage Pro2 at MCBT, recording 30-minute intervals.

Table 2. Behavioral aspects of female V. salvator at MCBT, Chennai and Gladys Porter Zoo

Activity	Female- MCBT	Female- Gladys Porter Zoo (Hairston and Burchfield, 1992)
Frequency of nesting	Observed once throughout the year	Three times a year (Jan, Apr, Sep)
Clutch size	12	9-20 in a clutch
Feeding	Fed typically pre/post-birth	Off-feed 14-21 days prior

Activity	Female- MCBT	Female- Gladys Porter Zoo (Hairston and Burchfield, 1992)
Digging	Sporadically at/near the same spot throughout the year	14-21 days before oviposition in the allocated nesting box
Mating	Not seen on land, the female was seen with wounds near the neck	Two months prior to egg-laying
Deposition of eggs	On the surface, within 24 hours	Initial laying of 1-2 eggs, eggs laid in bulk through several days
Ingestion of eggs	None, all collected immediately	2-4 eggs ingested by female post laying

From the incubation progress pattern, only turgid eggs survived to hatching; the softer, malformed eggs lost viability and rotted in the months following laying. Egg shape and structure were similar to that reported by Biswas and Kar, 1981 and Hairston and Burchfield, 1992. The incubation temperature is maintained, and the incubation period is within the range for this species (Hairston and Burchfield, 1992; Andrews, 1995; Horn and Visser, 1997). In the incubation trials by Hairston and Burchfield, 1992, they postulated that temperature variation causes certain abnormalities, such as "kinky tail" at 32 degrees in the juveniles. As reported by Shine *et al.*, 1998, a correlation can be drawn between the number of eggs laid being directly proportional to humidity and a temperature decrease (Table 1). Juvenile activity post hatching- quick movements, hissing with puffed up the throat, and tail whipping was reported as the behavior of healthy juvenile lizards by Biswas and Kar, 1981.

Thus, captive breeding and neonatal care of this lizard species can lead to extensive research on mating and nesting patterns, the effect of changing climate on reproductive patterns, the influence of temperature on hatching success, and juvenile morphology. The externally retained yolk sac treatment can be standardized and applied to other species with similar difficulties.

Acknowledgement

We sincerely thank the Trustees of the Madras Crocodile Bank Trust for their continued support and encouragement. We thank all the animal keepers for being the first responders in case of emergency/ incident and especially for their tireless efforts and commitment to animals and our environment. Further, we express our gratitude towards Coromandel International Ltd. for funding us with the equipment used for this study.

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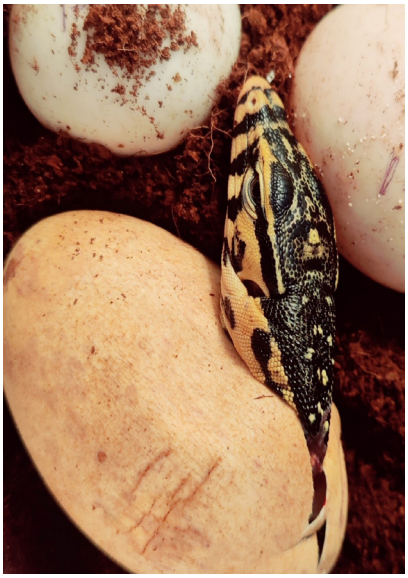
Plates (1-8)

1. *Female at nesting site laying an egg in lateral position after spraying of water*

2. *Eggs collected at forenoon and eggs collected post sunset- note malformed eggs*



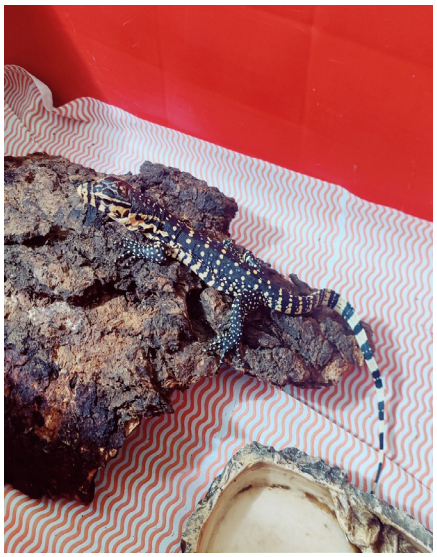
3. *Pipping of hatchling on Day 215 of incubation at ambient temperature*

4. *Hatchling with external protrusion of yolk- healthy yellow yolk observed*

5. *Degradation of yolk in 48 hours to brown tissue mass*

6. *Yolk removed from hatchling after ligation of umbilical cord*

7. *Lateral view of animal after successful procedure*



8. *Animal in temporary sterile enclosure equipped with water body and hide spots*

16 Zoo Keeper Record Keeping Made Easy and Practical

- Araddhya Siddhesh, Dr. Devanand Shirsat, Dr. Deepika Valsarajan and Dr. Komal V Raul
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Veermata Jijabai Bhosale Botanical Garden and Zoo located in heart of Mumbai City in Maharashtra is a heritage Grade-II Zoo having completed 162 years and is always seeking to do something innovative and creative as the years keep adding on. We endeavor to achieve perfection in all our efforts with the aim of providing best example for other zoos in future.

The Mumbai Zoo has already replaced the conventional method of moated animal displays/ exhibits and has adopted acrylic glass viewing exhibits for ease of display of animals and avoid public disturbance while side keeping in mind their natural habitat, physiological and social behavior which in turn helps to create a low stress environment. In addition to the natural habitat provision with implementation of proper species specific nutrition there is considerable improvement in behavior which further helps in promoting positive animal welfare, health and reproduction of zoo animals. We always take efforts to achieve this goal by various mediums of animal welfare, awareness program or educational activities.

One such aspect undertaken by the zoo is pursuing good record keeping. As per CZA guidelines all zoos are advised to maintain daily dairy by animal keeper in which they have to record the daily observations which have to be penned down by writing observations. Record keeping then become meticulous and cumbersome if the observations need to written in detailed manner. However many of the animal keepers have poor reading and writing skills and it becomes difficult for them to make note of the important things in the dairy in proper detailed manner. As a result keeper dairy maintenance gets affected.

In this view the team of veterinary doctors and biologists of VJBB zoo modified the existing CZA format for animal keeper record. The information of the daily dairy is provided to the animal keepers in the form of the charts, which are categorized as per species exhibited. .Considering the zoo keepers are local community people and are comfortable in their local language the zoo daily record is maintained in local Marathi language. It can be maintained in any local language as per the regions requirement of language. Aspects like food and water intake of animal , physical and behavioral changes, injuries , hygine, enrichments, enclosure maintenance etc. are noted in this dairy of animal keeper.

The following factors are covered in the daily zoo keeper charts:-

1) Name of the animal species 2) Number of animals 3) Gender of animals 4) Food intake 5) Water availability 6) Urine and stool observations 7) Physical and behavioral changes 8) Medication and treatment 9) Cleaning and hygiene maintenance 10) Enrichments 11) Safety measures

To make chart easy to understand we have incorporated symbols (pictures/ emojis) which are easy to understand even if the keeper is unable to read. This make it easy for animal keeper to mark/ note whether the daily things/observations are done or not. Below are the examples of charts for mammals, birds and reptiles.

Advantages of using the modified charts:

1) Keepers got involved in proper observation of animals.
2) Charts are easy to maintain and not bulky to store.
3) Easy to interpret as it is in local language and has symbols.
4) Easy to fill by tick and cross instead of writing in paragraphs.
5) Important observations are written down as 'Note'. which became easy to find.
6) Easy for data collection and compilation.
7) Record can be used for further research analysis.

We observed that this method of maintaining keeper daily dairy in the form of charts and symbols and breakdown of information has brought about following changes in the notion of the animal keepers towards record keeping such as:-

1) The keepers become more alert and responsible towards their daily animal observation and routine work schedule.
2) Recheck on important work aspects gets done timely.
3) Keepers became more accurate in animal observation and reporting.
4) Record gets maintained in systematic manner.

In Conclusion these charts can be modified or customized by any zoo as per their animal requirement/ daily duties/ weekly or monthly record system whichever is maintained at their Zoo. This chart system can also be maintain by head animal keeper/ supervisor/ curator/ biologist as per their requirement. We have started to maintain daily-duty dairy so that nothing gets missed in discharging and regulating duties of an animal keeper while taking due care of animals.

Animal Keepers Daily Checklist (Mammals)

Name of Species: No.of animals: Male- Female-												
Date Day	Exhibit C leaning	Animal Ate the food ?	Drinking water& water container cleaning	Urine and Stool	Behavioral change (Drowsy/ Active/ Uneasy)	Medication or Treatment	Feeding House cleaning	Footbath cleaning	Electric Fencing checking	Lock	Keeper Sign	Note
Head Keeper Sign: Supervisor Sign: Curator Sign:												

Animal Keepers Daily Checklist (Crocodile)											
Name of Species: No.of animals: Male- Female-											
Date Day	Exhibit cleaning	Lake cleaning	Is water available in the lake?	Animal Ate the food ?	Behavioural change (Drowsy/Active/Uneasy)	Urine and Stool	Medication or Treat-ment	Footbath cleaning	Lock	Keeper Sign	Note
Head Keeper Sign: Supervisor Sign: Curator Sign:											

Animal Keepers Daily Checklist (Birds)												
Name of Species: No. of Birds: Male- Female-												
Date Day	Feeding house cleaning	Exhibit cleaning	Drinking water& water container cleaning	Birds ate the food?	Behavioral change (Drowsy/ Active/ Uneasy)	Medication /Treatment	Physical changes (Injury, feather loss etc)	Footbath cleaning	Electric Fencing checking	Lock	Keeper Sign	Note
Head Keeper Sign: Supervisor Sign: Curator Sign:												

17 Learn While You Play : A Novel Interactive Education Programmes

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Introduction

Zoos are important public institutions that preserve natural heritage and protect endangered species in the region. While providing exhibits and amenities that attract and entertain visitors, zoos also aim to fulfill roles of conservation, facilitate scientific research and educate the public about the importance of their activities. At the same time one of the missions of the zoos is to support growth of environmental awareness through informal and formal education. Visiting the zoo is rarely consciously planned and structured. A visitor is left alone to wander through the zoo, to determine his/her own learning goals (if any), paths and means, and to learn through random direct observation. Despite the freedom this form of visits brings along, the visitors are treated as passive learners, who acquire information through looking at the zoo habitants and information boards displayed next to the animal.

Chennai Snake Park is a specialized zoo established in 1972, to conserve snakes and other reptiles and educate the visitors about its role in the ecosystem. For education purposes Snake Park has 39 species of reptile's exhibits in semi-natural condition. To educate the public we have the information board for each species positioned in front of the enclosure. Various boards having facts about the reptiles are fixed important places in the zoo. In our zoo we have an interpretation center having audio and visual presentations. For attracting visitors the zoo has interactive displays such as the Spitting cobra model, and other interactive games namely physical learning exercise (frog jump exercise, Ring throw), Virtual learning find out the hidden animals and can you find out how many we etc) and Technological learning (scan QR code to identify the snakes) etc.

Educational Games

As we mentioned above we are having three types of interactive games namely virtual learning, Physical learning and Technological learning. To play the games, the zoo visitors completed different tasks; each task has its value to learning about the reptiles in our zoo.

1. Physical Learning

For instance, visitors were asked to pick up the animal name from the card, then they had to identify the correct animal from the photographs, then they threw the ring on the particular animal which they identified. If they throw the ring on the particular animal, photographs will get the reward. Similarly, the bow and arrow game is another interesting play. One has to identify the venomous snake on the board and throw the arrow in the correct picture, and will be rewarded.

Fig.1. Interactive game - Ring throw

Fig.2. Interactive game - Bow and Arrow

Frog jumping exercise will also give better exercise that uses your body weight to activate muscle groups across your body. This exercise will strengthen your calves, glutes, hamstrings, quads and leg muscles. And reduces stiffness and leg pain, helps in melting away unnecessary fat from different sections of your body and boosts up memory level.

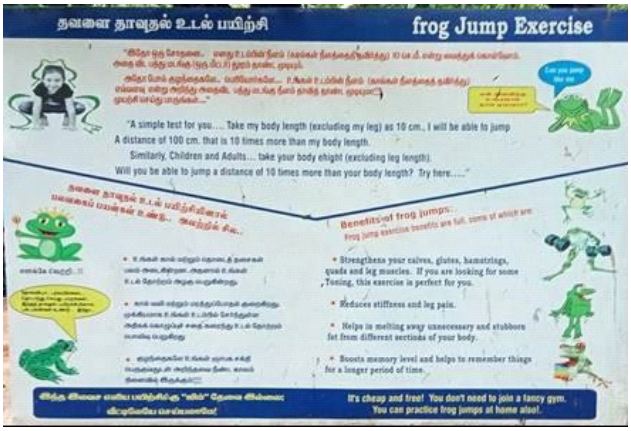

Fig.3. Interactive game Frog Jumping Exercise

2. Virtual Learning

Virtual learning concerned with issues of learning, training and entertainment. Our park we have such games for the visitors, like finding the hidden animals from the photographs, and snake puzzles, arranging snake species wise and identifying how many chameleons are in the enclosure etc. These are the games enhancing, motivating and stimulating learners' understanding about snakes.

Fig.4.Identify how many Chameleons in the enclosure

3. Technological Learning

Visitors may use the mobile devices to scan QR code which is placed on the wall for searching the animals. Visitors scan the QR code they will get the answer, from the answer they will identify and group the snake species. To conclude Chennai Snake Park is one of the most excellent educations and research centers for reptiles in the country.

Fig.5. Technological Learning

18 Enriching the Well-being of Sloth Bears through Novel Enrichments-WSOS

- Srinu S. Maharana, Adhithyan N K, Pooja Acharya, Baijuraj MV, Ilayaraja S.

Keeping the biological needs of any captive animal in concern, the enclosure design, and environment would have to be a replica of the wild that the species occupies (Azevedo *et al*., 2023; Tyagi *et al*., 2015; Young 2004). To encourage species-appropriate behaviour and mental activities, enrichment plays an important role in alleviating boredom in captive animals (Mason *et al*., 2007).

Physical habitat

If an animal behaves in captivity the same way as it would in the wild, it is assumed to be in a good state of well-being. As bears have evolved to exhibit complex patterns of behaviours, the provision of environmental enrichment would facilitate increased enclosure utilization patterns and behavioural diversity. Adding trees and enclosure vegetation are ideal for promoting natural behaviour such as exploring, foraging climbing etc. In addition, decayed tree trunks and logs can be manipulated by animals to enhance investigative behaviour and forage. To maintain homeostasis through thermoregulation and hydration, animals need water bodies addressing species-specific requirements.

Figure 1. *Strategically planned natural vegetation with elevated platforms to encourage the bear for climbing and resting.*

Figure 2. *Pools in socialization area allow bears to splash around during hot summers.*

Figure 3. *Hammock prepared with jute sack to provide warmth during winter.*

Dietary enrichment

In wild, animals spend maximum time in searching for food and eating but in captivity there's a fixed feeding schedule and diet. Hence, to keep the animal occupied and to create high level of cognitive association, it's important to practice presentation of food materials through various methods. This includes, altering the feeding locations and frequency, rotation of food items, feeding logs etc.

Figure 4. *Wholesome fruits (grapes, mango, watermelon) along with dates and diluted honey frozen overnight and provided to bears in summer thus enhance manipulatory behaviour and cooling down.*

Figure 5 & 6. *Puzzle feeder with coconut pulp, peanut and roasted gram to enhance cognitive ability in bears (left) and wooden log with drilled holes laded with jaggery, dates and coconuts (right).*

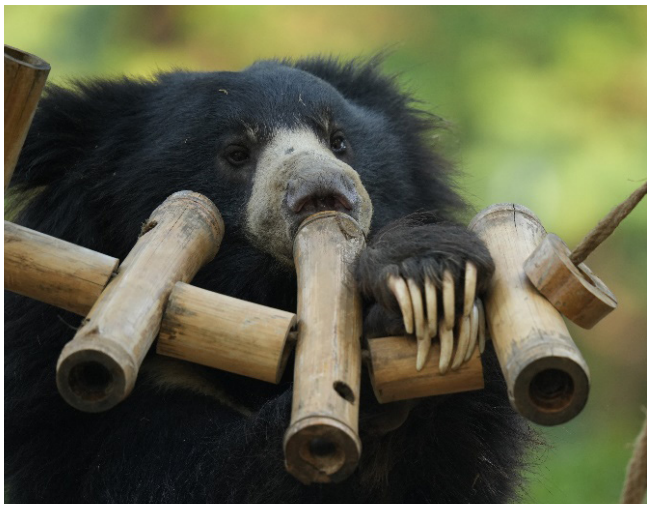

Figure 7 & 8. *Bamboo feeders filled with jaggery, peanut, coconut pulp, and roasted gram smeared with honey then sealed with straws, to enhance bear suctioning capabilities (left and right).*

Figure 9. Feeder balls filled with dates, jaggery roasted gram and peanuts and provided to bears facilitating exercise, exploration, interaction with the environment.

Figure 10. Pipe and rolling barrel feeder with dates, coconut pulps, roasted gram, and peanuts to encourage manipulative and foraging behaviour.

Discussion

The enrichments at Agra Bear Rescue Facility are designed considering the needs of the bears housed. Most of the sloth bears housed in Agra Bear Rescue Facility are in their old age. So, the enrichment design has to be altered as per their physical condition. In such a way, the bears will be able to access and enjoy the enrichment. The natural tree cover in each enclosure supports us in designing more innovative structural enrichments. The feeding enrichments are modified as per the bear's age groups and their physical condition. It is very important to plan separate enrichment for young bears, old bears, and blind bears.

Figure 11. *Ladder enrichment smeared with peanut butter and honey to facilitate the bear for stretching.*

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19 Conservation Breeding for Species Recovery: The Road Ahead

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Conservation breeding programmes are globally recognized as a critical ex-situ conservation tool to prevent species extinction, particularly for taxa facing severe population declines, habitat loss, and genetic erosion in the wild (IUCN, 2014; WAZA, 2015). Implemented within a science-based framework, these programmes aim to establish and manage genetically viable, demographically stable captive populations that can serve as insurance against extinction, support research and conservation education, and, where appropriate, facilitate population reinforcement or reIntroduction following internationally accepted guidelines (IUCN/SSC, 2013). Globally, coordinated breeding initiatives led by zoological institutions, conservation agencies, and specialist network organisations (e.g., World Association of Zoos and Aquariums (WAZA), European Association of Zoos and Aquaria (EAZA), and Association of Zoos and Aquariums (AZA)) increasingly emphasize population genetics, animal welfare, and integration with in-situ conservation actions. Worldwide, coordinated initiatives led by zoological and conservation networks have successfully reintroduced species such as the California condor (*Gymnogyps californianus*), Arabian oryx (*Oryx leucoryx*), Przewalski's horse (*Equus przewalskii*), and black-footed ferret (*Mustela nigripes*), demonstrating the potential of well-managed conservation breeding linked to habitat protection (IUCN, 2014; AZA, 2021).

The importance of ex-situ conservation as a core function of Indian zoos was recognized soon after India's independence. Early recommendations by the Indian Board for Wildlife, followed by the Expert Committee on Zoo Management (1972–1973), laid the foundation for structured zoo management in the country (MoEF, 1998). Subsequent National Wildlife Action Plans (1983; 2002–2016) reaffirmed the role of zoos in ex-situ conservation, particularly through conservation breeding, rehabilitation, and reIntroduction of endangered species in accordance with IUCN guidelines (MoEFCC, 2017). Under these frameworks, the CZA was identified as a key institution for developing national capacity in conservation breeding. The National Zoo Policy (1998) further defined zoos as institutions dedicated to biodiversity conservation, conservation education, and research. It emphasized coordinated ex-situ breeding of endangered species, especially those with little or no chance of survival in the wild, to serve as an insurance population and, where feasible, as a source for reIntroduction. In the context of accelerating habitat loss and species decline, Indian zoos are increasingly required not only to sustain captive populations but also to contribute directly to the recovery of wild populations (MoEF, 1998).

In India, conservation breeding has evolved from sporadic captive propagation to a policy-driven, coordinated national programme under the Central Zoo Authority, aligned with the National Zoo Policy and National Wildlife Action Plans (CZA, 2018). The Indian approach emphasizes prioritization of critically endangered and

range-restricted species, structured studbook management, institutional capacity building, and close linkage between in-situ and ex-situ management, positioning conservation breeding as a strategic component of the country's broader wildlife conservation framework. Notable Indian examples include the Gharial (*Gavialis gangeticus*), Red panda (*Ailurus fulgens*), and Pygmy hog (*Porcula salvania*), where captive-bred individuals have been released to reinforce wild populations (WII, 2014; CZA, 2020). Collectively, these global and national experiences underscore the role of conservation breeding as a strategic, evidence-based component of modern wildlife conservation when integrated with in-situ management and long-term monitoring.

Conservation Breeding Programme for prioritised species: Governance and support mechanisms of the Central Zoo Authority

India's Conservation Breeding Programme (CBP), coordinated by the Central Zoo Authority (CZA), is "a coordinated effort to maintain healthy, genetically diverse populations of endangered animals in human care" that identifies and prioritises species for ex-situ conservation to safeguard threatened wildlife and support broader in-situ recovery objectives (CZA, 2018). According to official CZA guidelines and recent Ministry of Environment, Forest and Climate Change reports, 74 indigenous faunal species have been identified for focused conservation breeding in Indian zoos, encompassing mammals, birds, reptiles, and amphibians (CZA, 2020; MoEFCC, 2023). Of these, the CZA has prioritised around 35 species for concerted support, with 18 species already funded for establishing off-display conservation breeding facilities, and additional species receiving phased prioritisation for funding and technical assistance. Prioritisation is based on field conservation status, threat levels, and the necessity of establishing genetically viable assurance populations in captivity that can serve as demographic buffers, sources for research, education, and potential reIntroductions (IUCN/SSC, 2013; CZA, 2018).

The Central Zoo Authority (CZA) plays a central role in enabling conservation breeding efforts across Indian zoos through the following core mechanisms:

1. Identification and prioritisation: The CZA, in consultation with wildlife experts and field managers, identifies species that require conservation breeding based on extinction risk, declining wild populations, and inability of natural habitats to sustain viable populations. It subsequently prioritises a subset of these species for institutional support and funding.
2. Technical guidelines and norms: The CZA has established detailed guidelines and norms for Conservation Breeding Programmes, which prescribe principles for demographic and genetic management, founder selection, studbook maintenance, health monitoring, and linkage with in-situ programmes. These guidelines incorporate international best practices and emphasise continuity of expertise and resources for successful outcomes.

3. Financial assistance for off-display facilities: Zoos hosting prioritised species receive financial grants to develop off-display conservation breeding centres dedicated to sensitive breeding work away from public disturbance. Funding is staggered and linked to progress reporting, ensuring accountability and continued support.
4. Coordination and capacity building: The CZA designates coordinating zoos responsible for managing species-specific programmes, maintains studbooks, facilitates animal exchange between Indian and international institutions, and fosters collaborations with research organisations such as Laboratory for the Conservation of Endangered Species (LaCONES), Indian Veterinary Research Institute (IVRI) , and Wildlife Institute of India (WII) to strengthen husbandry, reproductive, and genetic management.
5. Insurance populations & genetic management: An important strategic objective has been to develop demographically and genetically healthy ex-situ populations as "insurance" against wild population declines, following IUCN ex-situ management principles. These populations also underpin potential future reIntroductions or genetic augmentation of wild stocks (CZA, 2018; Conde et al., 2013).

Conservation Breeding Programmes worldwide: At a glance

Conservation breeding programmes across the world have evolved into strategically coordinated, science-driven interventions aimed at preventing extinction and supporting species recovery where in-situ conservation alone is insufficient (IUCN, 2014). These programmes focus on maintaining genetically diverse, demographically stable captive populations that can serve as long-term insurance, facilitate ecological research, and, under suitable conditions, contribute to population reinforcement or reIntroduction in line with IUCN principles.

At a global scale, conservation breeding is implemented through structured regional and international mechanisms such as Species Survival Plans (SSPs), European Endangered Species Programmes (EEPs), and Global Species Management Plans (GSMPs), coordinated by zoo and conservation networks including WAZA, AZA, and EAZA (WAZA, 2015). Successful applications extend across diverse taxa and ecological contexts, including the recovery of the Golden lion tamarin (*Leontopithecus rosalia*) in Brazil, the European bison (*Bison bonasus*) in Eastern Europe, the Whooping crane (*Grus americana*) in North America, and amphibian rescue programmes for species such as the Panamanian golden frog (*Atelopus zeteki*) (Conde et al., 2013). These examples highlight how conservation breeding can be adapted to species with differing life histories, social systems, and habitat requirements.

Contemporary programmes increasingly prioritize quality over quantity, emphasizing genetic integrity, behavioural competence, and ecological suitability (Frankham et al., 2017). Advances in reproductive biology, assisted breeding technologies, and genomic tools have improved the management of small and fragmented populations, while standardized global databases enable coordinated decision-making across institutions and countries. Importantly, conservation breeding is now widely recognized as most effective when embedded within broader conservation strategies that address habitat protection, threat reduction, and post-release monitoring, reinforcing its role as a dynamic and adaptive component of global biodiversity conservation.

Greens Zoological Rescue and Rehabilitation Centre and its conservation breeding initiatives

Greens Zoological Rescue and Rehabilitation Centre (GZRRC), Jamnagar, has emerged as a strategically significant ex-situ conservation institution in India, integrating wildlife rescue, rehabilitation, and scientifically planned conservation breeding programmes. Positioned within a broader national conservation framework, the Centre aligns its objectives with the Central Zoo Authority (CZA), IUCN guidelines, and global best practices in population management, genetics, and animal welfare. GZRRC's conservation breeding efforts focus on both charismatic megafauna and highly threatened taxa, reflecting a balanced approach that addresses ecological relevance, conservation urgency, and long-term recovery potential (CZA, 2018; IUCN/SSC, 2013).

One of the flagship initiatives at GZRRC is the conservation breeding and management of Cheetahs (*Acinonyx jubatus*), a species recently reintroduced to India after regional extinction. The Centre contributes to strengthening ex-situ population management capacity by developing specialised infrastructure, veterinary preparedness, and behavioural management protocols essential for maintaining genetically viable and behaviourally competent individuals. GZRRC has achieved notable success in the captive breeding of cheetahs, a species that has been known for its poor reproductive performance under ex-situ conditions. Worldwide, only a limited number of institutions have been able to breed cheetahs consistently in captivity (Marker & O'Brien, 2012), and within India, GZRRC stands among an exceptionally small group, being only the second facility in the country to record such success. The Centre currently maintains one of the largest captive cheetah populations globally, underscoring its advanced husbandry protocols, specialised enclosure design, and scientifically managed breeding practices. This achievement positions GZRRC as a significant contributor to global cheetah conservation efforts and as a potential regional hub for cheetah conservation breeding and research. These efforts support national cheetah recovery goals by providing a contingency population and advancing institutional expertise in managing large, wide-ranging carnivores under conservation breeding frameworks.

The White-rumped vulture (*Gyps bengalensis*) programme represents GZRRC's commitment to species recovery through targeted ex-situ interventions. Given the catastrophic population collapse of *Gyps* vultures in the Indian subcontinent, conservation breeding at GZRRC emphasizes biosecure housing, strict pharmaceutical control (notably Nonsteroidal Anti-Inflammatory Drugs (NSAID) exclusion), and genetic and demographic management to support long-term supplementation of wild populations. This initiative complements national vulture recovery action plans and reinforces the role of zoos as critical partners in averting species extinction (CZA, 2020; Prakash et al., 2012).

GZRRC has also undertaken conservation breeding of Spix's macaw (*Cyanopsitta spixii*), a globally iconic species once extinct in the wild. Participation in such a high-profile international conservation effort underscores the Centre's capacity to operate within complex global breeding networks, adhere to stringent biosecurity and genetic protocols, and contribute meaningfully to international species recovery programmes coordinated across continents (Juniper, 2002; WAZA, 2015).

The Centre's work with Asiatic lions (*Panthera leo persica*) focuses on maintaining a genetically healthy insurance population that complements in-situ conservation in the Gir landscape. Recognising the risks

associated with single-population endemism, GZRRC's ex-situ management emphasizes pedigree-based breeding, demographic stability, and disease risk mitigation, thereby supporting national objectives for long-term species resilience.

Similarly, conservation breeding and holding facilities for the Greater one-horned rhinoceros (*Rhinoceros unicornis*) at GZRRC contribute to safeguarding a species that, despite recent population recovery, remains vulnerable due to habitat fragmentation and stochastic threats. The Centre's approach integrates specialised enclosure design, nutritional management, and veterinary monitoring to ensure physical and reproductive fitness, reinforcing the role of ex-situ populations as insurance against unforeseen population declines in the wild (CZA, 2020).

GZRRC has established integrated scientific infrastructure to strengthen conservation breeding and long-term species management. The Conservation Genetics Laboratory supports genetic profiling, parentage analysis, and assessment of genetic diversity to inform scientifically managed breeding programmes and minimise inbreeding risks. The Disease Diagnostic Laboratory provides early detection and monitoring of infectious and non-infectious diseases, enabling preventive health care, biosecurity surveillance, and rapid response to disease outbreaks in captive populations. Complementing these facilities, the Frozen Zoo functions as a biorepository for cryopreserved genetic material, including gametes and tissues, ensuring long-term genetic security and supporting future assisted reproductive technologies and genetic restoration efforts. Together, these facilities enhance GZRRC's capacity to align conservation breeding programmes with global best practices (Frankham et al., 2017; WAZA, 2015).

Collectively, these programmes position GZRRC as a progressive conservation institution that transcends traditional zoo functions. By integrating rescue and rehabilitation with structured conservation breeding, genetic management, and alignment with national and global recovery strategies, GZRRC exemplifies the evolving role of modern zoos as scientifically driven conservation partners capable of supporting species survival in an era of accelerating biodiversity loss.

Concept of Population and Subspecies in conservation breeding and its relevance in the Indian zoo context

The concepts of population and subspecies form the biological foundation of conservation breeding programmes, as they represent the evolutionary and genetic structure within species. A population is generally defined as a group of interbreeding individuals occupying a particular geographic area and sharing a common gene pool, while a subspecies denotes a geographically or ecologically distinct population exhibiting consistent genetic, morphological, or behavioural differences. In conservation breeding, recognizing these units is essential to avoid genetic homogenization, preserve local adaptations, and maintain evolutionary potential, particularly when captive-bred individuals are intended for long-term management or potential reIntroduction.

Internationally, conservation breeding has moved from species-level aggregation to population- and lineage-based management. Tools such as studbooks, pedigree analyses, and molecular genetic assessments are employed to retain maximum genetic diversity, minimize inbreeding, and ensure demographic stability within defined population units. This approach is especially critical for species with fragmented distributions, where individual populations may represent unique evolutionary lineages adapted to specific ecological conditions.

In the Indian context, the population and subspecies concept is of particular relevance due to the country's pronounced biogeographic complexity and high levels of regional endemism. Historically, many captive populations in Indian zoos were assembled without adequate consideration of geographic origin or taxonomic status, resulting in mixed-lineage stocks with limited conservation value. This has posed significant challenges for scientifically credible conservation breeding and for any future release or reinforcement programmes.

Recent initiatives under the Central Zoo Authority increasingly emphasize population-based management, founder provenance documentation, and genetic characterization. The lion-tailed macaque (*Macaca silenus*), an endemic primate of the Western Ghats, exemplifies the need for population-level management,

as fragmented subpopulations exhibit genetic and demographic isolation. Similarly, the Capped langur (*Trachypithecus pileatus*), which shows regional variation across northeastern India and adjoining regions, requires careful lineage management to avoid admixture of distinct population units. For wide-ranging carnivores such as the Dhole (*Cuon alpinus*), population structuring across different landscapes highlights the importance of maintaining representative genetic stocks in captivity rather than treating the species as a single homogeneous unit. Small ungulates such as mouse deer (*Moschiola indica*), including recently recognized cryptic species and geographically restricted populations, further underscore the risks of taxonomic uncertainty and mixed-origin breeding in zoos.

Incorporating population and subspecies considerations into conservation breeding programmes enhances their scientific robustness and conservation relevance. In the Indian zoo context, such an approach ensures alignment between ex-situ populations and in-situ conservation priorities, supports species recovery planning, and safeguards the evolutionary distinctiveness of India's wildlife. Strengthening taxonomy, population genetics, and coordinated studbook management will remain critical to maximizing the long-term conservation value of breeding programmes in Indian zoos.

Integrating Genetics into Indian Conservation Breeding Programmes (CBP's)

Genetic management is a cornerstone of effective conservation breeding, as it determines the long-term viability, adaptability, and conservation value of captive populations. In small or fragmented populations typical of many threatened species in India, loss of genetic diversity, inbreeding depression, and accumulation of deleterious alleles pose significant risks if breeding is not guided by genetic principles. Integrating genetics into conservation breeding programmes therefore shifts the objective from short-term population increase to the maintenance of evolutionary potential and fitness.

Globally, conservation breeding programmes increasingly rely on population genetics, pedigree analysis, and molecular tools to guide founder selection, pairing decisions, and population structure management. Studbooks and software-based population modelling are used to maximize retention of genetic diversity and equalise founder representation across generations. Molecular techniques, including microsatellites, mitochondrial DNA, and more recently genome-wide markers, help clarify taxonomic status, identify subspecies, and resolve uncertainties in provenance, issues that are particularly relevant for taxa with wide or fragmented distributions.

In the Indian context, the integration of genetics into conservation breeding has gained momentum under the Central Zoo Authority's planned and coordinated programmes. Institutions such as the Laboratory for Conservation of Endangered Species (LaCONES), Hyderabad, play a key role in providing genetic characterization of founders, assessing relatedness, and supporting population management decisions. Genetic inputs are especially critical for species with limited founder numbers in captivity, such as the Lion-tailed macaque (*Macaca silenus*), Pygmy hog (*Porcula salvania*), Gharial (*Gavialis gangeticus*), and several threatened carnivores and small ungulates. For species like the Capped langur (*Trachypithecus pileatus*) and Indian mouse deer (*Moschiola indica*), genetic tools are indispensable for resolving population or species boundaries and avoiding inadvertent admixture in captive stocks.

Despite these advances, challenges remain in mainstreaming genetics across all Indian zoos. Incomplete pedigree records, historical mixing of lineages, limited sampling of wild populations, and shortages of trained geneticists and bioinformatic capacity constrain effective implementation. Addressing these gaps requires institutionalizing genetic screening at the inception of breeding programmes, strengthening linkages between zoos and research institutions, and building capacity among zoo biologists and veterinarians to interpret and apply genetic data.

Integrating genetics into Indian conservation breeding programmes enhances their scientific credibility and aligns ex-situ management with in-situ conservation goals. By ensuring that captive populations retain genetic diversity, population integrity, and adaptive potential, genetic-informed breeding strengthens the role of Indian zoos as strategic partners in national species recovery efforts and long-term biodiversity conservation.

Aligning with Global Practices

Aligning Indian conservation breeding programmes with global best practices is essential to ensure scientific credibility, genetic robustness, and long-term conservation relevance. Internationally, conservation breeding is guided by standardized frameworks developed by organizations such as the International Union for Conservation of Nature (IUCN), World Association of Zoos and Aquariums (WAZA), Association of Zoos and Aquariums (AZA), and European Association of Zoos and Aquaria (EAZA). These frameworks emphasize evidence-based decision-making, population-level management, genetic integrity, animal welfare, and strong integration between ex-situ and in-situ conservation efforts.

A defining feature of global practice is the use of coordinated regional or global species management programmes, supported by international studbooks and population management software, to maximize genetic diversity and demographic stability across institutions. Indian conservation breeding initiatives under the Central Zoo Authority increasingly reflect this approach through national studbook development, adoption of standardized record-keeping systems, and collaboration with international species specialists. Membership of Indian zoos in global data platforms such as ZIMS further facilitates transparency, data sharing, and alignment with international population management norms.

Global best practices also place strong emphasis on genetic and taxonomic clarity prior to initiating breeding programmes. The growing integration of molecular genetics in Indian programmes, through institutions such as LaCONES, mirrors international trends that use genetic tools to define management units, avoid hybridization, and guide founder selection. Additionally, the increasing focus on off-display conservation breeding centres, rather than public display-driven breeding, aligns Indian practice with international models that prioritize animal welfare and conservation outcomes over exhibition.

Finally, alignment with global practices underscores the importance of clearly defined objectives, rigorous monitoring, and adaptive management. ReIntroductions and population reinforcements are undertaken cautiously, following IUCN guidelines and preceded by habitat readiness assessments and threat mitigation. By progressively embedding these principles into policy and practice, Indian conservation breeding programmes are positioning themselves within the global conservation framework, enabling meaningful collaboration, knowledge exchange, and contribution to international species recovery efforts.

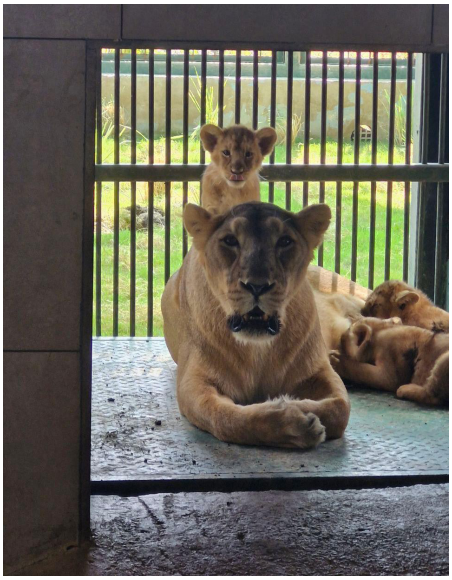
Need to Establish a Taxon Advisory Group (TAG) for the Indian Conservation Breeding Programme

The establishment of Taxon Advisory Groups (TAGs) is a globally accepted best practice in conservation breeding and species management, providing taxon-specific scientific guidance for planning, implementation, and evaluation of breeding programmes. TAGs function as expert bodies comprising taxonomists, field biologists, geneticists, veterinarians, zoo managers, and conservation practitioners who collectively ensure that conservation breeding decisions are evidence-based, coordinated, and aligned with both ex-situ and in-situ conservation priorities. In the Indian context, the creation of formal TAGs is a critical requirement to strengthen the scientific foundation and governance of national conservation breeding programmes.

Indian conservation breeding initiatives currently involve multiple species across diverse taxa, each with unique ecological, genetic, and management requirements. Without taxon-specific advisory mechanisms, there is a risk of inconsistent prioritization, inappropriate founder selection, lineage mixing, and suboptimal breeding outcomes. TAGs can address these gaps by defining conservation units (population/subspecies), setting breeding and demographic targets, identifying research priorities, and providing standardized guidance on enclosure design, nutrition, veterinary care, and behavioural management tailored to each taxonomic group.

The relevance of TAGs is particularly acute in India, where taxonomic uncertainty, cryptic species, and strong population structuring are common across many groups, including primates, carnivores, reptiles, amphibians, and small ungulates. TAGs would play a pivotal role in integrating taxonomy and genetics into conservation breeding by advising on provenance documentation, genetic screening protocols, and studbook management. They would also serve as a critical interface between field conservation and captive management, ensuring that ex-situ populations are aligned with in-situ recovery goals and potential reIntroduction landscapes.

Institutionally, TAGs would support the Central Zoo Authority by providing independent, expert-driven inputs into species prioritization, Conservation Breeding Management Plans (CBMPs), and periodic programme review. They would facilitate coordination among zoos, research institutions, and state wildlife authorities, while also enabling alignment with international specialist groups under the IUCN SSC and global zoo associations. By formalizing TAGs within the Indian conservation breeding framework, India can enhance scientific rigor, improve accountability, and ensure that limited resources are directed toward species and populations with the highest conservation value.



Overall, the establishment of Taxon Advisory Groups represents a strategic step toward institutionalizing adaptive, science-led conservation breeding in India. TAGs would not only improve breeding outcomes but also reinforce the role of Indian zoos as integral partners in national and global species recovery efforts.

The Way Forward

The future effectiveness of conservation breeding programmes in India will depend on strengthening scientific foundation, institutional coordination, and long-term policy commitment. Moving beyond species-level propagation toward population- and genetics-based management must become the norm across all participating zoos. This requires embedding genetics, taxonomy, and demographic planning into every stage of conservation breeding from species prioritization and founder selection to breeding, transfers, and potential reIntroductions.

A critical next step is the formal establishment and operationalization of Taxon Advisory Groups (TAGs) under the Central Zoo Authority, with clear mandates and integration into policy and decision-making. TAGs should function as permanent expert bodies guiding Conservation Breeding Management Plans, reviewing programme performance, and ensuring alignment between ex-situ populations and in-situ conservation priorities. Strengthening national studbooks, standardizing data management through platforms, and expanding genetic screening capacity will further enhance programme coherence and scientific rigor.

Equally important is sustained investment in capacity building. Training zoo biologists, veterinarians, and managers in population biology, genetics, and adaptive management will enable Indian zoos to transition fully into conservation-focused institutions. Stronger collaboration with state wildlife departments, protected area managers, academic institutions, and international conservation networks will be essential to ensure that conservation breeding complements habitat protection and threat mitigation efforts.

Finally, conservation breeding must be viewed as a dynamic, long-term conservation tool rather than a short-term intervention. Clear objectives, periodic evaluation, and adaptive management should guide programme evolution, with reIntroductions undertaken cautiously and strategically. By institutionalizing best practices, fostering scientific leadership, and reinforcing integration between in-situ and ex-situ conservation, India can position its conservation breeding programmes as a credible and impactful component of national and global biodiversity conservation efforts.

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