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CENTRAL ZOO AUTHORITY

PLANNED BREEDING PROGRAMS IN INDIAN ZOOS

ASSESSMENT & STRATEGIC ACTIONS

Planned breeding programs in Indian zoos

ASSESSMENT & STRATEGIC ACTIONS

Central Zoo Authority
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Planned Breeding Programs in Indian Zoos: Assessment and Strategic Actions (2024)

This report reflects the collaborative efforts of the committee constituted by the Central Zoo Authority to review and evaluate the state of conservation breeding programs in Indian zoos. The members Lakshminarasimha R., Hemanth Kumar, and P.C. Tyagi undertook the majority of the work related to data compilation and were exclusively responsible for the development of the review framework, method design, data analysis, and drafting of the report. Secretarial assistance was provided by Apurva Bandal and Dr. Natasha Vashisht. Dr. Nilofer Begum participated in two meetings and contributed to the deliberations. The committee carried out its functions under the oversight of Akanksha Mahajan, DIG (Hq.), CZA.

Disclaimer: The views and opinions expressed in this report represent the collective input of the committee members and do not necessarily reflect the official policy or position of the Central Zoo Authority (CZA) or all affiliated organizations. The data and recommendations are based on information available at the time of publication, and while every effort has been made to ensure accuracy, there may be discrepancies or gaps in the data due to limitations in reporting or availability. This report is intended to provide constructive insights into the management of conservation breeding programs. Zoos and other institutions referenced should interpret the findings and recommendations as a collaborative effort to enhance practices, and not as criticism of their operations. The CZA accepts no responsibility for any errors or omissions in the data, nor for any consequences arising from the interpretation or use of this report. Institutions are encouraged to contribute to further refinement of the data and methodologies to support ongoing and future conservation initiatives.

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FOREWORD

The conservation of India's rich and diverse wildlife is a responsibility that demands vision, collaboration, and adaptability. Zoos play an integral role in this endeavor by acting as centers of education, awareness, and research, while also serving as crucial repositories for the conservation of threatened species through ex situ efforts. Recognizing this, the Central Zoo Authority (CZA) has prioritized the implementation and review of conservation breeding programs as a cornerstone of its mission.

The present report represents a comprehensive review of the conservation breeding programs implemented across India's recognized zoos. Undertaken by a specially constituted committee, this review is both timely and significant. It identifies existing strengths, gaps, and areas for improvement, providing actionable recommendations to align these programs with evolving global practices and to ensure their efficacy in meeting national conservation goals.

The findings of this report underscore the need for a paradigm shift towards population-centric management, greater emphasis on genetic, demographic, and behavioral integrity, and stronger collaboration among zoos and international conservation partners. The recommendations, grounded in robust analysis, provide a roadmap for refining our conservation breeding programs and integrating them more effectively with in situ efforts.

I extend my gratitude to the committee members and all contributors for their diligent efforts in compiling this detailed review. Their work will serve as a foundation for driving meaningful reforms in our conservation breeding initiatives. It is my hope that the insights and recommendations contained herein will guide all stakeholders—zoo managers, conservationists, and policymakers—in our collective pursuit of safeguarding India's wildlife heritage for generations to come.

Place: New Delhi
Date: December 15, 2024

(Sanjay Kumar Shukla)

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Executive summary

Conservation breeding programs are a vital component of modern wildlife conservation, offering a critical safety net for species at risk of extinction due to habitat loss, climate change, and other anthropogenic pressures. These programs are designed to establish demographically viable and genetically-diverse captive populations that closely mirror their wild counterparts. By supporting species recovery through reintroduction into natural habitats, they bridge the gap between ex situ and in situ conservation efforts, complementing broader strategies aimed at ensuring the long-term survival of threatened species.

Global zoo collections house nearly 15% of threatened terrestrial vertebrates (Conde et al., 2011). However, the workflow needed to establish captive populations that serve both as *models* (for instance captive populations used for research or husbandry development for related species) and *representatives* (for instance captive populations reflecting the genetic and behavioral characteristics of their wild counterparts) of wild conspecifics often lacks coherence. The inherently complex nature of conservation breeding, which requires long-term commitment, substantial financial resources, and strategic planning, poses significant challenges to achieving species recovery goals. Therefore, conservation breeding is considered only a last resort, when other conservation options are insufficient or unfeasible. Studies (Bowkett, 2009; Rahbek, 1993; Snyder et al., 1996) have also highlighted potential pitfalls, including domestication, hybridization, administrative continuity and the diversion of resources away from in situ conservation.

A critical challenge for the global zoo community is managing threatened species as metapopulations. This entails moving individuals across borders and coordinating conservation efforts among zoos and other institutions at a national & international scale. Studies indicate that maintaining sustainable metapopulations of more than 250 individuals often requires collaboration among 20 or more zoos distributed across thousands of kilometers (Conde et al., 2013). Addressing these challenges demands robust collaboration, long-term strategies, and integration with broader conservation actions to ensure the success of conservation breeding programs and their contributions to global biodiversity conservation.

In India, the Central Zoo Authority (CZA) holds a legally mandated responsibility to oversee and guide national-level ex situ conservation efforts. This includes identifying *endangered* species and assigning recognized zoos to undertake captive breeding initiatives. The initiation of conservation breeding programs in the mid-2000s marked a significant milestone in the ex situ conservation framework of the country.

By 2011, 74 species across 43 zoos were identified to pilot this initiative, guided by comprehensive norms and guidelines specifically developed for this purpose (see Appendix C &

section 2). These 74 species, representing 16 orders, comprised 62% mammals, 32% birds, and 6% reptiles and amphibians. However, species representation within each order was uneven, with certain orders being overrepresented in terms of selected species. Species selection was, in general, guided by their conservation status at the time but was also influenced by states' interests in undertaking breeding programs and the presumed financial stability of *large zoos* assigned this responsibility.

Over time, 26 species (of the 74 identified) were prioritized (see Appendix A) to receive financial assistance for establishing dedicated facilities for conservation breeding & cover operational expenses. The conservation breeding programs envisioned the creation of a population of 250 pedigreed individuals per targeted species, with at least 100 individuals housed within Indian zoos as part of a globally managed population. This approach emphasized cooperative management of ex situ populations across zoos worldwide, focusing on establishing physically, genetically, and behaviorally competent populations. Such collaboration was intended to enhance the conservation value of these populations, ensuring alignment with broader conservation goals and supporting long-term species recovery efforts.

When initiated, these programs were broadly modelled on frameworks adopted by regional zoo associations worldwide, such as the *90/100 goal*, which aimed to maintain a desired level of genetic diversity over a long time-frame. However, much has changed since the inception of these programs, both in terms of:

Species conservation status: The status of several species that was initially selected has changed, necessitating reevaluation of their continuation or exclusion in breeding programs. Additionally, there may now be species that warrant inclusion in these programs, either due to emerging threats or newly identified conservation needs.

Conservation breeding practices: The captive breeding of endangered species for conservation purposes gained momentum in the 1970s, with frameworks like the *ark paradigm* proposing the retention of 90% genetic diversity over 100 years as a foundational goal. While this framework informed the CZA's adoption of planned breeding programs in the 2000s, modern advancements in conservation genetics, behavior, and population management have highlighted the need for updated approaches. Recent strategies emphasize integrating ex situ and in situ conservation through the IUCN's *One Plan Approach*, adopting collaborative metapopulation management across zoos, and utilizing advanced analytical tools like population viability analysis and adaptive management frameworks. These advancements address challenges such as small founder populations, poor genetic moni-

toring, and limited behavioral alignment of captive-bred animals with wild populations. To ensure long-term sustainability, planned breeding programs must adopt comprehensive conservation breeding plans, prioritize genetic and demographic health, and align with global conservation goals.

The need to adapt to these changes underscores the importance of periodic review and recalibration of conservation breeding initiatives to ensure their continued relevance and effectiveness in addressing contemporary conservation challenges. This flexibility is essential for maintaining the dynamic nature of conservation breeding and its ability to respond to new ecological, scientific, and societal priorities.

As over a decade has passed since the initiation of conservation breeding programs in Indian zoos, it was deemed necessary to conduct a systematic review to evaluate the progress, assess the efficacy of these programs, and formulate a roadmap for their future implementation. To address this, the CZA constituted a committee tasked with reviewing ongoing conservation breeding programs and providing a framework for their future operations, utilizing a high-level workflow as outlined in Appendix H, which was recommended by the Technical Committee in its 106th meeting and subsequently approved in the 40th meeting of the Central Zoo Authority. The committee was given a timeline of six months to complete its objectives, which were as follows:

1. Examine the status of ongoing conservation breeding programs under the CZA for the identified animal species in Indian zoos, as per CZA guidelines, norms, and regulations.
2. Review the current list of species identified for conservation breeding programs and recommend amendments to the list based on the current conservation scenario.
3. Evaluate the conservation breeding and satellite facilities of zoos for the selected species on a case-by-case basis.
4. Identify the constraints faced by zoos in achieving conservation breeding targets.
5. Review proposals received by the CZA from zoos across the country regarding conservation breeding programs.
6. Formulate or revise guidelines for conservation breeding programs for species identified by the CZA.

This review aligns with CZA's Vision Plan 2021–2031, which emphasized *Strengthening ex situ conservation of endangered native species guided by the National Zoo Policy and adoption of*

the One Plan Approach. The Vision Plan identified the following objectives related to conservation breeding:

1. **Review the Current Species List**: Reassess the species currently selected for planned conservation breeding programs using a standardized five-step decision process developed by the IUCN.
2. **Identify Additional Species**: Identify other endangered native species requiring ex situ conservation measures, using the five-step decision process.
3. **Revise Species List**: Based on this analysis, develop a revised list of endangered native species for conservation breeding programs to be implemented by CZA.
4. **Secure Financial Support**: Ensure financial assistance for implementing planned conservation breeding programs for endangered species.

Due to the committee's broad scope and the limited time-frame, not all assigned tasks could be completed. Specific limitations included:

→ **Data Submission**: Only a few zoos provided the required data for evaluation.

→ **Limited Physical Evaluations**: The committee could physically evaluate only a limited number of zoos due to time and logistical constraints.

→ **Reliance on Secondary Data**: Hence, much of the data was derived from secondary sources such as published inventories, studbooks, and other zoo reports.

As a result, the aspects addressed during the given time-frame included an assessment of ongoing conservation breeding programs (primarily conducted using secondary data), review of the species list currently identified for planned breeding, and, an evaluation of constraints in the implementation of these programs. Proposals for the initiation of new conservation breeding programs were not considered. It was deemed imprudent to evaluate new proposals while the existing framework and ongoing programs were under review. Once the current framework and programs have been comprehensively evaluated and revised, consequently new proposals can be assessed using the updated framework. The next logical step following this review would be to develop revised guidelines for conservation breeding programs. These guidelines should be a derivative of this comprehensive assessment and can only be formulated after the report is accepted by the CZA. This step will ensure that the revised guidelines are grounded in the findings of this systematic review and are aligned with the overarching goals of ex situ conservation in India.

This report puts-forward the assessment and strategic actions related to the planned breeding programs initiated by the CZA for select endangered species in recognized Indian zoos. It focuses on their implementation, challenges, and outcomes. This report is structured to include an introduction to the programs' objectives, an outline of the legal and regulatory frameworks, and an analysis of ongoing breeding efforts. This analysis examines population trends, challenges, and key findings, while highlighting advancements in captive species management. It concludes with actionable recommendations to strengthen breeding programs, complemented by annexures detailing species prioritization, population metrics, and evaluation framework and template for conservation breeding plan.

The key findings from the assessment of the ongoing planned breeding programs are presented Order-wise to reflect the variability in outcomes and challenges across taxonomic groups. Given the large number of species involved, this approach also enabled to understand patterns and issues specific to each order, derived from species-wise assessments described in section 3. The review of conservation breeding programs for endangered species across Indian zoos highlights notable variability in the implementation, management, and outcomes across taxonomic orders. Despite efforts to align these programs with the goals of conserving biodiversity and mitigating species extinction, significant gaps persist, ranging from program initiation to long-term population management.

Artiodactyla, Carnivora, and Galliformes represent some of the most diverse orders targeted for planned breeding, encompassing numerous species of conservation concern. However, the assessment reveals that many programs for these orders remain either uninitiated or poorly managed. For instance, taxonomic misidentification, as seen in the Alpine Musk Deer (*Moschus chrysogaster*) and Himalayan Serow (*Capricornis sumatraensis tahr*), has complicated population management, while limited founder diversity and a lack of systematic marking or pedigree tracking have undermined the genetic integrity of captive populations. While some successes, such as the Gaur (*Bos gaurus*) and Indian Chevrotain (*Moschiola indica*), demonstrate the potential for growth and recovery, they also expose broader challenges, including inconsistent record-keeping, uncoordinated transfers, and inadequate husbandry practices.

Among **Primates, Squamata, and Perissodactyla**, similar issues emerge. Many species face declining or stagnating populations due to low birth-to-death ratios, sub-optimal social management, and, poor genetic diversity. For species such as the King Cobra (*Ophiophagus hannah*) and Western Hoolock Gibbon (*Hoolock hoolock*), specialized ecological and behavioral needs remain unmet, limiting reproductive success and long-term viability. Habitat requirements and taxonomic ambiguities further constrain the management

of species like the Indian Wild Ass (*Equus hemionus khur*) and Himalayan Salamander (*Tylototriton himalayanus*), which have shown minimal growth despite decades of conservation efforts.

Orders with fewer species, including **Otidiformes, Accipitriformes, and Testudines**, demonstrate mixed progress. Conservation breeding programs for vultures, such as the White-rumped Vulture (*Gyps bengalensis*) and Indian Vulture (*Gyps indicus*), have achieved steady population growth. However, issues such as unsexed individuals and underutilized founder stocks highlight the need for enhanced genetic and demographic monitoring. Similarly, species like the Nicobar Pigeon (*Caloenas nicobarica*) under Columbiformes and the Red-crowned Roofed Turtle (*Batagur kachuga*) under Testudines exhibit small, stable populations but lack the systematic management necessary to enhance their conservation potential. In contrast, species like the Shaheen Falcon (*Falco peregrinus peregrinator*) and Malabar Pied Hornbill (*Anthracoceros coronatus*) have yet to see any structured conservation efforts, with populations primarily consisting of solitary or rescued individuals.

Among smaller orders such as **Rodentia, Pholidota, and Caudata**, populations are either stagnant or declining, often sustained only through wild acquisitions. The Indian Giant Squirrel (*Ratufa indica*) and Indian Pangolin (*Manis crassicaudata*) exemplify this trend, with minimal breeding success and poor genetic tracking compromising their conservation value. The Himalayan Salamander (*Tylototriton himalayanus*) stands out with its recent population growth, albeit within a single institution and without structured management, highlighting the potential for focused efforts even under resource constraints.

Across all orders, common challenges emerge: small populations, limited demographic and genetic monitoring, inadequate incorporation of species biology into husbandry practices, insufficient technical oversight at the proximate level, inadequate documentation of individual histories and lack of marking, inconsistent adherence to breeding protocols, and a lack of inter-institutional coordination. Programs frequently suffer from insufficient founder representation, incomplete pedigree tracking, and fragmented small stocks spread across multiple zoos with limited collaboration. While some species, such as the Dhole (*Cuon alpinus*), Asiatic Lion (*Panthera leo persica*), and Red Panda (*Ailurus fulgens*), have shown moderate success, these efforts are often offset by systemic gaps in management and oversight.

Between 2006 and 2011, approximately Rs. 10.81 crores (Rs. 108.1 million) was allocated to zoos for establishing these programs[1]. While financial assistance continues for some pro-

[1] https://cza.nic.in/uploads/documents/guidelines/english/g-12.pdf

grams, it is now primarily directed towards recurring expenses such as enclosure maintenance and development, remuneration for technical personnel, feeding costs, and other operational expenditures. Despite the reduced funding, the cumulative financial support remains significant. Information from the Annual Report of the CZA indicates an allocation of approximately Rs. 18.13 crores (Rs. 181.1 million) to zoos engaged in planned breeding programs between 2011 and 2021.

These findings underscore that while India's zoos have made notable progress in housing and breeding several endangered species, the overall effectiveness of conservation breeding programs is hindered by persistent foundational and operational challenges. Despite substantial financial investments significant gaps remain in program implementation. Addressing these issues will require not only enhanced funding allocation but also the establishment of comprehensive frameworks, adoption of standardized protocols, and improvements in genetic and demographic management practices. Strategic collaboration among zoos and integration of *ex situ* initiatives with *in situ* conservation strategies will be critical to maximizing the impact of these programs and ensuring the preservation of India's rich biodiversity.

In line with this the following is proposed (refer to subsection 5.2 for further details) –

→ *Taxonomic consistency* – Species included in conservation breeding programs must be accurately identified, to the subspecies level, taking into account geographically isolated populations and natural species variations. Hybridized specimens must be excluded to preserve genetic integrity. While the Wild Life (Protection) Act, 1972, provides legally recognized species names, these may occasionally differ from internationally accepted nomenclature due to ongoing taxonomic reclassifications. To address these discrepancies, the Central Zoo Authority (CZA) should adopt a standardized taxonomic framework aligned with global conventions and ensure that it is curated and regularly updated through ZOO-MIS. This system would serve as a definitive guide for zoos, ensuring consistency and scientific rigor in species identification and management.

→ *Rationalisation of species identified for planned breeding* – As highlighted earlier, it may not be prudent at this juncture to introduce new species and further expand the list of species identified for planned breeding programs. A formalized framework needs to be developed to guide such decisions.

Most existing assessments of species conservation status, particularly IUCN Red List assessments, are relatively outdated and represent global scenarios rather than country-specific contexts. India-specific conservation assessments are crucial to identify potential candidates for planned breeding programs accurately. While individual research papers

and reports provide valuable insights, compiling them into a cohesive and reliable species conservation assessment as part of this report was impractical.

Furthermore, species conservation efforts must align with *IUCN's revised Guidelines on the Use of Ex Situ Management for Species Conservation* (IUCN, 2014). These guidelines emphasize the five-step decision-making process designed to optimize the contribution of ex situ management to broader conservation goals.

For the species already identified, whether through ongoing programs or as candidates for planned breeding, this assessment offers a preliminary understanding of their sustainability and the necessity for program continuation or potential phase-out. However, the final rationalization of species can only be achieved following detailed evaluations on finer-scale parameters, including genetic viability, demographic trends, ecological relevance, and institutional capacity.

A subjective assessment of the sustainability of each program is presented in this report to serve as baseline for future work wherein species were categorised based on the following four scenarios (see section 5 for details):

1. *Scenario 1: No Program Initiated [Yellow]*
2. *Scenario 2: Persistent Small Populations and Limited Growth [Blue]*
3. *Scenario 3: Sub-optimal Demographic and Genetic Correlates [Green]*
4. *Scenario 4: Large Populations but Misaligned Conservation Priorities [Pink]*

→ *Financial Assistance* – During the initial phases of conservation breeding programs, the Central Zoo Authority (CZA) allocated substantial funding to zoos for establishing and operating these initiatives. However, over time, as CZA's overall funding has diminished, the financial support provided to zoos has also decreased, now being limited primarily to maintenance expenses. This reduction in financial assistance has had cascading effects on the implementation and sustainability of these programs.

There is a widespread perception among state governments and zoo authorities that conservation breeding is primarily funded by the CZA, leading to minimal financial allocation by the states themselves for these programs. Consequently, many programs face acute financial challenges, affecting critical aspects such as enclosure maintenance, the construction of new facilities to accommodate growing populations, and the incorporation of advancements in enclosure design. This stagnation in infrastructure development hinders the success and scalability of conservation breeding programs, compromising their effectiveness.

To ensure the continuation and success of these programs, increased financial support is essential. CZA should prioritize conservation breeding programs in its funding strategy and actively facilitate fund-raising efforts in accordance with government norms. Collaborative mechanisms, such as partnerships with national and international conservation organizations, corporate sponsorships, and grants, should also be explored to bridge funding gaps. Without adequate financial investment, these programs risk becoming stagnant and unable to achieve their intended conservation objectives. Prioritizing funding allocation to conservation breeding programs is imperative for their long-term sustainability and impact.

While the CZA should continue to facilitate financial support, including raising funds in accordance with government norms, greater ownership by state governments is critical. A shared financial responsibility model could be implemented, where states contribute a defined percentage of the required funding for these programs, ensuring they have a vested interest in the success of the initiatives.

→ *Objectivity in Future Actions and Adaptive Management* – The assessment highlights the need for structured, objective frameworks to guide the next phases of conservation breeding programs. Future actions should be rooted in long-term strategies and guided by an adaptive management approach, enabling flexibility and responsiveness to emerging challenges, opportunities, and new scientific insights.

For instance, the existence of infrastructure for certain species—developed at significant resource expense—should not unduly bias species selection or program prioritization. While infrastructure is an important asset, species selection should be guided by evidence-based criteria, including the species' conservation needs, ecological significance, and alignment with global best practices such as the IUCN's guidelines on ex situ management.

The focus should remain on achieving measurable conservation outcomes rather than being influenced by sunk costs or historical decisions. By fostering objectivity and incorporating adaptive management principles, programs can ensure resources are utilized effectively, priorities are regularly reassessed, and programs evolve in response to changing circumstances and conservation goals.

→ The categorization of species based on subjective assessments should be finalized through a more detailed, objective approach. This necessitates a species-wise evaluation of details to determine the appropriate course of action for each species. To achieve this, structured workshops (for instance those modeled on the basis of Integrated Collection

Assessment and Planning (ICAP) framework (Traylor-Holzer et al., 2019) or Conservation Needs Assessments[2]) should be conducted. These workshops, designed for identified zoo personnel (preferably biologists) from recognized zoos housing conservation breeding species, will employ the *One Plan Approach* and guide the development of long-term conservation breeding plans, following the format provided in Appendix D.

The workshops should be organized *Order*-wise, involving species experts, biologists, zoo managers, and veterinarians. They should preferably be led by a team familiar with the process, given its complexity, requiring substantial data assimilation and strategic planning for future actions.

→ These workshops should result in detailed 10-year conservation breeding plans, including financial projections. These plans will allow the Central Zoo Authority (CZA) to evaluate and secure the necessary funding to effectively sustain the breeding programs.

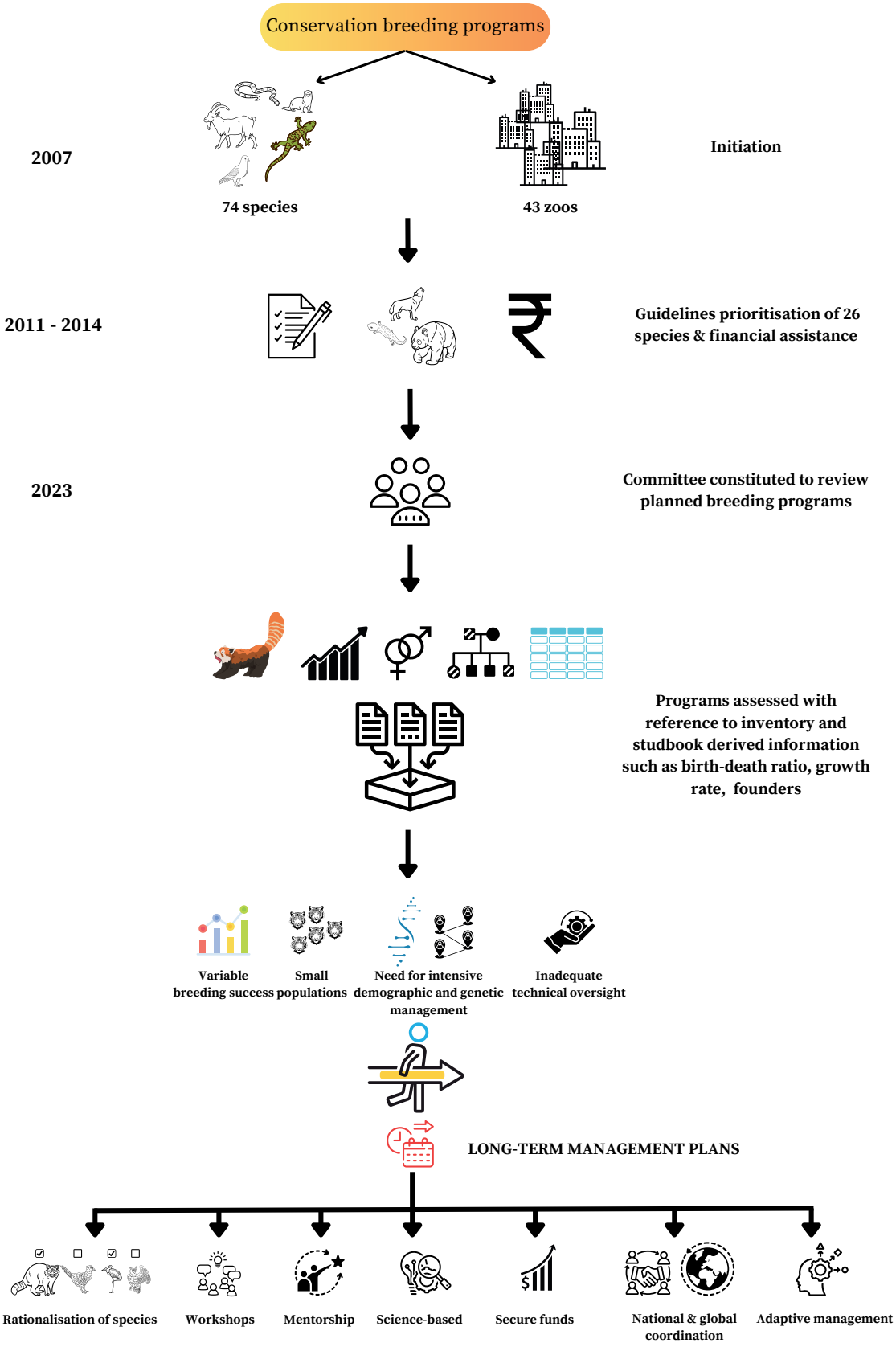
→ A mentorship framework is proposed to appoint species experts who will provide technical guidance and oversight throughout the planning and execution phases. This mentorship will be pivotal in addressing program-specific challenges and ensuring alignment with conservation objectives.

→ Proposed collaborations with international conservation bodies, including IUCN, will enhance access to global expertise, promote knowledge exchange, and refine the inclusion and exclusion criteria for species under planned breeding programs. These collaborations will also enable the organization of global workshops to incorporate cutting-edge conservation practices into Indian programs.

Conservation breeding programs, while critical, must be viewed as one component of a holistic conservation strategy that integrates habitat protection, restoration, and other in situ conservation measures. Through strategic prioritization, cooperative management, and global collaboration, these programs can effectively contribute to the preservation of threatened species.

[2]https://www.conservationneeds.org/

GRAPHICAL ABSTRACT



1 Introduction

One of the functions assigned to the Central Zoo Authority as per Section 38C of the Wild Life (Protection) Act, 1972 is –

> *(d) identify endangered species of wild animals for purposes of captive breeding and assigning responsibility in this regard to a zoo*;

Further, the Wild Life (Protection) Act, 1972, through an amendment in 2022, expanded the definition of *zoo* under Section 2(39) of the Wild Life (Protection) Act, 1972 –

> *'zoo' means an establishment, whether stationary or mobile, where captive animals are kept for exhibiting to the public or ex-situ conservation and includes a circus and off-exhibit facilities such as rescue centres and conservation breeding centres, but does not include an establishment of a licensed dealer in captive animals.*

This amendment which includes conservation breeding centres under the definition of zoos reflects the growing recognition of their role in ex-situ conservation efforts. By including these centers within the definition of a zoo, the Act brings them under its regulatory framework, ensuring that they operate under proper standards and contribute effectively to wildlife conservation.

In alignment to the statutory functions, the Central Zoo Authority (CZA) in its 4th meeting held in August 1992 established a committee dedicated to the identification of endangered native fauna suitable for conservation breeding in Indian zoos. Initially, 35 species of mammals, birds, and reptiles were identified for this purpose. Deliberations on the progress of this initiative took place during a CZA meeting in January 2005, resulting in the formation of a subcommittee dedicated to conservation breeding. The momentum built up to an international conference titled *India's Conservation Breeding Initiative* held in February 2008. One major outcome of this event was the formulation of general recommendations for effective conservation breeding strategies.

Recognizing the need for a standardized approach, the CZA's Technical Committee, in its 55th meeting in September 2010, advocated for the creation of an Expert Group on Conservation Breeding. This led to the development and adoption of guidelines for conservation breeding programs by December 2011. As part of this initiative, 74 native threatened fauna species were chosen for targeted breeding, with 43 recognised zoos designated to participate or coordinate these breeding efforts.

Further, in 2014, the CZA in an attempt to streamline efforts, shortlisted 26 high-priority endangered species (Appendix A) from the initial list of 74 species. Collaborations were established with various zoos and states, and conservation breeding programs for 23 species were

initiated. Furthermore, consultations with the scientific community and other stakeholders, played a pivotal role in establishing the criteria for this prioritization, thereby ensuring that the Conservation Breeding Programme remained scientifically robust and focused.

The formal initiation of these programs took place between 2007 and 2010. While a cursory review was conducted in 2014 (while prioritising species), more than a decade has since passed from the beginning of these breeding programs. Given the time elapsed, there was a proposition to systematically review and evaluate the progress and efficacy of these programs and to outline future directions. In line with this, based on the recommendations from the Technical Committee during its 106th meeting on 27/9/2022, the CZA Secretariat established a committee. This committee was tasked with reviewing the ongoing planned breeding programs, as detailed in the Office Order bearing Computer No: 156445 dated 23/6/2023 and reconstituted on 17/05/2024.

Conservation breeding facility for Western Tragopan (Tragopan melanocephalus) at Sarahan (Shimla), Himachal Pradesh, highlighting seasonal contrasts of dry summer and snow-covered winter, replicating the species' natural climatic conditions.

2 Extant statutory provisions and guidelines

The National Zoo Policy, 1998, underscores the primary objective of zoos to support and strengthen national biodiversity conservation efforts, with a focus on wild fauna. In line with this, paragraph 2.1.1 emphasizes the role of zoos in -

> *Supporting the conservation of endangered species by giving species, which have no chance of survival in wild, a last chance of survival through coordinated breeding under ex-situ conditions and raise stocks for rehabilitating them in wild as and when it is appropriate and desirable.*

As per Rule 2(c) of Recognition of Zoo Rules, 2009, a *Conservation Breeding Centre* is defined as –

> *the facility specially dedicated to planned conservation breeding of an endangered species of wildlife.*

and, Rule 2(f) of Recognition of Zoo Rules, 2009, defines *Endangered species* as -

> *species included in Schedule I and Schedule II of the Act.*

and, Rule 2(g) of Recognition of Zoo Rules, 2009, defines *Critically endangered species* as -

> *an endangered species whose total number in all the zoos in the country put together does not exceed 200.*

The relevant norms pertaining to the acquisition and transfer of animals by recognised zoos in the context of conservation breeding include, norm (6) under Rule 10 (9) which is -

> *The Central Zoo Authority shall assign the responsibility of conservation breeding of the identified critically endangered species to identified zoos having technical capabilities and housing facilities, preferably close to the distribution range of the species and every zoos shall help the identified zoos in implementing the breeding programme.*

and norm (9) under Rule 10(3) which is -

> *Any decision of the Central Zoo Authority about any animal being sent to a particular zoo for augmenting the number of founder animals for the conservation breeding programme of the species shall be binding on the concerned zoo.*

Further, the following guidelines have been formulated for guiding the conservation breeding programs coordinated by the Central Zoo Authority –

i) Guidelines for the establishment and scientific management of zoos in India – 2008[3]

ii) Guidelines/norms for conservation breeding programme of the Central Zoo Authority – 2011[4]

iii) Concept paper on In-situ ex-situ linkage -Conservation Breeding of Endangered Wild Animal Species in India – undated[5]

The *Guidelines for the establishment and scientific management of zoos in India* stipulates that conservation breeding of identified endangered species shall be taken up in India and the Central Zoo Authority shall coordinate conservation breeding programmes of identified critically endangered species in Indian Zoos at national level with following objectives –

i) Developing physically, genetically and behaviourally viable populations of healthy animals of identified species for the purpose of display in zoos;

ii) Developing physically, genetically and behaviourally viable populations of healthy animals to act as insurance and raise stock for rehabilitating them in wild as and when it is appropriate and desirable.

The overarching goal of the planned breeding programmes was -

> *...The target is to have atleast 250 pedigreed & physically, genetically and behaviourally competent individuals of each targeted species in the world in captivity of which at least 100 must be in India...*

To implement planned breeding programs, the CZA designated select zoos to undertake the breeding of identified species, assigning them either coordinating or participatory roles. Coordinating zoos, situated near the species' natural habitat, were tasked with establishing the initial stock from founder individuals and developing off-display facilities for the program. They received financial assistance for these efforts. Participating zoos, on the other hand, were responsible for maintaining satellite populations once sufficient numbers were bred at the coordinating zoos. They also played a crucial role in educating the public and raising awareness about the programs. The following aspects were specified for undertaking planned breeding programs -

[3] https://cza.nic.in/uploads/documents/guidelines/english/G-1.pdf
[4] https://cza.nic.in/uploads/documents/guidelines/english/g-12.pdf
[5] https://cza.nic.in/uploads/documents/CBP/concept%20paper.pdf

→ Breeding strategies should be devised to ensure that animals managed in conservation breeding program maintain an acceptable level of heterozygosity (or genetic variation) even up to the 10th generation.

→ Ideally, the breeding program should commence with around 25 founder animals. These founders should be unrelated, exhibit high genetic diversity, and preferably be of wild origin or have traceable lineage. Recognizing potential challenges, it's acknowledged that if 25 founders are not readily available due to constraints, the program can initiate with a smaller number. In such cases, it remains crucial to incorporate additional founders in the subsequent years, based on availability.

→ To maximize the retention of genetic diversity, efforts should be made to ensure equal representation of all founders in each generation. The program should strictly avoid interbreeding among the descendants of the same founder. This necessitates effective marking of each animal born within the program to track lineage and ensure they are bred with offspring of different founders. A consistent theme throughout the breeding strategy is to maintain even representation of all founders in the subsequent generations.

→ Surplus animals, which exceed the targeted numbers, can be displayed in zoos or introduced to the wild, following pilot projects that develop expertise in re-wilding processes.

→ Given that some loss of genetic diversity is expected with each successive generation, it's pivotal to achieve the target effective population in as few generations as possible. To this end, the program should ensure that every animal's reproductive potential is fully tapped, and no founder remains unproductive.

→ Before initiating the conservation breeding program, each potential founder animal must undergo rigorous physical health screenings. Ideally, these examinations should be supervised by the National Referral Centre. Stringent disease prevention measures must be established and adhered to without exceptions.

→ For assessments related to genetic health and reproductive potential, collaboration with LaCONES, Centre for Cell and Molecular Biology, Hyderabad is essential prior to integrating any founder animal into the breeding initiative. Should there be instances of breeding failures, comprehensive reproductive examinations are recommended. If deemed necessary, assisted reproduction techniques might be employed. The sequence of steps identified for planned breeding programme for critically endangered wild animal species in India in recognised zoos is provided in Appendix C.

Four-horned Antelope (Tetracerus quadricornis) at National Zoological Park, New Delhi.

3 Overview of ongoing planned breeding programs

3.1 Statement of the problem

The planned breeding programs were initiated by the CZA for 74 threatened Indian fauna and 43 zoos that were identified to initiate these programs. Of the 43, 29 zoos were assigned *coordinating* role entrusted to initiate breeding programs for 56 species. Additionally, 33 zoos were assigned *participating* role for 47 species (the higher number of participating zoos is attributed to some zoos holding dual roles as both coordinating and participating roles). No recognised zoos were designated to undertake the breeding of 14 species (see Appendix E).

This review represents a multi-faceted analysis of conservation breeding programs in India, designed to navigate the inherent challenges of limited data availability while providing meaningful insights. Ideally, comprehensive assessments require individual-level life-history data for all species. However, logistical constraints in accessing and compiling such detailed data necessitated the adoption of an alternative approach.

Data for this review was sourced through annual inventory records, studbooks (where available), and information provided by coordinating and participating zoos. Specifically, inventory data submitted by zoos between 2007 and 2021, studbook data updated between 2015 and 2022, and additional records spanning 2014 to 2024 obtained during committee proceedings were utilized. For a deeper understanding of trends for selected species, long-term inventory records from 1996 to 2020 were also analyzed, offering a broad perspective on species housed in Indian zoos over time.

Given this, parameters were selected to ensure uniformity across all species. This avoided discrepancies where some species might receive detailed scrutiny while others lacked adequate evaluation. Consequently, population-level parameters were prioritized, as individual-level data were not available for most species. While this approach is inherently less granular than individual-level analyses, it provides a robust foundation for a preliminary and high-level assessment.

Global assessments by regional associations, such as the European Association of Zoos and Aquaria (EAZA), often employ finer-scale parameters, including generation lengths, founder representation in breeding, and detailed pedigree tracking. These were not possible here due to the absence of comprehensive data. Nonetheless, the parameters used in this review offer a valuable index for evaluating the performance of conservation breeding programs and identifying areas for improvement.

The analysis addressed the following primary questions to provide a structured evaluation of the data:

1. What have been the population trends of species involved in the conservation breeding programs since their inception?
2. How do the birth-to-death ratios for each species compare across different zoos and across time?
3. What role have coordinating and participating zoos played in the population dynamics of the species?
4. What are the key drivers of population growth or decline (e.g., acquisitions, births, deaths, transfers) for each species within the breeding programs?
5. What is the proportion of species for which detailed pedigree or genetic records have been maintained, and how does this impact population management?

This structured analysis, while constrained by data limitations, provides actionable insights into the status and performance of conservation breeding programs in India. It offers a foundation for evidence-based decision-making and prioritization to refine these programs and enhance their effectiveness in conserving threatened species.

3.2 Results

The key findings from the analysis are summarised below:

i) The taxonomic composition and IUCN status of the 74 species identified for planned breeding are shown in Figure 1.

ii) The taxonomic categorization of these species is presented in Figure 2, which includes 16 orders represented across 29 families. Given the diversity of species, the results are organized by taxonomic order to provide an organised overview.

iii) Order *Artiodactyla*: This order has the highest representation among species identified for planned breeding by the CZA, encompassing six families (Bovidae, Cervidae, Moschidae, Platanistidae, Suidae, and Tragulidae) and including 17 species. The findings from the status review indicate the following –

→ No planned breeding programs have been initiated by any recognised zoo for **seven** species *viz.* Tibetan Antelope (*Pantholops hodgsonii*), Nilgiri Tahr (*Nilgiritragus hylocrius*), Ganges River Dolphin (*Platanista gangetica*), Wild Water Buffalo (*Bubalus*

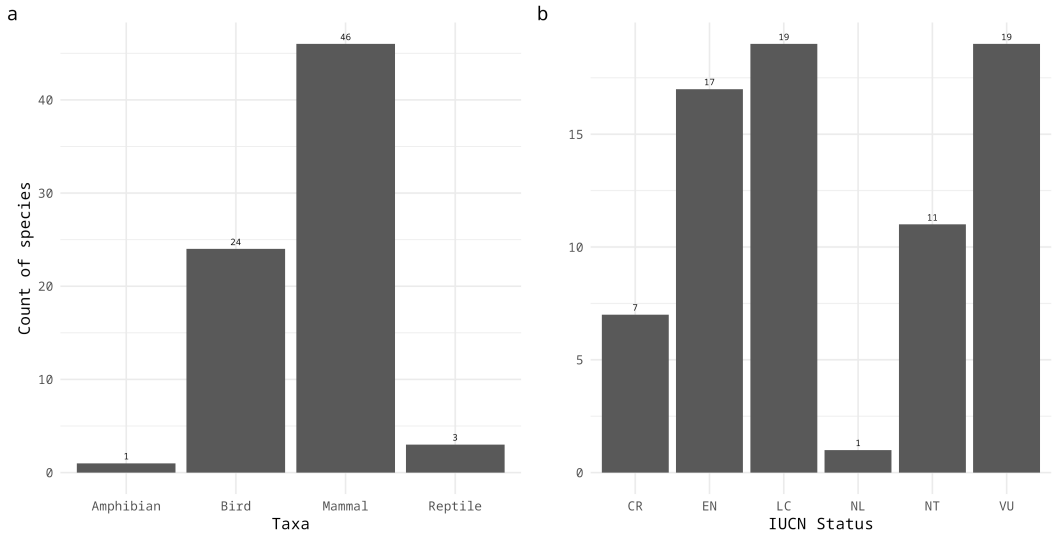


Figure 1: (a) Taxa-wise count of the species identified for planned breeding programs; (b) IUCN status of the species identified for planned breeding programs.

arnee), Pygmy Hog (*Porcula salvania*), Alpine Musk Deer (*Moschus chrysogaster*) and Hangul [Kashmiri Stag] (*Cervus hanglu hanglu*). However, it is pertinent to note that –

In the case of Wild Water Buffalo *Bubalus arnee*, the natural population of this endemic species is estimated to be 2,500 individuals, with a decreasing trend as per the 2016 IUCN assessment. This species is classified as *Endangered* and has no record of captive populations in Indian zoos. Further, the Government of Chhattisgarh is in the process of establishing a conservation breeding center at Barnawapara Wildlife Sanctuary with six wild-born (1.5 – An adult male-female pair and four female sub-adults) individuals captured from Manas National Park, Assam. Additionally, 13 presumed feral hybrid individuals (7 males, 6 females) housed at Udanti-Sitanadi Wildlife Sanctuary are excluded from breeding programs due to hybridization with domestic livestock.

In the case of Pygmy Hog *Porcula salvania*, the natural population is estimated to range between 100 and 250 individuals. Classified as *Endangered* by the IUCN in 2016, the species has only in sporadically housed in a few Indian zoos as small stocks. Further, a conservation program is currently underway in Assam, managed collaboratively by Aaranyak and the Government of Assam. The program involves conservation breeding and reintroduction. Following recent

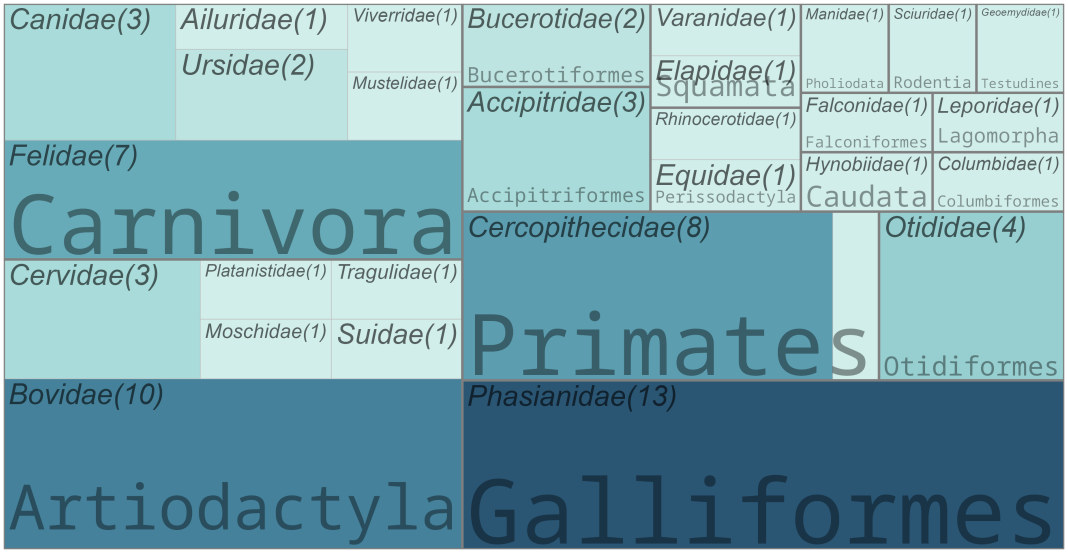


Figure 2: Taxonomic catergorisation of the species identified for planned breeding programs.

amendments to the Wild Life (Protection) Act, 1972, CZA recognition may eventually be required. While no data on captive stock is available, Aaranyak reports that 116 individuals have been released into the wild since 2008[6].

In the case of the Alpine Musk Deer (*M.chrysogaster*), no recent estimates of natural populations are available as per the IUCN which projects a decreasing trend based on a 2014 assessment. Classified as *Endangered*, this species has no record of captive populations in Indian zoos. This species is primarily found in the central to eastern Himalayas and identified for the planned breeding program. There has been a confusion in correctly distinguishing this species from the Himalayan Musk Deer (*Moschus leucogaster*), which is distributed from the western to eastern Himalayas. Due to their sympatric distribution, it is possible that zoos have misidentified these species. It appears that zoos in Himachal Pradesh have likely housed *M. leucogaster*, while those in Uttarakhand and West Bengal have likely housed *M. chrysogaster*. The historic population at the Musk Deer Breeding Centre near Chopta, Uttarakhand, and individuals housed at Padmaja Naidu Himalayan Zoological Park, Darjeeling, were probably *M. chrysogaster*. Currently, no recognized zoo reports holding captive stock of this species, suggesting that a breeding program was never initiated.

→ Himalayan Serow (*Capricornis sumatraensis tahr*) – No recent estimates of natu-

[6]https://aaranyak.org/division/threatened-species-recovery-programme/

ral populations are available as per the IUCN which projects a decreasing trend based on a 2020 assessment. Classified as *Endangered*, there is no record of this sub-species housed in Indian zoos. The species initially identified for the planned breeding program was Serow (*Nemorhaedus sumatraensis*), which has since been reclassified as *Capricornis sumatraensis*, commonly referred to as Mainland Serow, with Himalayan Serow (*Capricornis sumatraensis tahr*) recognized as a subspecies (Mori et al., 2019). Recognized zoos tend to incorrectly identify the species in alignment with updated phylogenetic information. For instance, the coordinating zoo, Assam State Zoo cum Botanical Gardens, reports housing *C. sumatraensis*, while the participating zoo, Manipur Zoological Garden, reports housing *C. crispus*, the Japanese Serow, which is not native to India. Accurate species identification is crucial before proceeding further, as other zoos have reported different species as well. Lady Hydari Park Animal Land (Meghalaya Zoo) reports holding *C. rubidus*, the Red Serow, and Himalayan Zoological Park, Sikkim, reports holding *C. tahr*. Given these discrepancies, it is not prudent to assume the species currently housed by these zoos without a systematic examination of the specimens to confirm their correct taxonomic identity. However, all reported Serow (*Capricornis spp.*) populations across coordinating, participating, and other zoos have remained small stocks, consisting of fewer than six individuals, often housed in just one or two zoos. Breeding has been sporadic, and these populations have not been managed in a sustainable manner.

→ The Blue Sheep (*Pseudois nayaur*), Himalayan Tahr (*Hemitragus jemlahicus*), and Markhor (*Capra falconeri*) are three species of montane ungulates that have been housed in two or three zoos. No recognized zoo has been assigned a coordinating or participating role for *C. falconeri*. The Blue Sheep, classified as *Least Concern* by the IUCN in 2014, has an estimated wild population of 47,000–414,000 individuals, and a mean captive population size of 8.3 individuals derived from 21 years of data, housed in an average of 1.9 zoos. The Markhor, categorized as *Near Threatened* in 2014, has an estimated wild population of 5,754 individuals with an increasing trend, and a mean captive population size of 4.8 individuals over 16 years, maintained in 1.5 zoos on average. The Himalayan Tahr, classified as *Near Threatened* by the IUCN in 2020 with a decreasing population trend, has no specific wild population estimates, but has a mean captive population size of 7.7 individuals over 27 years, housed in an average of 2 zoos.

P. nayaur and *H. jemlahicus* have been housed in the coordinating zoo, Himalayan Zoological Park, Sikkim, with fewer than three individuals since 2014. Other zoos,

including Padmaja Naidu Himalayan Zoological Park (Darjeeling), Himalayan Nature Park (Himachal Pradesh), and Pt. Govind Ballabh Pant High Altitude Zoo (Uttarakhand), have sporadically housed these species.

Overall, these species have been maintained as small collections, with fewer than 20 individuals at any given time over the past decade. The birth-to-death ratio for the period 2000–2022 in *P. nayaur*, *H. jemlahicus*, and *C. falconeri* stands at 1.45, 1.42, and 1, respectively. While both *P. nayaur* and *H. jemlahicus* show positive growth in the second half of the last decade, their populations remain small due to a limited number of founders, leading to slow growth. See Figure A-1 for details.

→ Barasingha [Swamp Deer] (*Rucervus duvaucelii*) – Initially classified as *Cervus duvaucelii* and *Cervus duvaucelii branderi*, the species was selected for planned breeding with Nawab Wajid Ali Shah Zoological Garden, Uttar Pradesh, as the coordinating zoo for *C. duvaucelii*, and Kanan Pendari Zoological Park, Chhattisgarh, for *C. d. branderi*. Since then, taxonomic revisions have reclassified the species into the genus Rucervus, with three recognized subspecies: *R. d. duvaucelii* (Wetland Barasingha), *R. d. branderi* (Hard-ground Barasingha), and *R. d. ranjitsinhii* (Eastern Barasingha). There are no specific estimates for the wild population of Barasingha, but the population trend is decreasing as per the 2015 IUCN assessment, which classifies the species as *Vulnerable*.

Based on 27 years of data, the mean captive population size of *R. duvaucelii* is 159.1 individuals, housed in an average of 13 zoos. Currently, more than 20 zoos, including the coordinating institutions, house *Rucervus duvaucelii*. However, these zoos do not distinguish between subspecies, resulting in a lack of subspecies-specific data. As a herd species, parentage or pedigree records have been poorly maintained, leading to a population with insufficient pedigree documentation. The taxonomic ambiguity, compounded by poor parentage records, has resulted in a population that, while numerically substantial, lacks essential information regarding its origins. Consequently, neither the genetic nor demographic health of the population can be reliably assessed. Furthermore, the founder or source populations have not been accurately identified or recorded.

Currently, there are over 300 individuals of *R. duvaucelii* in Indian zoos, with nearly 100 of these housed in the two coordinating zoos, namely Nawab Wajid Ali Shah Zoological Garden, Uttar Pradesh, and Kanan Pendari Zoological Park, Chhattisgarh. Notably, over 85 individuals are located at Nawab Wajid Ali Shah Zoological Garden. The birth-to-death ratio for the period 1995–2022 is approximately 1.75.

There is evidence to suggest that animals managed as part of the breeding program have been transferred between zoos without sufficient consideration of the potential impact on the population. Due to the lack of adequate records, it is difficult to assess the effects of these transfers. Nevertheless, it remains crucial to account for population changes resulting from transfers, as they significantly affect both the genetic diversity and demographic stability of the population.

A summary of the history of the captive stock is provided in Figure A-2.

→ Indian Gazelle [Chinkara] (*Gazella bennettii*) – Since the identification of *Gazella bennettii* for planned breeding, three subspecies have been recognized: the Deccan Chinkara (*G. b. bennettii*), Desert Chinkara (*G. b. christii*), and Salt Range Chinkara (*G. b. salinarum*). However, no zoo has been assigned a coordinating role for this species. The participating zoos include Sakkarbaug Zoo, Gujarat, Indroda Nature Park, Gujarat, and Mahendra Chaudhury Zoological Park, Punjab. The natural populations of this species is estimated to range between 50,000 and 70,000 individuals, with a decreasing trend noted in the 2016 IUCN assessment, which classifies the species as *Least Concern*.

Based on 27 years of data, the mean captive population size is 127.4 individuals, housed in an average of 20 zoos. Despite fluctuating population numbers over the years, there has been no significant growth in the captive population. This can be attributed to a low birth-to-death ratio of 0.748 for the period 2000–2022, indicating a declining or unsustainable population trend in captivity. In most cases, *G. bennettii* is managed primarily as a species for display or exchange, rather than with a focus on long-term conservation breeding goals. Most individuals are unmarked, making it difficult to trace their history in captivity. Founders have not been identified, and there are no comprehensive records or herdbooks documenting the population.

None of the zoos have identified the individuals to the subspecies level, and most of the animals are maintained in display enclosures without specific breeding facilities. Parentage records are not maintained, and the population is not pedigreed, which hinders effective management and genetic planning. Moreover, zoos have not been cautious about transferring animals between institutions, with transfers occurring largely without regard to the genetic or demographic health of the population.

A summary of the history of the captive stock is provided in Figure A-3.

→ Brow-antlered Deer (*Rucervus eldii spp.*) – The subspecies *R.e. eldii* has been identified for a planned breeding program, with Manipur Zoological Garden, Manipur,

designated as the coordinating zoo. Participating zoos include Alipore Zoological Garden, West Bengal, National Zoological Park, Delhi, and Assam State Zoo Botanical Garden, Assam.

Only one subspecies, *R. e. eldii*, is recognized and is presumably the one housed across Indian zoos. The population is severely inbred, having descended from a few unidentified founders. The population in the coordinating zoos has primarily been sourced from Sri Chamarajendra Zoological Gardens, Karnataka, and the National Zoological Park, New Delhi. There are no specific estimates for the wild population of Eld's Deer, but the population trend is decreasing as per the 2014 IUCN assessment, which classifies the species as *Endangered*.

Based on 27 years of data, the mean captive population size is 182 individuals, housed in an average of 15 zoos. There are no maintained pedigree, parentage, or individual histories, which greatly hinders the ability to monitor genetic diversity and manage the population effectively. The birth-to-death ratio for the period under study is 1.40, suggesting a population that is sustaining itself but without significant growth. Most individuals remain unmarked, making it difficult to track their history or movements between institutions. Additionally, no herdbook has been developed, further complicating the management of the population.

The subfigure(d) in Figure A-4 indicates a relatively stable population from 2000 to 2010, followed by a gradual increase in population. Post-2020, a significant spike in the population is observed, suggesting recent success in breeding programs or acquisitions. Despite the historical lack of pedigree management, the species' population appears to be increasing, particularly in recent years. However, the absence of genetic management tools like herdbooks and proper individual marking raises concerns about the long-term sustainability of this growth, given the inbred nature of the population.

A summary of the history of the captive stock is provided in Figure A-4.

→ Four-horned Antelope (*Tetracerus quadricornis*) – Since its identification for planned breeding, three subspecies have been recognized: *T. q. quadricornis*, *T. q. iodes*, and *T. q. subquadricornis*, which are predominantly distributed in central and eastern India, eastern India, and southern India, respectively. The wild population is estimated to range between 7,000 and 10,000 individuals, with a decreasing trend noted in the 2016 IUCN assessment, which classifies the species as *Vulnerable*.

Sakkarbaug Zoo, Gujarat is designated as the coordinating zoo, with Sri Venkateswara Zoological Park, Andhra Pradesh and Bhagwan Birsa Biological Park, Jharkhand as

participating zoo.

Over a span of 27 years, the mean captive population size for this species has been 149.6 individuals, housed in an average of 24 zoos. More than 200 individuals are housed in nearly 30 zoos; however, none are held at Bhagwan Birsa Biological Park, Ranchi. Despite high numbers, the birth-to-death ratio for the period under review is 0.823, reflecting a declining or unsustainable population trend. Nearly all the individauls remain on public display without a designated off-display breeding area. A significant management gap is the absence of a herdbook, parentage records, and individual histories compunded by the failure to identify individuals to the subspecies level in most zoos. This has resulted in a sizable but poorly managed population, with limited demographic and genetic data to evaluate the population's quality. Reports of numerous deaths in the latter half of the previous decade further underscore the pressing need for improved management practices to ensure the long-term viability of this species in captivity.

A summary of the history of the captive stock is provided in Figure A-5.

→ Gaur (*Bos gaurus*) – Sri Chamarajendra Zoological Gardens, Karnataka is assigned as the coordinating zoo for *B. gaurus* breeding program, with Arignar Anna Zoological Park, Tamil Nadu and Bondla Zoo, Goa as participating zoos. The wild population of this species is estimated to range between 6,000 and 21,000 individuals, with a decreasing population trend. Classified as *Vulnerable* by the IUCN in 2016.

More than 150 individuals are housed across nearly 20 zoos in India. The birth-death ratio is 1.81, indicating that for every death, there are approximately 1.81 births, suggesting a moderately growing population. However, only a few animals in the captive population have been marked, but no detailed pedigree or parentage records exist. This lack of documentation points to a high likelihood of inbreeding, with no identified founders, which presents significant concerns about genetic diversity.

While the population is increasing in number, it is largely unmanaged in terms of genetic and demographic oversight. The absence of comprehensive genetic monitoring, combined with the risks of inbreeding, raises concerns about the long-term sustainability of the population. Though some newer individuals have been marked, the majority of older animals remain unmarked, making it challenging to trace their histories or manage the population effectively across generations.

A summary of the history of the captive stock is provided in Figure A-6.

→ Indian Chevrotain (*Moschiola indica*) – Initially identified for planned breeding as

Tragulus meminna (Mouse Deer), the species has since been taxonomically reclassified as *Moschiola indica*, commonly known as the Indian Spotted Chevrotain or Indian Mouse Deer. Nehru Zoological Park, Telangana, is designated as the coordinating zoo, with Nandankanan Zoological Park, Odisha, as a participating zoo. There are no recent population estimates or trends available for this species; however, the recent anecdotal evidence from field surveys in India suggests that the natural populations are stable and increasing across its distribution range.

There are nearly 300 individuals housed across approximately 15 zoos, with around 250 of these individuals housed in the coordinating zoo and 25 in participating zoos. *M.indica* is a prolifically breeding species, with a birth-to-death ratio of 3.04, indicating rapid population growth. However, no detailed pedigree records have been maintained, which has resulted in a poorly pedigreed population despite successful breeding.

A studbook has been maintained for the species, covering approximately 58% of the population's known pedigree. All existing stock descends from 11 identified founders. Some individuals (>100) from the breeding program have been released into the wild, though the genetic and demographic impact of these releases is unclear. While the species' management has been relatively better compared to others, there has been a focus on promoting breeding without corresponding population management. This has led to prolific growth but with a lack of comprehensive pedigree tracking.

Although some animals are marked for identification, not all individuals are consistently marked, which limits the ability to trace individual histories. Additionally, animals from the breeding program have been transferred for exchange purposes, which may have been counterproductive to the genetic integrity of the population.

A summary of the history of the captive stock is provided in Figure A-7.

iv) Order *Carnivora*: This order includes six families (Ailuridae, Canidae, Felidae, Mustelidae, Ursidae, and Viverridae) that account for a total of 15 species. The findings from the status review indicate the following –

→ No breeding program has been initated by any recognised zoos for **six** species *viz.* Asiatic Cheetah (*Acinonyx jubatus venaticus*), Asiatic Golden Cat (*Catopuma temminckii*), Binturong (*Arctictis binturong*), Brown Bear (*Ursus arctos*), Sun Bear (*Helarctos malayanus*) and Rusty-spotted Cat (*Prionailurus rubiginosus*). It is pertinent to note that –

In the case of *C. temminckii* (Asiatic Golden Cat), identified for planned breeding with Assam State Zoo and Botanical Gardens as the coordinating zoo, the species has been consistently housed by the coordinating zoo and sporadically by other zoos in the eastern region, though only with a few individuals. Since its identification for planned breeding, the nominate subspecies *C. t. temminckii* was recognized, but zoos have reported no specific information about this subspecies. There are only two records of this species breeding in Indian zoos in the early 1990s and 2000s, but these could be misreported acquisitions recorded as births since the histories could not be traced. Other than these, there have been no known births, and most housed specimens appear to be rescue individuals. Thus, it is inferred that the breeding program never commenced.

For *P. rubiginosus* (Rusty-spotted Cat), Sanjay Gandhi National Park & Zoo in Maharashtra and Rajiv Gandhi Zoological Park in Maharashtra were designated as coordinating and participating zoos, respectively. The coordinating zoo reported 9 births in the early 2000s, with no subsequent births. Between 1998 and 2022, 22 deaths were reported. The population has largely been maintained at the coordinating zoo, with occasional rescued specimens received by other zoos. Fewer than 10 animals have been housed in captivity in the history of this species, leading to the inference that no breeding program was ever effectively initiated.

In the case of *A. binturong* (Binturong), Sepahijala Zoological Park was identified as the coordinating zoo, with Assam State Zoo and Botanical Gardens, Assam, and Aizawl Zoo, Mizoram, as participating zoos. Fewer than 15 individuals have been housed in four or fewer zoos, and over the last decade, numbers have remained below 10. The species has been sporadically housed, mostly with rescued specimens. Breeding has been sporadic, with a birth-to-death ratio of 0.3. The coordinating zoo has never bred the species. Most animals have been housed in other zoos as pairs or single individuals for display purposes only, indicating that no planned breeding program was ever initiated.

For *H. malayanus* (Sun Bear), Aizawl Zoo in Mizoram was designated as the coordinating zoo, with Assam State Zoo and Botanical Gardens as the participating zoo. Only a few animals have been sporadically housed in the coordinating and participating zoos, with fewer than five individuals housed in recognized zoos at any given time. The species has never bred in captivity, and systematic records have not been maintained. It is inferred that no planned breeding

program was ever initiated.

For *U. arctos* (Brown Bear), it is likely that the program targeted the Indian subspecies *U. a. isabellinus*. The designated coordinating zoo, Himalayan Nature Park in Himachal Pradesh, has housed around 2–3 individuals since 2004. While there have been four breeding events, they were sporadic and not sustained, and several deaths occurred, rendering these births ineffective from the perspective of population development. There is no dedicated breeding enclosure, and all animals have always been housed in display enclosures. Based on this information, it is reasonable to conclude that no systematic attempts were made to initiate a structured breeding program for this species.

→ Asiatic Lion (*Panthera leo persica*) – *P.l. persica* has been identified for a planned breeding program, with Sakkarbaug Zoo in Gujarat designated as the coordinating zoo. The participating zoos include Nehru Zoological Park (Telangana), Van Vihar National Park Zoo (Madhya Pradesh), National Zoological Park (Delhi), and Rajkot Municipal Zoo (Gujarat). There are no specific estimates for the wild population of the endemic Asiatic Lion, but the population trend is stable as per the 2008 IUCN assessment, which classifies the species as *Endangered*.

More than 250 individuals are housed across recognised zoos, with over 80 lions at the coordinating zoo and 10–20 individuals in each participating zoo. The male-to-female sex ratio is 71.8, indicating a female-biased population, which could benefit breeding efforts if managed effectively. As seen in subfigure (d) of Figure A-8, there has been an increase in both births and deaths toward the end of the observed period. However, this increase is accompanied by a rise in acquisitions, and the low birth-to-death ratio indicates a lack of intrinsic population growth. This trend suggests that the population's stability is largely dependent on external acquisitions rather than natural reproduction within the captive population.

The birth-to-death ratio is 0.967, suggesting that births are almost equivalent to deaths, which reflects minimal intrinsic growth in the population. This ratio implies that without active management or an increase in births, the population may not sustain itself in the long term.

There are African lions, hybrids, and Asiatic lions in Indian zoos. Unfortunately, hybridization has occurred across several zoo populations, primarily due to a lack of breeding records and uncontrolled transfers between institutions. Some zoos have also shifted between African, hybrid, and Asiatic lions without proper genetic information, resulting in compromised genetic integrity within the captive Asiatic

Lion population. This situation underscores an urgent need for better management practices and genetic monitoring.

Moreover, several rescued specimens have been added to the captive stock at the coordinating zoo without comprehensive documentation, which further complicates record-keeping and population management. Also, a studbook for the Asiatic Lion exists; however, it is rarely integrated into population management practices and has not been updated in a long time. The information within the studbook is not systematically available, making it challenging to keep records current and hindering effective genetic and demographic management of the population.

A summary of the history of the captive stock is provided in Figure A-8.

→ Bengal Tiger (*Panthera tigris tigris*) – *P.t. tigris* has been identified for planned breeding program, with Van Vihar National Park Zoo in Madhya Pradesh designated as the coordinating zoo. The participating zoos include National Zoological Park (Delhi), Nehru Zoological Park (Telangana), Nandankanan Zoological Park (Odisha), Mahendra Chaudhury Zoological Park (Punjab), and Arignar Anna Zoological Park (Tamil Nadu). The wild population is estimated to range between 2,608 and 3,905 individuals, with a decreasing population trend and classified as *Endangered* by the IUCN in 2021.

Close to 300 individuals are housed in around 50 recognised zoos. However, fewer than 20 individuals are present in the coordinating and participating zoos. The birth-to-death ratio is 0.811, suggesting that births are insufficient to offset deaths, which could lead to a decline if external additions were not consistently supplementing the population. The male-to-female sex ratio is 90.3, indicating a slight male bias.

A key issue is the frequent addition of rescued tigers to the captive population, which, although valuable for conservation, complicates genetic management due to the lack of comprehensive pedigree information. The inclusion of rescued animals without proper genetic tracking poses a threat to the genetic integrity of the captive population.

Additionally, the presence of leucistic and other color morphs within captive populations raises concerns. Currently, there is no clear policy in India regarding the breeding of these morphs, which hold little conservation value. The deliberate breeding of leucistic tigers with normal morphs to increase leucistic offspring undermines conservation objectives by compromising genetic diversity. A formal policy on the management of color morphs in breeding programs is urgently needed.

One of the major challenges is the lack of reliable pedigree management across Indian zoos. Although a studbook for the Bengal Tiger exists, it is rarely integrated into population management practices and has not been updated in a long time. Furthermore, the information within the studbook is not systematically accessible, making it difficult to keep records current and to manage the population effectively. The absence of reliable pedigree data is exacerbated by inconsistent practices, such as breeding leucistic tigers. A thorough genetic assessment of the captive tiger population is crucial to address these gaps and improve management practices.

As indicated in subfigure (d) of Figure A-9, there has been an increase in acquisitions, particularly in the latter half of the last decade. This acquisition trend, along with the stable population size despite the low birth-to-death ratio, suggests that regular additions are sustaining the population.

Given the success of wild-to-wild translocations in restoring tiger populations in the wild, captive breeding for reintroduction may not be necessary. Conservation goals for the captive Bengal Tiger program should be reevaluated to focus on broader in-situ strategies that align with successful conservation efforts in natural habitats.

Moreover, most zoos lack dedicated off-display areas for Bengal Tigers, which limits the ability to manage and monitor the population effectively. The uniform population sizes across coordinating and participating zoos reflect the need for a more strategic approach in the distribution and management of these tigers within the breeding program.

A summary of the history of the captive stock is provided in Figure A-9.

→ Clouded Leopard (*Neofelis nebulosa*) – This species was identified for a planned breeding program with Sepahijala Zoological Park in Tripura designated as the coordinating zoo, and Assam State Zoo-cum-Botanical Garden in Assam as the participating zoo. The wild population is estimated to range between 3,700 and 5,580 individuals, with a decreasing population trend and classified as *Vulnerable* by the IUCN in 2020.

The population has remained small, with fewer than 25 individuals across all zoos. The coordinating zoo currently houses most of the individuals, with approximately 10–15 animals, while the participating zoo has only housed individuals historically. Overall, the species has been housed in 5–6 zoos, including both coordinating and participating institutions.

The population has rarely shown growth and, in fact, has fluctuated and declined

over the past decade. The birth-to-death ratio is 0.590, indicating that deaths have consistently outpaced births, limiting population growth. Additionally, the male-to-female sex ratio is 173, signifying a significant male bias, which may further hinder successful breeding outcomes.

Some breeding activity occurred in the early part of the last decade, but it has not substantially contributed to population growth. Sporadic breeding efforts have been observed, yet higher death rates have largely offset these gains, leading to a variable growth and a small population.

A summary of the history of the captive stock is provided in Figure A-10.

→ Asiatic Wild Dog [Dhole] (*Cuon alpinus*) – *C. alpinus* was identified for a planned breeding program, with Indira Gandhi Zoological Park in Andhra Pradesh designated as the coordinating zoo and Arignar Anna Zoological Park in Tamil Nadu as a participating zoo. The wild population is estimated to range between 949 and 2,215 individuals, with a decreasing population trend and classified as *Endangered* by the IUCN in 2015.

The mean captive population is 40 individuals, derived from 27 years of data, maintained in an average of six zoos. The species is housed in fewer than 10 zoos across India, with a total population of approximately 120 individuals. The coordinating zoo has maintained around 20 individuals over the years, though there has been significant growth in the last decade, resulting in a population of over 40 individuals. The male-to-female sex ratio is 102, indicating a balanced population in terms of sex distribution. The birth-to-death ratio is 1.67, suggesting that births significantly exceed deaths, resulting in the observed population increase.

As shown in subfigure (d) of Figure A-11, there has been a notable increase in births during the latter half of the past decade, contributing to the recent population growth. However, a critical issue with this population is the limited number of founding animals & consequently low founder diversity. The majority of the current population is descended from only a few individuals (less than five), which may impact the long-term viability of the breeding program.

→ *Canis lupus sp.* – Both subspecies of *Canis lupus* occurring in India, namely the Indian Grey Wolf (*C. l. pallipes*) and the Tibetan Grey Wolf (*C. l. chanco*), were initially listed under different taxonomic names (*C. himalayensis* and *C. lupus* respectively), but have since been reclassified as per current taxonomy. Previously, no subspecies were specified; however, they are now recognized as *C. l. pallipes* and *C. l. chanco*.

For *C. l. pallipes*, Sakkarbaug Zoo in Gujarat has been designated as the coordinating zoo, with no participating zoos assigned. For *C. l. chanco*, Padmaja Naidu Himalayan Zoological Park in West Bengal is the coordinating zoo, while Himalayan Nature Park (Himachal Pradesh), Pt. Govind Ballabh Pant High Altitude Zoo (Uttarakhand), and Himalayan Zoological Park (Sikkim) are participating zoos.

C.l. pallipes – The population of *C. l. pallipes* has nearly tripled over the past two decades, increasing from around 50 to over 150 individuals. The coordinating zoo, Sakkarbaug, houses over 60 individuals (approximately 40% of the total population), resulting from prolific breeding in the last decade. However, it is likely that the founders are limited, leading to an inbred population. The coordinating zoo's population remained below 20 individuals for most of the time, but in the last 5–6 years, it has nearly tripled. This suggests that breeding may be inconsistent and could be a result of a few over-represented breeding individuals. Due to the lack of systematic records, it is challenging to fully understand the dynamics. The overall birth-to-death ratio is 1.34, indicating a growing population, while the male-to-female sex ratio is 118, suggesting a slight male bias. Summary shown in Figure A-12

C.l. chanco – The population of *C. l. chanco* is fewer than 25 individuals, housed in four or fewer zoos. This population is declining, with few births, an aging population, and high mortality rates. The male-to-female sex ratio is 72.1, indicating a significant female bias, while the birth-to-death ratio is 0.692, pointing to a population in decline. Summary shown in Figure A-13

→ Red Panda (*Ailurus fulgens*) – *A. fulgens* has been identified for a planned breeding program, with Padmaja Naidu Himalayan Zoological Park in West Bengal designated as the coordinating zoo and Himalayan Zoological Park in Sikkim as the participating zoo. There is an ongoing consideration to treat the two taxa within Ailuridae, *Ailurus fulgens fulgens* (Himalayan Red Panda) and *Ailurus fulgens styani* (Chinese Red Panda), as separate species, with the former being the focus of conservation efforts in India.

Over the past two decades, the population has grown from 10 to 30 individuals, with very few acquisitions. The birth-to-death ratio stands at 1.45, suggesting that births have contributed significantly to population growth, as indicated in subfigure (d) of Figure A-14. However, the male-to-female sex ratio is 114, reflecting a slight male bias. Breeding activity is confined to the coordinating zoo, with no breeding occurring at the participating zoo. The breeding program largely relies on a few

individuals, with no intake of additional founders. Consequently, founder diversity and overall genetic diversity are likely limited. Although a studbook exists, its recommendations are not fully implemented, as breeding remains confined to a small number of individuals within a single institution, and no transfers between zoos occur.

Attempts to acquire individuals as part of the Global Species Management Plan (GSMP) have not been successful. Experimental reintroduction efforts have been undertaken, but these have met with limited success, as mortality rates among released individuals have been higher than anticipated. Achieving a self-sustaining population in the wild will likely require further time and more refined reintroduction techniques.

A summary of the history of the captive stock is provided in Figure A-14.

→ Smooth-coated Otter (*Lutrogale perspicillata*) – *L. perspicillata* has been identified for a planned breeding program, with Kamla Nehru Zoological Garden in Ahmedabad designated as the coordinating zoo. No participating zoos have been assigned.

The species has been sporadically kept and bred at the coordinating zoo. However, Dr. Shyamaprasad Mukharjee Zoological Garden in Surat (which is neither coordinating or participating) has shown a more pronounced breeding history, albeit limited in scale, with over 15 individuals currently housed and hence has been used as a special case for comparison only. In total, around 25 individuals are held in captivity across 6–7 zoos. Systematic records and pedigree management are lacking, and breeding has occurred largely without structured oversight. It is likely that a few individuals from the original stock adapted well to captivity at Shyamaprasad Mukharjee Zoological Garden, leading to successful breeding as an exception. Breeding records indicate that animals are often bred and exchanged without a coordinated breeding strategy, potentially impacting the genetic health of the population. The male-to-female sex ratio is 141, indicating a male-biased population, while the birth-to-death ratio is 0.812, suggesting that deaths have outpaced births over time. This low birth-to-death ratio may hinder sustainable population growth.

A summary of the history of the captive stock is provided in Figure A-15.

→ Snow Leopard (*Panthera uncia*) – *P. uncia* has been identified for a planned breeding program, with Padmaja Naidu Himalayan Zoological Park in West Bengal as the coordinating zoo. The participating zoos include Himalayan Nature Park (Himachal Pradesh), Pt. Govind Ballabh Pant High Altitude Zoo (Uttarakhand), and Himalayan

Zoological Park (Sikkim).

Over the past two decades, the captive population has generally remained around 10 individuals, with a brief increase to approximately 15 individuals in the last decade. Breeding has been sporadic, with some individuals disproportionately represented due to uneven breeding efforts, which has resulted in over-representation of certain lineages. Additionally, the pedigree information is only partially known, creating management challenges in terms of genetic diversity. The birth-to-death ratio stands at 0.945, suggesting a slight decline in population over time. The male-to-female sex ratio is 81.43, indicating a female-biased population, which may affect future breeding potential.

Notably, only the coordinating zoo actively engages in the planned breeding of this species, with very few acquisitions recorded over the years. Consequently, the population dynamics are largely regulated by intrinsic factors, driven by births and deaths rather than external additions.

A summary of the history and status of the captive population is provided in Figure A-16.

v) Order *Galliformes*: This order is represented solely by the Phasianidae family, which includes 13 species. The findings from the status review indicate the following –

→ Four species, namely the Blood Pheasant (*Ithaginis cruentus*), Hume's Pheasant (*Syrmaticus humiae*), Sclater's Monal (*Lophophorus sclateri*), and Tibetan Eared-pheasant (*Crossoptilon harmani*), have not been housed in any recognized zoo to date, and consequently, no breeding programs have been initiated for these species.

→ Red Junglefowl (*Gallus gallus*) – There are no specific estimates for the wild population of the Red Jungle Fowl, but the population trend is decreasing as per the 2024 IUCN assessment, which classifies the species as *Least Concern*. This is the most represented species within this order, with over 400 individuals distributed across nearly 50 zoos. The species exhibits a birth-to-death ratio of 1.67, indicative of population growth. However, the male-to-female sex ratio is 86.7, suggesting a female-biased population.

Currently, there is no recognized coordinating zoo for the Red Junglefowl, although the National Zoological Park in New Delhi and Aizawl Zoo have been designated as participating zoos. There are no systematic records of the species' breeding history in captivity, and lineage information is lacking.

Of particular concern is the potential incorporation of hybridised stock into the breeding population, which could have compromise the genetic integrity of the captive stock. Despite prolific breeding, the lack of parentage records, random breeding practices, unplanned transfers, and potential hybridization limit the conservation value of the current population.

→ Blyth's Tragopan (*Tragopan blythii*) – This species is housed exclusively at a single breeding center in Kohima, which operates as a satellite facility for Nagaland Zoological Park. Since the initiation of the breeding program, the majority of acquisitions have been wild-born individuals, primarily rescued birds, with the intention of establishing a breeding population.

Of the 34 wild-origin birds brought into the facility, only three have successfully bred and produced offspring. Currently, around 15 birds are housed in the facility, originating from a limited number of wild founders, which likely results in low genetic diversity. The population is still in its initial founding phase, and efforts are ongoing to establish a viable breeding population with a more stable genetic base.

→ Seven species in this order, namely the Grey Peacock-pheasant (*Polyplectron bicalcaratum*), Satyr Tragopan (*Tragopan satyra*), Temminck's Tragopan (*Tragopan temminckii*), Himalayan Monal (*Lophophorus impejanus*), Western Tragopan (*Tragopan melanocephalus*), Cheer Pheasant (*Catreus wallichii*), and Grey Junglefowl (*Gallus sonneratii*) have been housed intermittently in coordinating and participating zoos and have shown sporadic breeding success.

Most of these species are maintained in small collections of fewer than 50 individuals, with *P. bicalcaratum* being a notable exception (see Figure A-17). However, *P. bicalcaratum* exemplifies the challenges species face when failing to adapt to captivity, likely due to sub-optimal breeding practices and poor husbandry. This species was primarily housed at the Alipore Zoological Garden, a participating zoo, while Assam State Zoo served as the coordinating zoo, with Padmaja Naidu Himalayan Zoological Park as another participating zoo. The population of *P. bicalcaratum* declined from over 70 individuals to just five males in recent years, with a birth-death ratio of 0.671 (see Figure A-18).

T. melanocephalus is managed intensively at Sarahan Pheasantry, the designated coordinating zoo. Approximately 50 individuals, all descended from an initial founder population of eight, are housed there. A studbook is actively maintained, and its recommendations are effectively integrated into the management of the captive population. However, challenges related to the small pop-

ulation size and limited genetic diversity persist.

C. wallichii is a species with prolific breeding success; however, it too suffers from limited founder diversity, and breeding success remains variable. Both *C. wallichii* and *T. melanocephalus* are part of ongoing experimental reintroduction programs.

G. sonneratii has exhibited substantial population growth, though this species is derived from around 10 individuals sourced from the same location, resulting in limited founder diversity from the outset.

A major issue affecting breeding success in most captive pheasant populations is the lack of natural parental care. Many hens fail to incubate eggs or rear chicks naturally, resulting in high chick mortality or hand-rearing. Hand-rearing, however, can compromise the conservation value of these programs by producing individuals that may not fully represent the behaviors and adaptations of their wild counterparts. This challenge has been effectively addressed in *T. melanocephalus* through long-term scientific management that incorporates ecological and behavioral requirements into captive husbandry practices. The limited population sizes of these species in captivity, coupled with their extended time in captivity with low population development (over a decade or more since identification for planned breeding), suggest that further detailed analysis may not yield additional insights at this stage (see Table 1 for descriptive metrics of select pheasant species).

Species	**Median population size**	**Range**	**Birth-death ratio**
Polyplectron bicalcaratum	54	5–75	0.67
Tragopan satyra	3	0–6	0.21
Tragopan temminckii	7.5	0–24	1.33
Lophophorus impejanus	27	3–37	0.61
Tragopan melanocephalus	17	2–45	1.72
Catreus wallichii	33	6–92	1.57
Gallus sonneratii	38	7–92	1.08

Table 1: Comparative population metrics of threatened pheasants identified for planned breeding for the period 1995–2022.

vi) Order *Primates*: This order comprises two families (Cercopithecidae and Hylobatidae) and includes a total of nine species.

→ Hoolock Gibbon (*H.hoolock*) – Identified for planned breeding with Biological Park in Itanagar, Arunachal Pradesh as the coordinating zoo, and Aizawl Zoo in Mizoram, Assam State Zoo-cum-Botanical Garden in Assam, and Sepahijala Zoological Park in Tripura as participating zoos.

When initially identified for planned breeding, the species was listed as the Eastern Hoolock Gibbon (*H. leuconedys*). Since then, the taxonomic classification has split the Hoolock Gibbon into two species: Eastern Hoolock Gibbon (*H. leuconedys*) and Western Hoolock Gibbon (*H. hoolock*). Indian zoos primarily report housing *H. hoolock*. The IUCN Red List notes the uncertain distribution of *H. leuconedys* in India. While most captive individuals are assumed and or reported to be *H. hoolock*, verifying the exact species identity through morphological or molecular methods may be beneficial for conservation management.

H.hoolock is generally held in small group sizes across zoos, with a median group size of around three individuals Figure A-19. The total population in Indian zoos remains below 50 individuals, exhibiting a slight male bias and a low birth-to-death ratio, reflecting challenges in reproductive success and survival rates in captivity. For further details, refer to Table 2 & Figure A-20.

Species	**Median population size**	**Range**	**Birth-death ratio**	**Male-female ratio**
Trachypithecus pileatus	11	2–30	0.08	126
Trachypithecus geei	6	3–28	0.20	118
Macaca silenus	60	15–75	0.59	111
Macaca fascicularis	13	0–20	0.58	173
Trachypithecus johnii	26	3-54	0.83	85
Macaca leonina	6	3-27	1.50	150
Macaca arctoides	46	12–61	0.50	103
Trachypithecus phayrei	5	4-6	3.00	91
Hoolock hoolock	27	8-47	0.24	111

Table 2: Comparative population metrics of threatened primates identified for planned breeding for the period 1995–2022.

→ In case of Cercopithecines –

Capped Langur (*T. pileatus*), Gee's Golden Langur (*T. geei*), Northern Pig-tailed

Macaque (*M. leonina*) & Hoolock Gibbon (*H. hoolock*) show low birth-death ratios (0.08 to 0.24) and small to moderate median population sizes (6–27 individuals), with population ranges generally below 50. The combination of small populations and low birth-death ratios indicates limited breeding success and high mortality. *T. pileatus* and *M. leonina* show significant male biases (sex ratios of 126 and 150), potentially limiting breeding opportunities.

Lion-tailed Macaque (*M. silenus*), Stump-tailed Macaque (*M. arctoides*) and Nilgiri Langur (*T. johnii*) show moderate median population sizes (26–60 individuals) and birth-death ratios between 0.50 and 0.83, with relatively balanced sex ratios. Their population ranges are also moderate (up to 75 individuals).

Phayre's Leaf Monkey (*T.phayrei*) is housed only in a few zoos as small collections.

Crab-eating Macaque (*M. fascicularis*) has a median population size of 13, with a wide range (0–20) and a moderate birth-death ratio of 0.58. However, it has a significant male bias (sex ratio of 173), which may hinder breeding success due to the limited number of breeding females. The population range suggests fluctuations in population size over time, potentially due to high turnover.

In general, the number of zoos housing each primate species has decreased over the years. Most species have been housed predominantly in group sizes of five or fewer individuals, with the notable exception of *M. fascicularis*. The median group size for the majority of species remains around five (Figure A-19). Certain species, such as *M.silenus*, *M.arctoides*, and *H.hoolock*, display high variability in group sizes over the years. This variability likely reflects adjustments during the initial phases of population establishment. Over time, reduced birth-to-death ratios and inter-zoo transfers—mainly for exchange and display purposes—have contributed to smaller group sizes across multiple institutions (see Figure A-21 for housing trends and group size variability over time).

vii) Order *Otidiformes*: Four species, namely the Asian Houbara (*Chlamydotis macqueenii*), Bengal Florican (*Houbaropsis bengalensis*), Lesser Florican (*Sypheotides indicus*) and Great Indian Bustard (*Ardeotis nigriceps*), were identified for planned breeding. Independent conservation breeding programs are currently conducted by the governments of Rajasthan and Gujarat for *A. nigriceps* and *S.indicus*. However, these programs are not yet recognized by the Central Zoo Authority (CZA). Following the 2022 amendment to the Wild Life (Protection) Act, 1972, there is potential for these facilities to be officially incorporated into CZA's planned breeding programs in the future.

viii) Order *Accipitriformes*: Three species of vultures – Indian Vulture (*Gyps indicus*), Slender-billed Vulture (*Gyps tenuirostris*), and White-rumped Vulture (*Gyps bengalensis*) – are currently identified for planned breeding programs. The populations of all three *Gyps sp.* have steadily increased over the years. There are over 200 individuals of both *G. bengalensis* and *G. indicus*, while *G. tenuirostris* has a smaller captive population of just over 50 individuals. *G. bengalensis* has been in captivity for more than 25 years, whereas the other two species entered captivity around the mid-2000s.

The population growth rates derived from annual census trends indicate variable rates during the early years of population establishment (2007-2010, coinciding with the programs' initiation). In recent years, growth rates have stabilized around a value close to 1, suggesting a steady population.

The majority of individuals for all three species are housed at the Vulture Conservation & Breeding Centre in Pinjore, the coordinating zoo since the program's inception. While Nehru Zoological Park, Nandankanan Biological Park, and Sakkarbaug Zoological Park have also housed these species, only the latter two have achieved sporadic breeding success. Assam State Zoo & Botanical Gardens has not yet housed these species for conservation breeding. It is pertinent to note here that the Bombay Natural History Society operated a designated conservation breeding centres for Vultures in Madhya Pradesh, Assam and West Bengal which are not recognised by CZA. In future, the possibility of these facilities to be operated in conjuction with recognised faciliteis in the vicinity may be required.

Pedigree analysis reveals that the captive population consists primarily of F0 (wild-origin founders) and F1 (first-generation captive-bred birds), with only one F2 bird documented for *G. indicus*. Notably, a large number of wild-origin birds have not yet bred, presenting substantial potential to serve as founder stock. However, the number of unsexed birds remains unusually high within the captive population, highlighting a need to streamline management.

A comprehensive review of the vulture conservation breeding program was conducted in 2021, and the findings are detailed in the report *Proceedings of the Technical Workshop for the Central Zoo Authority Coordinated Vulture Conservation Breeding Program*[7].

A summary of the history and status of the captive populations for *G. bengalensis*, *G. indicus*, and *G. tenuirostris* is presented in Figure A-22, Figure A-23, and Figure A-24, respectively.

[7] https://cza.nic.in/publications/en/page/2

ix) Order *Bucerotiformes*: Two species of hornbills, the Malabar Grey Hornbill (*Ocyceros griseus*) and the Malabar Pied Hornbill (*Anthracoceros coronatus*), were identified for planned breeding. Currently, there is no coordinating zoo designated for these species. Nehru Zoological Park in Telangana is designated as the participating zoo for both the species. There is no history of *O. griseus* being housed in captivity, and thus, no breeding program has been initiated for this species. For *A. coronatus*, records indicate that it has never been housed at the participating zoo, nor is there any documented history of breeding in captivity. Fewer than 20 individuals are displayed in zoos, with no breeding program in place. Given these circumstances, it is safe to conclude that a structured conservation breeding effort has not been initiated. A summary of the status and history of *A. coronatus* in captivity is provided in Figure A-25.

x) Order *Columbiformes*: Only one species in this order, the Nicobar Pigeon (*Caloenas nicobarica*), has been identified for planned breeding. The coordinating zoo is the Biological Park in the Andaman & Nicobar Islands, with Nehru Zoological Park in Telangana and Kamla Nehru Zoological Garden in Gujarat designated as participating zoos.

Currently, fewer than 30 individuals are housed across these zoos, with the majority in the coordinating zoo. The birth-to-death ratio stands at 0.962, indicating a stable but limited population increase. However, despite consistent breeding over the years, the lack of systematic management will likely affect viability. There are no systematic breeding records, and the program lacks a structured breeding plan. Additionally, majority of the birds are unsexed, meaning no parentage or life history records are maintained. Although births have been recorded, the population may have lost its conservation potential due to poor management practices.

A summary of the species' history in captivity is provided in Figure A-26.

xi) Order *Falconiformes*: Only one species in this order, the Peregrine Falcon (*Falco peregrinus*), was initially identified for planned breeding. Since then, the Indian subspecies, the Shaheen Falcon (*F. p. peregrinator*), has been recognized as the target for conservation. Currently, Mahendra Chaudhury Zoological Park in Punjab is designated as the coordinating zoo, with Nahargarh Biological Park in Rajasthan as a participating zoo.

Historically, there have been sporadic records of this species being housed in zoos, primarily as unsexed, solitary individuals. No records of successful breeding exist, as most individuals were likely rescued and housed as single birds until they naturally died out. Consequently, no formal conservation breeding program has been initiated for this species.

xii) Order *Squamata*: This order is represented by two families *viz.* Varanidae and Elapidae & includes two species –

→ Asian Water Monitor (*Varanus salvator*) – *V. salvator* was identified for planned breeding, with the Biological Park in the Andaman & Nicobar Islands designated as the coordinating zoo and the Madras Crocodile Bank Trust in Tamil Nadu as a participating zoo.

Historically, a significant population of nearly 80 individuals was housed pre-2000; however, this population has seen a substantial decline over the years. A majority of the individuals remain unsexed, and the birth-to-death ratio stands at a low 0.385, indicating more deaths than births over time. The participating facility previously housed over 30 individuals but currently only has a pair, while the coordinating zoo has consistently maintained fewer than 10 individuals.

The species has not been effectively managed in captivity, with no systematic records, poor breeding success, and limited marking for identification, resulting in low birth rates. A summary of the captive history of *V. salvator* is at Figure A-27.

→ King Cobra (*Ophiophagus hannah*) – *O. hannah* was identified for planned breeding, with Pilikula Biological Park in Karnataka designated as the coordinating zoo, and Bannerghatta Biological Park in Karnataka and the Madras Crocodile Bank Trust in Tamil Nadu as participating zoos.

The zoo population has varied between 40-60 individuals over the years, showing a general decline. The birth-to-death ratio stands at 1.04, indicating a close balance between births and deaths. However, a significant number of individuals remain unsexed, and the coordinating zoo houses the majority of the population.

The existing enclosure, although designated for conservation breeding, is insufficient in size and complexity for a species as large and solitary as the King Cobra. Modifications or expansion of the enclosure are necessary to provide adequate space that promotes natural behaviors. Additionally, the absence of individual marking and the lack of systematic pedigree and life history records severely limits tracking of individual animals and effective management of genetic diversity, which is crucial for the long-term viability of the population. Nearly 100 individuals have been released into the wild, but there has been no post-release monitoring or habitat assessment to evaluate the success or necessity of these reintroductions.

The program currently lacks a systematic approach. Wild founders have been included without thorough assessment, and breeding attempts continue despite known gaps in King Cobra husbandry knowledge. This ad hoc approach raises

concerns about the genetic integrity and health of the captive population. Furthermore, recent molecular studies suggest a potential reclassification of this species. This reclassification should be considered in any future conservation or management actions.

A summary of the captive history of *O. hannah* can be found in Figure A-28.

xiii) Order *Perissodactyla* – This order is represented by two species, the Greater One-horned Rhino (*Rhinoceros unicornis*) & Indian Wild Ass (*Equus hemionus khur*). Assam State Zoo-cum-Botanical Garden, Assam is the coordinating zoo, with Sanjay Gandhi Biological Park in Bihar, National Zoological Park in Delhi, and Kanpur Zoological Park in Uttar Pradesh as participating zoos for *R.unicornis* and Sakkarbag Zoo is coordinating zoo for *E.h. khur*.

R.unicornis – The population has consistently ranged between 30-40 individuals, housed across approximately 10-15 zoos. The male-to-female sex ratio is 159, indicating a male-biased population. Although the birth-to-death ratio is relatively low at 0.68, the population has remained stable, likely due to the regular addition of wild-caught individuals. Records for this species are fairly well-maintained, with a founder base of 12 individuals (see Figure A-29).

E.h. khur – The captive population of this species was below 15 individuals in the early part of the last decade, and increased to around 17 in recent years, though it remains in fewer than five zoos. The male-to-female sex ratio is 1.22, indicating a male bias. The birth-to-death ratio is 0.84, suggesting that births have been declining over the years, while acquisitions have increased. There are limited records, as this species is primarily managed as a small breeding population for display purposes, with animals occasionally transferred to other zoos for exhibit (see Figure A-30).

xiv) Order *Caudata* – The only amphibian identified for planned breeding is the Himalayan Salamander (*Tylototriton himalayanus*), with Padmaja Naidu Himalayan Zoological Park in West Bengal designated as the coordinating zoo and no participating zoos.

The species has been housed exclusively at the coordinating zoo since 2004-2005, with the population increasing from 9 individuals to 50 by 2022. Notably, approximately 75% of the individuals remain unsexed. During this period, only 7 deaths have been reported, which seems improbable and suggests potential inaccuracies. The birth-to-death ratio is reported at 5.26, though this likely reflects an anomaly. No deaths have been reported in the last 12 years, and there have been no acquisitions or disposals.

While some breeding has occurred, it has been inconsistent; out of 18 recorded hatchlings, they were produced only in 3 separate years with counts of 6, 10, and 21 hatchlings, respectively. There are no individual marking systems or detailed life history records, and the population remains a sporadically breeding stock without a structured management plan.

xv) Order *Lagomorpha* – This order is represented by a single species, the Hispid Hare (*Caprolagus hispidus*), which currently lacks a designated coordinating zoo. Assam State Zoo-cum-Botanical Garden is listed as a participating zoo for this species. Historically, only two zoos have reported housing this species: Sajjangarh Biological Park in Rajasthan housed 19 individuals from 2013 to 2015, but no reports have followed since. Given the species' natural distribution in eastern India, these records are likely due to misidentification. Additionally, Jungle Mahal Zoological Park in West Bengal reported 4 individuals in 2008, though these animals were lost to follow-up, and all were unsexed. There are no records of breeding for this species, and it is presumed that no planned breeding program has been initiated.

xvi) Order *Rodentia* – This order is represented solely by the Indian Giant Squirrel (*Ratufa indica*). The species is managed with Pilikula Biological Park in Karnataka designated as the coordinating zoo, while Arignar Anna Zoological Park in Tamil Nadu, Rajiv Gandhi Zoological Park and Wildlife Research Centre in Maharashtra, and Bhagwan Birsa Biological Park in Jharkhand are participating zoos.

The total population of *R. indica* in captivity has remained variable, generally around 40 individuals or fewer, distributed across approximately 15 zoos. The mean population per zoo is low, with an average holding of 2.11 individuals, a standard deviation of 1.51, and an interquartile range (IQR) of 2. These metrics indicate a small stocks and uneven distribution of individuals among zoos.

The male-to-female sex ratio stands at 84.5, showing a slight female bias. The birth-to-death ratio is 0.14, highlighting the minimal breeding success and reliance on wild-caught individuals to sustain the population. Both coordinating and participating zoos typically house only a few animals each, with acquisition records primarily showing additions rather than births, as depicted in Figure A-31. Mortality rates have been relatively high, further underscoring the challenges in sustaining the population through captive breeding.

The lack of individual marking, pedigree tracking, and systematic inclusion of animals for breeding suggests that this population is maintained more as a display or conservation

placeholder rather than through an organized breeding program.

xvii) Order *Pholiodata* – This order is represented solely by the Indian Pangolin (*Manis crassicaudata*). Nandankanan Biological Park has been designated as the coordinating zoo, with no additional participating zoos involved. The population of *M. crassicaudata* across zoos in India has steadily declined over the years, with only 2 to 3 zoos currently housing around 20 individuals. While the coordinating zoo has successfully bred the species, the overall birth-to-death ratio remains low at 0.43. The male-to-female ratio is skewed, with around 80% of individuals being male, and many individuals remain unsexed. Additionally, wild-caught animals are regularly rescued and introduced into the captive population, though breeding success is generally slow and limited. Only a small proportion of individuals actively contribute to breeding, leading to uneven genetic representation. Consequently, acquisitions from the wild continue to dominate the population, with the overall contribution from captive births remaining low (Figure A-32).

xviii) Order *Testudines* – The Red-crowned Roofed Turtle (*Batagur kachuga*), previously listed as *Kachuga kachuga*, has undergone taxonomic reclassification to reflect updated scientific understanding.

Currently, there is no designated coordinating zoo for its conservation breeding program. The Madras Crocodile Bank Trust serves as a participating zoo, housing over 75 individuals out of a total captive population exceeding 100. Notably, a significant proportion of these turtles remain unsexed, which poses challenges for breeding efforts. The overall birth-to-death ratio stands at 1.37; however, there has been a decline in births over recent years. Additionally, the lack of comprehensive life history records hinders the development of a systematic breeding plan for this critically endangered species. The history of *B. kachuga* in captivity is depicted at Figure A-33.

3.3 Summary of findings

The Central Zoo Authority has implemented planned breeding programs for 74 threatened Indian species across 43 zoos, which were assigned coordinating and participating roles. Despite these efforts, the breeding programs exhibit varied success rates and face multiple challenges. Key issues include insufficient integration of species-specific biological knowledge into husbandry practices, poor data management, limited genetic monitoring, and inconsistent breeding protocols.

In this analysis, the data is derived from longitudinal records submitted by zoos, including inventory reports, studbooks, and other specifically requested records. While there is a

possibility of occasional errors—such as species misidentification or inadvertent errors introduced during the digitization of historical records—the impact of these minor discrepancies is likely minimal. Given the vast quantity of data spanning several decades, minor inconsistencies are smoothed out, making it unlikely that they would significantly alter observed patterns and trends. Further, to ensure data quality, several validation steps have been applied, such as consistency checks across multiple sources and cross-referencing with other available records. These measures aim to minimize the effects of any potential errors, thus enhancing the reliability of the observed trends and findings.

In any conservation breeding program, the foundation must be accurate taxonomic identification of the species involved. However, some programs exhibit fundamental issues in this area. First, it is crucial to remain current with taxonomic revisions, including specific details such as type locality, as these classifications may evolve over time. Second, correct identification should ideally extend to the subspecies level where applicable. Given the planned nature of these breeding programs, it is essential that all species are accurately identified at the subspecies level to maintain genetic integrity and conservation value. For instance, species such as *M. chrysogaster* and *C.s. tahr*, have historically been subject to taxonomic inaccuracies, which may necessitate reassessment in the future. Addressing these challenges might be vital to ensure that the programs are grounded in scientifically sound, up-to-date taxonomic practices.

Most programs were initiated with existing stock, lacking systematic efforts to identify and acquire genetically diverse founders. As a result, founder diversity is low, with programs often beginning with animals sourced from single locations. Additionally, animals have been transferred without regard for their impacts on population structure, especially in social species. This practice has resulted in isolated or unpaired animals spread across various coordinating and participating zoos, undermining breeding success.

Infrastructure maintenance has been inconsistent, with many programs seeing only initial investments in enclosures, which have degraded over time. The absence of regular health assessments, clear husbandry protocols, and dynamic enclosure enrichment to support a full range of species-specific behaviours — particularly reproductive behaviours such as incubation and rearing — further restricts breeding outcomes. The use of studbooks, while helpful for tracking lineage, is challenging for group-living species where parentage tracking is difficult. Establishing a specialized *herdbook* system could improve management for these species.

A major finding is the disparity in breeding effectiveness across taxonomic groups. Species in orders such as *Artiodactyla* and *Carnivora* show limited or sporadic breeding success, often due to small, fragmented populations with low genetic diversity. Inadequate life-history and pedigree records increase the risk of inbreeding and reduce long-term viability. For example, several orders show low birth-to-death ratios, suggesting that their populations are sustained

more by wild acquisitions than by captive births.

Foundational infrastructure to support structured breeding is often lacking. Programs for species like the *B. kachuga* and *V. salvator* are hindered by inadequate sexing (although being sexually dimorphic), complicating pair management. Many species, including vultures and pangolins, have a high proportion of unsexed individuals, making genetic and demographic management challenging.

Reliance on wild-caught animals to sustain captive populations is another significant issue. Wild acquisitions, while seemingly maintaining population numbers, can compromise genetic integrity and stability by introducing unassessed individuals. This practice is a short-term solution that does not improve captive management and may negatively impact wild populations. This is especially problematic in species like the Asiatic Lion and King Cobra, where frequent wild additions dilute conservation objectives.

Certain species, such as the Red Panda and Himalayan Salamander, have shown growth in specific facilities but face sustainability challenges due to low founder numbers and restricted genetic diversity. Others, like the Asiatic Lion, Bengal Tiger, suffer from hybridization and unregulated breeding of color morphs, detracting from their conservation value.

Data management inconsistencies also obstruct program success. While studbooks exist for some species, such as the Asiatic Lion and Bengal Tiger, they are rarely integrated into active management. Consequently, many captive populations lack comprehensive genetic and demographic oversight, essential for maintaining viable, healthy populations.

In summary, the review highlights the need for –

→ Enhanced genetic and demographic management through regular updates to studbooks, accurate sexing, and systematic individual marking.

→ Dedicated breeding areas and enclosures that meet species-specific needs and enable monitoring without disturbance.

→ Improved life-history and pedigree documentation to track lineage, manage genetic diversity, and reduce inbreeding.

→ More selective acquisition and breeding policies, prioritizing breeding outcomes over wild acquisitions to develop self-sustaining captive populations.

→ Specialized training and capacity building for zoo personnel in scientific population management to facilitate data-driven, effective breeding programs.

→ Competent and skilled personnel are crucial to successfully implement these strategies. Trained staff in population management, genetic monitoring, and species-specific

husbandry practices are essential for shifting from ad hoc to structured, scientifically-informed breeding practices. This approach will enhance the long-term success of conservation breeding efforts in Indian zoos, fostering sustainable, genetically viable populations.

Himalayan Red Panda (Ailurus fulgens fulgens) at conservation breeding centre at Padmaja Naidu Himalayan Zoological Park, West Bengal.

4 Advances in management of threatened species in captivity for conservation purposes

The captive breeding of endangered species for conservation, including potential release or support of species restoration, gained momentum in the 1970s and 1980s. The study by Soulé et al. (1986) proposed a theoretical framework for managing captive populations, advocating for the retention of 90% of the original gene diversity over a 200-year time frame, with a 100-year target often adopted for practical application. This concept, while groundbreaking at the time, has since been refined by advances in conservation genetics and a greater understanding of the challenges facing threatened species. When the CZA began institutionalising planned breeding programs in the 2000s, the 90/100 goal, already widely accepted by regional associations and zoos globally for endangered species in the preceding decades, provided a practical framework for a then poorly understood subject and was therefore readily adopted.

Evidently, the *ark paradigm* by Soulé et al. (1986) provided the foundational framework for the initiation of captive breeding programs, leading to the development of scientific principles, methods, and tools for managing threatened species in captivity. These advancements continue to have far-reaching implications for contemporary conservation efforts.

Maintaining genetic diversity remains crucial, and its compromise, often through inbreeding, can negatively impact reproduction, individual health, and longevity, increasing extinction risk (Ryan et al., 2002). Additionally, the suitability of captive-bred animals for reintroduction decreases with successive generations in captivity (Earnhardt, 2010). The original 100-200 year timeline, while ambitious, may no longer be feasible given the accelerated rate of species and habitat decline. Conservation priorities have shifted towards more immediate actions, recognizing that even 25-50 years represent a significant time-frame in the context of rapid global change (Lacy, 1989).

Recognizing the complexities of captive management, a more holistic approach has emerged, seeking to optimize the conservation potential of captive populations beyond the initial focus on genetic diversity. The current paradigm emphasizes minimizing the loss of gene diversity while mitigating adaptation to captive environments and preserving species-specific behaviors (Olney et al., 1993; Lacy, 2009; Williams and Hoffman, 2009; McPhee and Carlstead, 2010; Leus et al., 2011; Rose, 2022). This contemporary paradigm acknowledges the dynamic interplay of genetic, behavioral, and environmental factors in shaping the long-term viability and conservation value of captive-bred animals.

As demonstrated by several studies (Baker et al., 2011; Long et al., 2011; de Man et al., 2016; Traylor-Holzer et al., 2019), the sustainability measures implemented as part of the *ark paradigm* were not universally applicable across all taxa. As a consequence, two newer ap-

proaches gained traction: addressing sustainability itself and the concept of integrated conservation.

The first approach led to improvised methods for population sustainability, such as the AZA's cooperative animal management programs (Irwin et al., 2013), population viability analysis of longitudinal zoo collections (Che-Castaldo et al., 2019) and global programs such as Global Species Management Plans (Gusset, 2013). The second approach led to the development of the *One Plan Approach* (OPA) to species conservation planning (Byers et al., 2013) by the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Conservation Planning Specialist Group (CPSG). The OPA advocated for the *joint development of management strategies and conservation actions for all populations of a species by all responsible parties to produce a single, comprehensive conservation plan for a species.*

The OPA also guided the formulation of 2015 World Zoo & Aquarium Conservation Strategy (Barongi et al., 2015). Subsequently, the IUCN SSC revised the *Guidelines on the Use of Ex Situ Management for Species Conservation* (IUCN, 2014). The revised guidelines present a five-step process to evaluate the potential benefits and appropriateness of ex situ activities within a species conservation strategy (McGowan et al., 2017). This structured approach ensures that any ex situ actions are carefully considered and designed to effectively support the species' conservation in the wild.

Small populations face the risk of an extinction vortex, where random demographic and genetic factors—such as environmental variability, reproductive rates, and genetic diversity loss—interact to amplify extinction risks (Frankham et al., 2010). In the wild, fragmented and small populations need active management to maintain genetic and demographic stability. Zoo and aquarium populations, typically small and dispersed across institutions, similarly require focused management to achieve specific conservation or non-conservation objectives.

Setting a uniform goal, such as maintaining 90% genetic diversity over 100 years, may inadvertently overlook critical factors like breeding potential and behavioral needs. This genetic target, while crucial, may place uneven emphasis on genetics at the expense of broader population health considerations, particularly where small populations face limitations beyond genetic interventions alone.

A comprehensive long-term management plan can expand beyond genetic targets to address demographic, genetic, behavioral, veterinary care, and research needs tailored to each species' situation. Pedigreed populations offer significant potential for demographic and genetic management; however, advanced molecular techniques may increasingly be required to validate that theoretical genetic diversity (estimated from pedigree records) aligns with actual genetic diversity. These technological advancements highlight the importance of collaborative, holistic population management strategies that ensure robust conservation outcomes.

It is therefore imperative that the CZA recast its framework and guidelines for planned breeding programs to reflect recent advancements in the management of threatened species in captivity for conservation purposes. This revision should incorporate the latest advances in theoretical and practical knowledge of population management especially with reference to the following:

i) IUCN One Plan Approach: Planned breeding programs should not operate in isolation but should complement in situ conservation efforts. All programs should be aligned with the IUCN's revised *Guidelines on the Use of Ex Situ Management for Species Conservation* (IUCN, 2014), including the five-step decision-making process to optimize the contribution of ex situ actions to species conservation.

ii) Metapopulation management (Pedrono et al., 2004): Multiple zoos housing a species across their institutions effectively form a metapopulation – a network of individuals of the same species, managed collaboratively as a single population. Recognizing that not all individuals can be housed in a single or a few zoos, cooperative management is essential. This necessitates a shift away from treating species as commodities with exchange value, prioritizing their conservation value instead. Clear guidelines should be established, outlining how to best distribute animals and genetic diversity across different zoo sub-populations, and specifying criteria for transferring individuals between regions. This strategic approach will help maximize genetic diversity within the metapopulation, minimize inbreeding within sub-populations, and reduce adaptation to captive environments. Furthermore, populations held in foreign zoos should be integrated into these strategies, fostering international collaboration. While general guidelines are valuable, species-specific metapopulation viability analysis can offer crucial insights for optimizing long-term viability and genetic diversity. This analysis should incorporate species-specific traits, regional sub-population data, and explore various management scenarios to ensure the long-term health and conservation potential of the species.

iii) Conservation breeding plans: All planned breeding programs must be guided by a long-term plan (at least for a period of 10 years) which specifies program's purpose, goals, measurable indicators for targets, and overall species management strategies for conservation.

iv) Analytical framework: Periodic reviews are crucial for planned breeding programs. Recent advances in analytical methods, such as simulation modelling, population viability analysis, pedigree analysis, and longitudinal data analysis, should be employed in these

assessments. Programs should also incorporate *adaptive management* principles, allowing for adjustments based on new information and changing circumstances.

Clouded Leopard (Neofelis nebulosa) at Sepahijhala Zoological Park, Tripura.

5 Actionable steps

To strengthen conservation breeding efforts in India, planned breeding programs require consistent monitoring and evaluation to measure success effectively. While many ongoing programs face challenges, they have also led to important insights and some notable achievements, establishing a valuable foundation from which future efforts can build.

The terminology used to describe breeding initiatives in zoos carries significant implications for how such programs are perceived and implemented. Terms like *captive breeding*, *planned breeding*, and *conservation breeding* are often used interchangeably, but each has distinct connotations and implications.

Captive breeding emphasizes the management of species in a controlled environment, often detached from broader conservation objectives. While it remains widely understood, its use can unintentionally downplay the connection to in situ conservation efforts and ecosystem health.

Planned breeding, on the other hand, highlights a structured approach to breeding programs. However, it lacks an explicit focus on the conservation goals, such as ensuring that zoo populations remain viable, genetically diverse, and representative of their wild counterparts.

Conservation breeding is perhaps the most comprehensive and appropriate term, underscoring the alignment of breeding programs with species recovery objectives and the integration of ex situ efforts with broader conservation strategies. This term captures the essence of maintaining populations in zoos that not only sustain themselves over generations but also preserve the genetic, behavioral, and ecological characteristics of their wild counterparts.

Regardless of the terminology chosen, the focus must remain on population management across zoos. Effective conservation breeding programs must ensure that zoo populations are not isolated but are managed as coordinated metapopulations. This approach requires collaboration among institutions, systematic genetic and demographic management, and adherence to protocols that aim to mirror the dynamics of wild populations. Ensuring that zoo populations resemble their wild counterparts as closely as possible is critical to maintaining their conservation value and long-term sustainability.

A key success has also been the ability to maintain certain vulnerable species in captivity, which, even under difficult circumstances, has created an opportunity to deepen our understanding of these species. This knowledge has led to more informed husbandry practices,

particularly for species such as the Western Tragopan, Red Panda and Asiatic Lion, where facilities have shown positive population growth at some locations. These initial gains underscore the importance of maintaining a science-driven approach that can be refined and adapted over time.

These programs have also enabled Indian zoos to begin documenting critical genetic and life-history data. For instance, the introduction of studbooks for species like the Asiatic Lion and Bengal Tiger provides a foundation for structured genetic management. While the integration of these tools into active population management is still evolving, the initial steps toward centralized record-keeping have been achieved. These efforts point toward a future where data-driven decisions can support the stability of captive populations, aligning more closely with global standards. In summary, while challenges remain, these programs have established a foundation for science-based conservation breeding in India. They provide valuable lessons and insights that can guide more refined practices moving forward.

5.1 Key elements for strengthening conservation breeding program

To build a truly effective conservation breeding program, a more structured and systematic approach is needed which addresses the following aspects.

→ Strategic species assessment and prioritization: A successful conservation breeding program begins with a careful selection of species based on a rigorous assessment framework. While this initial assessment highlights specific challenges, it does not yet provide a robust basis to determine which species merit inclusion or continuation in a breeding program. Relying solely on IUCN status or breeding success in captivity is insufficient. Instead, species prioritization should incorporate a more formal structure, such as the IUCN's Five-Step Process and other frameworks such Integrated Conservation Assessment and Planning (ICAP) or Conservation Needs Assessments[8], to make informed, evidence-based decisions.

Rationalizing the list of species for breeding programs must include considerations like population viability, genetic diversity needs, and ecological relevance in both captive and wild contexts. The aim should be to identify species where captive breeding can have meaningful conservation impacts, not simply to manage those that breed well in captivity. To make such determinations, species assessments should go beyond husbandry success, incorporating data on population trends, habitat conditions, and the potential for successful reintroduction.

[8] https://www.conservationneeds.org/

→ Management of populations: Following species prioritization, coordinated management of the populations within the breeding program is essential. Many breeding programs were initiated with existing stock but lacked systematic efforts to acquire genetically diverse founders. Moving forward, founder acquisition must be carefully planned, emphasizing genetic diversity and health considerations from the outset (see Crow and Kimura (1970) and Lacy (1994) for principles regarding management of founders) while accounting for effective population sizes (N_e). The impact of *ad-hoc* animal transfers on population dynamics, especially in social species, also underscores the need for coordinated population management. Lessons learned from these programs highlight the importance of improving genetic diversity and population health through planned acquisitions, strategic transfers, and inter-zoo collaboration.

In addition, the *transactional approach* to animal transfers – where animals are treated as possessions in exchanges, often driven by what one zoo can offer or receive in return – should be eliminated, especially within the context of breeding programs. Instead, transfers should be mediated through principles of scientific population management to support broader conservation goals. The Central Zoo Authority should exercise its legislative authority more stringently to ensure that all transfers are guided exclusively by principles of scientific population management, aligning with conservation priorities rather than zoos' interests.

→ Husbandry: With foundational species prioritization and population management in place, effective husbandry becomes the next critical component. For many species, substantial information on husbandry protocols, behavioral ecology, and management practices is already available. Rather than reinventing these protocols, the emphasis should be on effective integration of existing knowledge into breeding program strategies. A science-driven approach that applies these well-established practices will allow for a smoother transition to structured conservation goals without the need to develop new protocols unnecessarily.

→ Acquisition of wild-caught/rescued specimens: The viability and sustainability of captive populations rely on carefully chosen founders that can support long-term genetic and demographic stability. While rescued individuals are often brought into captivity to relieve immediate distress, their induction into breeding programs should be carefully considered. Rescued animals typically lack clear genetic histories or health information, which can pose risks to the viability of a breeding program. Ideally, these individuals should be rehabilitated and released back into their natural habitats whenever possible, fulfilling the primary objective of rescue without complicating conservation breeding

efforts.

Integrating rescued individuals into breeding programs simply because they are rare or endangered may compromise the program's sustainability by introducing unknown genetic variables and health risks. A rigorous process should govern founder selection, ensuring that genetic diversity is maintained and that each individual contributes positively to the population's health. Similarly, while introducing wild-caught animals can sometimes enhance genetic diversity and population viability, unplanned or frequent acquisitions from the wild may harm wild populations, particularly for threatened species with fragmented distributions. Addition of wild-caught individuals should be a last resort and only occur when alternative sources, such as transfers from other captive populations, are unavailable. This approach prioritizes both the stability of wild populations and the sustainability of captive populations, ensuring that conservation breeding programs contribute positively to the overall species survival without depleting natural populations.

Sustainable breeding programs must rely on a balance between well-selected founders, minimal interference with wild populations, and a commitment to building self-sustaining captive populations that can support long-term conservation goals.

→ Capacity building and technical oversight: As the diversity of species in these programs grows, so does the need for specialized technical oversight to manage unique husbandry requirements. However, continuity in administration remains a challenge, as changes in leadership and a lack of trained personnel can hinder the long-term stability of these programs. Skilled, dedicated professionals are essential for implementing and sustaining these initiatives, especially for species with specific care needs or those whose biology is still not fully understood.

Globally, captive breeding programs are highly coordinated and operate with scientific rigor, bringing together biologists, veterinarians, and managers who collaborate with various stakeholders. Taxon Advisory Groups provide tailored recommendations, while regional species plans are regularly developed and monitored, often based on the IUCN framework. These global programs follow adaptive management principles, focusing on long-term management strategies to ensure continuity and resilience.

CZA's Vision Plan 2031[9] outlines a similar approach under Pillar 1, emphasizing *Strengthening ex situ conservation of endangered native species, guided by the National Zoo Policy and the adoption of a One Plan approach.* Achieving global standards requires enhancing the sci-

[9] https://cza.nic.in/uploads/documents/publications/english/Vision%20Plan4Oct2021%20(1).pdf

entific rigor of these programs. To initiate this process, it may be beneficial to adopt globally recognized frameworks and practices, gradually moving toward a more intensive, structured conservation breeding model that integrates adaptive management principles and is continuously evaluated to meet evolving conservation needs.

5.2 Scenarios and way forward

In this context, the following workflow is proposed –

→ Species for which planned breeding programs have not yet been initiated in any recognized zoo should be temporarily shelved. While this may include highly threatened species like *C. hispidus*, it is prudent to first focus on species with some established captive management experience. By refining breeding programs with these species, insights and practices can be optimized before expanding efforts to species new to captivity. See Appendix E for list of species. Among the identified species, some have consistently exhibited low population numbers in captivity, indicating challenges in establishment of viable populations. With a conservative approach species whose average captive populations have remained fewer than 10 individuals may also be temporarily deprioritized. This does not imply permanent exclusion but rather place them on a secondary priority list. Initial focus will be on improving breeding outcomes for species with larger captive populations, with plans to later expand efforts to those with lower representation in captivity (see Appendix F for species meeting these criteria). Given this, based on a subjective assessment of the sustainability of each program the species were categoriosed based on the following four scenarios:

1. **Scenario 1: No Program Initiated [Table 4]**

   Characteristics: No planned breeding program has been initiated for the species, or the species has negligible captive populations or breeding history.

   Implications: Indicates logistical, resource-based, or biological barriers to initiating or sustaining the program.

   Recommendations –

   - Put the program on hold until a feasibility assessment is completed
   - Assess the reasons for non-initiation (e.g., lack of founders, resources, or expertise).
   - Apply decision frameworks like the IUCN's five-step ex situ management process to evaluate the species' suitability.

- Resume the program only if barriers can be addressed and feasibility is established.

2. **Scenario 2: Persistent Small Populations and Limited Growth [Table 5]**

   Characteristics: Mean captive population size consistently below 10; birth-to-death ratio and growth rate below 1.0, indicating stagnation or decline.

   Implications: Suggests limited breeding success, founder acquisition, or resource allocation challenges.

   Recommendations –

   - Temporarily suspend the program.
   - Address gaps by acquiring new founders as necessary, improving representation, revising husbandry practices, and overcoming barriers to propagation.
   - Reassess feasibility using decision frameworks like the IUCN's five-step ex situ management process before reinstating the program.

3. **Scenario 3: Sub-optimal Demographic and Genetic Correlates [Table 6]**

   Characteristics: Captive population size consistently below 50; limited founder representation; absence of systematic pedigree or genetic monitoring; weak collaboration with other zoos or ex situ facilities.

   Implications: Undermines long-term sustainability and conservation value of the program.

   Recommendations –

   - Prioritize species based on updated IUCN guidelines and regional conservation needs.
   - Focus resources on species with high conservation impact and ex situ potential.
   - Phase out or temporarily suspend programs for species that do not meet these criteria.

4. **Scenario 4: Large Populations but Misaligned Conservation Priorities [Table 7]**

   Characteristics: Captive populations are large (mean size >50); breeding success is consistent; populations are globally represented. However, the species is of low conservation priority due to stable wild populations, unsuitable reintroduction habitats, or limited ecological or cultural significance.

Implications: Diverts resources from species with more critical conservation needs or ex situ potential.

Recommendations –

- Apply decision frameworks like the IUCN's five-step ex situ management process to evaluate the species' suitability.
- Collaborate globally to enhance founder representation and genetic diversity.
- Assess genetic relationships to prevent inbreeding and improve population health.
- Shift focus to other species if continued efforts do not align with conservation priorities or yield impactful outcomes.

→ Conservation breeding, or planned breeding, should prioritize population management as a whole, focusing on developing populations that serve as accurate models and representatives of their wild conspecifics. The emphasis should shift from merely maintaining terminological distinctions (e.g., *conservation breeding* or *planned breeding*) to managing populations with optimal demographic, genetic, and behavioral traits that align with their natural ecology and long-term conservation goals.

Network Zoo Approach and Meta-population Management: At the inception of the conservation breeding programs, designating one zoo as a *coordinating zoo* and others as *participating zoos* was a practical way to centralize leadership and streamline program efforts. However, over time, the rigid categorization of these roles has become less effective. Programs that rely heavily on a single coordinating zoo face risks of underperformance if that zoo fails to deliver on expectations due to resource or capacity constraints.

In the current context, this model should evolve into a network of zoos collectively managing species populations. This network approach, based on meta-population principles, envisions multiple zoos housing, breeding, and managing populations collaboratively. A networked structure ensures that:

- Success is distributed across institutions, reducing reliance on a single facility.
- Breeding and management efforts are optimized, with zoos leveraging their respective strengths.
- Genetic and demographic diversity is enhanced through structured animal exchanges and coordinated planning.

This approach fosters collaborative population management and aligns with global shifts in conservation strategies. It also ensures resilience in population management, as no single zoo's underperformance will jeopardize the entire program.

→ The Recognition of Zoo Rules (RZR), 2009, specifies that conservation breeding facilities should be dedicated but does not mandate off-display housing. Many zoos currently manage breeding populations in display enclosures, while others have developed extensive off-display facilities.

A cursory review of housing patterns reveals that:

- Mandating off-display housing may not be a necessity. Globally, there is no consensus or standard requiring off-display enclosures for conservation breeding. Rather, the key aspect is the quality and suitability of the enclosure, not its display status.
- Enclosures should reflect species ecology and provide animals with the ability to retreat to zones that are not visible to the public whenever they choose. This balances the benefits of display (education, awareness) with the need for natural behaviors and reduced stress.
- Keeping conditions should prioritize species-specific biological and ecological needs. This includes behavioral opportunities such as foraging, social interactions, and habitat complexity that mimic natural conditions.

Zoos should be encouraged to develop off-display facilities as a choice, not a mandate, depending on their specific requirements and resources. Where animals are kept on display, the enclosure design must incorporate zones of retreat and minimize human habituation to maintain the integrity of natural behaviors.

Behavioral Integrity and Moderate Habituation: The integrity of animal behavior should be a cornerstone of population management:

- Moderate levels of habituation may be inevitable, particularly for species housed on display. However, these impacts can be mitigated during pre-release phases through soft release protocols.
- Enclosures should be designed to minimize excessive habituation to human presence. This includes creating visual barriers, soundproofing, and reducing unnecessary human interaction during routine management.
- Behavioral monitoring should be a regular part of program assessments to ensure that animals retain the critical behaviors necessary for survival in the wild (e.g., predator avoidance, social structures, foraging strategies).

Focus on functionality, not display status: The crux of effective conservation breeding is not whether the animals are kept off display but whether the enclosure design and management protocols meet the requirements of the species. Zoos must:

- Develop enclosures that mimic the species' natural environment.
- Ensure animals are not constrained to public view at all times, with opportunities to retreat to secluded areas.
- Prioritize welfare and behavioral needs over rigid display requirements, maintaining a balance between public education and animal well-being.

→ **Long-term Conservation breeding plans** – To ensure the programs remain goal-oriented and effective, it is imperative to develop species-specific conservation breeding management plans. These plans, emerge as a key requirement of this assessment, should cover at least a 10-year horizon and include clearly defined objectives, measurable indicators of success, and strategies for achieving targets. While there has been no standardized format for these plans historically, this report provides a template to be followed. Every species identified for planned breeding programs must have such a plan in place to ensure program alignment with broader conservation goals.

→ **Technical Oversight** – The technical complexity of conservation breeding programs necessitates guided oversight beyond the capacity of individual zoos. The Central Zoo Authority (CZA) should lead efforts to develop species-specific conservation breeding plans through targeted workshops. These workshops should follow structured formats, such as Integrated Collection Assessment and Planning (ICAP) workshops or Conservation Needs Assessments[10], and focus on species identified under Scenarios 3 and 4, as well as already identified species requiring refinement in management strategies.

The workshops should involve subject-matter experts, zoo professionals, and conservation biologists to ensure robust and scientifically sound plans. They will also help assess the infrastructure, technical expertise, and resource availability of participating zoos, thereby providing critical insights into the competence of zoos to fulfill roles as coordinating or participating institutions for conservation breeding.

In addition to developing and refining breeding plans, the workshops can facilitate collaboration, capacity building, and the integration of advanced tools for population management, enclosure design, and species-specific behavioral monitoring. By embedding technical oversight into the conservation breeding framework, the CZA can ensure that

[10] https://www.conservationneeds.org/

programs remain scientifically rigorous, collaborative, and aligned with long-term conservation goals.

→ **Mentorship and Review Mechanisms** – Given the intensive and long-term nature of conservation breeding programs, the designation of mentors with expertise in species biology, population management, and captive breeding is proposed. Mentors should ideally be assigned at the species level or, where this is not feasible, at the order level. These mentors would act as focal points, offering regular guidance to zoos, addressing operational and technical challenges, and ensuring that programs align with conservation objectives.

Periodic reviews—conducted at least every three years—should assess progress against defined targets, identify gaps, and recommend corrective actions to maintain program efficacy. The continuity of these reviews is essential for sustaining the quality and relevance of conservation efforts. A tentative evaluation format, outlined in Appendix I, identifies the critical aspects to be addressed during these reviews. This format should be refined following a few pilot evaluations to assess its suitability for objective field data collection, ease of implementation, and its capacity to generate robust insights that enable a comprehensive and effective review process.

Given the technical nature of conservation breeding programs, these evaluations require a specialized and intensive approach distinct from routine zoo evaluation. While they may be coupled with periodic zoo evaluations, it is crucial that conservation breeding reviews are conducted independently, ensuring focused attention on the intricacies of these programs.

Furthermore, the scientific nature of the data collection demands that the evaluations be carried out by qualified personnel with expertise in conservation breeding and familiarity with the principles of scientific population management. Such an approach will ensure that the reviews yield reliable and actionable insights, strengthening the overall impact and effectiveness of conservation breeding initiatives.

Additionally, given the valuable insights gained by the committee members involved in this review, it may be beneficial to involve these members in the long-term for planning and coordination. Their involvement could include providing technical oversight, conducting higher-level evaluations of ongoing breeding programs, and refining long-term management plans. This approach ensures that the expertise acquired during the review process is continuously leveraged to enhance program outcomes.

→ **Integration with International Programs** – Conservation breeding efforts in Indian

zoos must not function in isolation but rather align with global initiatives to maximize their impact. Many species identified for planned breeding have populations managed in foreign zoos, offering opportunities for collaboration to enhance genetic diversity, population health, and long-term viability. Integration with international programs, such as Global Species Management Plans (GSMPs) and Regional Collection Plans (RCPs), can provide technical expertise, access to unrelated founders, and advanced tools for genetic and demographic management.

International partnerships can also enable knowledge exchange and capacity building through joint workshops, expert consultations, and cross-border research initiatives. Leveraging these collaborations will help Indian conservation breeding programs stay aligned with global best practices while contributing meaningfully to the species' conservation at an international scale. To this end, the Central Zoo Authority (CZA) should establish formal linkages with global zoo associations and international conservation bodies to ensure seamless coordination and mutual benefits.

Blyth's Tragopan (Tragopan blythii) at satellite conservation breeding centre of Nagaland Zoological Park in Kohima.

6 Concluding remarks

Effective conservation breeding programs require a paradigm shift from isolated zoo-level management to a population-centric approach, where all institutions housing a species are collaboratively managed as part of a coordinated metapopulation. This approach ensures that genetic diversity, demographic stability, and behavioral integrity are maintained across the entire captive population rather than being confined to isolated subpopulations.

Key principles of this paradigm include the development of structured breeding plans informed by pedigree and genetic analyses, strategic inter-zoo transfers to minimize inbreeding, and the establishment of collaborative management frameworks involving all participating institutions. Advanced analytical tools, such as population viability analysis, molecular genetic studies, and demographic modeling, should underpin these efforts, enabling evidence-based decision-making.

Conservation breeding extends beyond demographic and genetic management to incorporate the behavioral dimension, which is critical to the success of reintroduction and species recovery efforts. Captive populations must not only be genetically diverse and demographically stable but also behaviorally competent, exhibiting species-typical traits such as foraging, social interactions, reproduction, predator avoidance, and other natural behaviors essential for survival in the wild.

The interplay between genetic diversity, demographic stability, and behavior is fundamental to conservation success. Inbreeding or genetic bottlenecks can lead to reduced fitness, manifesting as impaired reproduction, social dysfunction, or maladaptive traits. Maintaining genetic diversity is essential to preserve behavioral plasticity, enabling species to adapt to dynamic environments. Simultaneously, demographic factors such as skewed sex ratios, small group sizes, or overcrowding can disrupt social structures necessary for species-specific behaviors, impacting both individual welfare and population dynamics.

Furthermore, population management must adopt adaptive strategies to address emerging challenges such as habitat alteration, disease risks, or evolving conservation priorities. This requires flexibility in planning and implementation, ensuring that conservation actions remain responsive to changing conditions.

By integrating genetic, demographic, and behavioral considerations into a cohesive population management framework, Indian zoos can significantly enhance the impact of their conservation breeding programs. This approach will ensure that captive populations remain viable and ecologically functional, capable of supporting broader efforts to restore and sustain species in the wild.

APPENDICIES

A Species prioritised for planned breeding in recognised zoos.

No.	Species
1	Pygmy hog (*Sus salvanius*)
2	*G.bengalensis, G.indicus, G.tenuirostris*
3	Hangul (*Cervus elaphus hanglu*)
4	Golden langur (*Trachypithecus geei*)
5	Wild Water Buffalo (*Bubalus arnee*)
6	Brow-antlered deer (*Rucervus eldii*)
7	Lion-tailed Macaque (*Macaca silenus*)
8	Red Panda (*Ailurus fulgens fulgens*)
9	Blyth's Tragopan (*Tragopan blythii*)
10	Asiatic lion (*Panthera leo persica*)
11	Greated One-horned Rhino (*Rhinoceros unicornis*)
12	Western Tragopan (*Tragopan melanocephalus*)
13	Phayre's Leaf Macaque (*Trachypithecus phayrei*)
14	Great Indian bustard (*Ardeotis nigriceps*)
15	Indian Wild Ass (*Equus hemionus khur*)
16	Nilgiri Langur (*Semnopithecus johnii*)
17	Alpine Musk Deer (*Moschus chrysogaster*)
18	Hoolock Gibbon (*Hoolock hoolock*)
19	Barasingha (*R. d. branderi*)
20	Nilgiri Tahr (*Nilgiritragus hylocrius*)
21	*Houbaropsis bengalensis* & *Sypheotides indicus*
22	Cheer Pheasant (*Catreus wallichi*)
23	Clouded Leopard (*Neofelis nebulosa*)
24	Red-crowned Roof Turtle (*Batagur kachuga*)
25	Snow Leopard (*Panthera uncia*)
26	Shaheen Falcon (*Falco peregrinus peregrinator*)

B Analysis of population trends of select species in planned breeding programs.

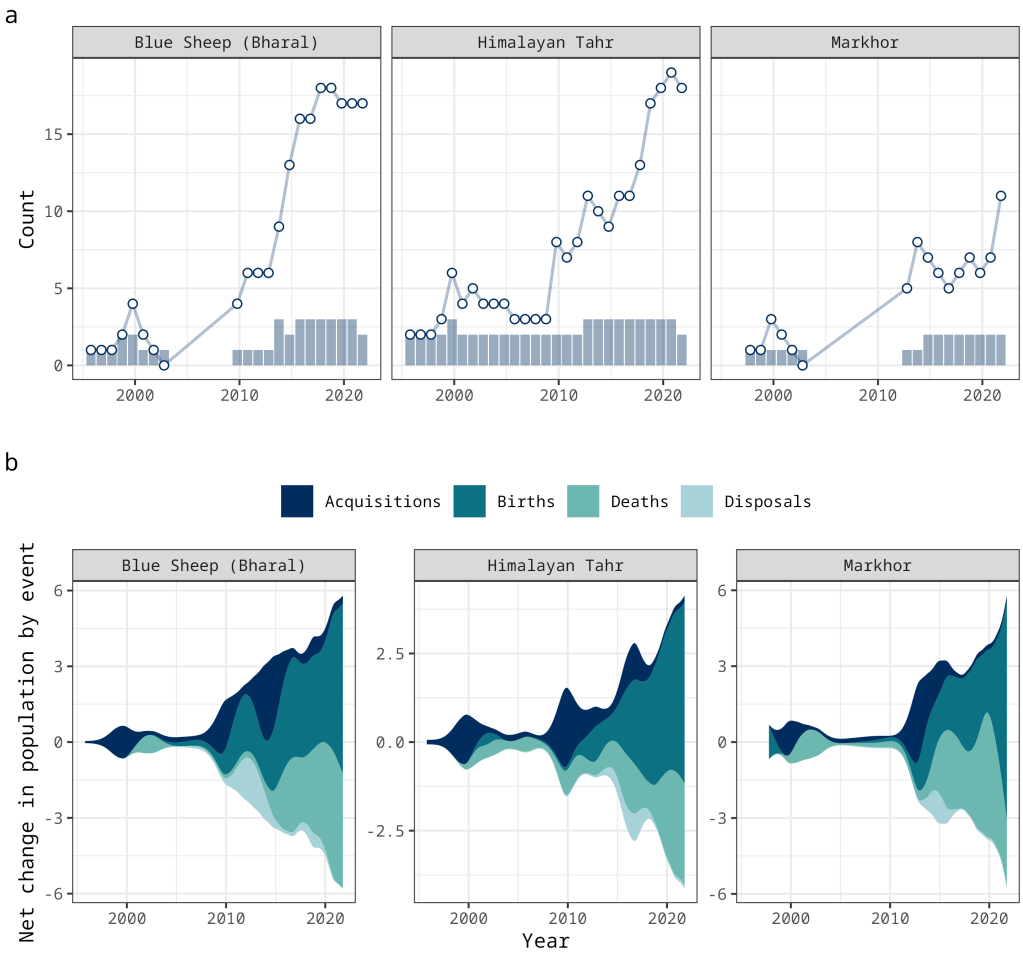


Figure A-1: Status of *Pseudois nayaur*, *Hemitragus jemlahicus* & *Capra falconeri*. (a) Population size over time, with bars indicating the number of holding institutions and line representing cumulative number of individuals across holding institutions and the general population trajectory; (b) Annual net change in population size attributed to acquisitions, births, deaths, and disposals.

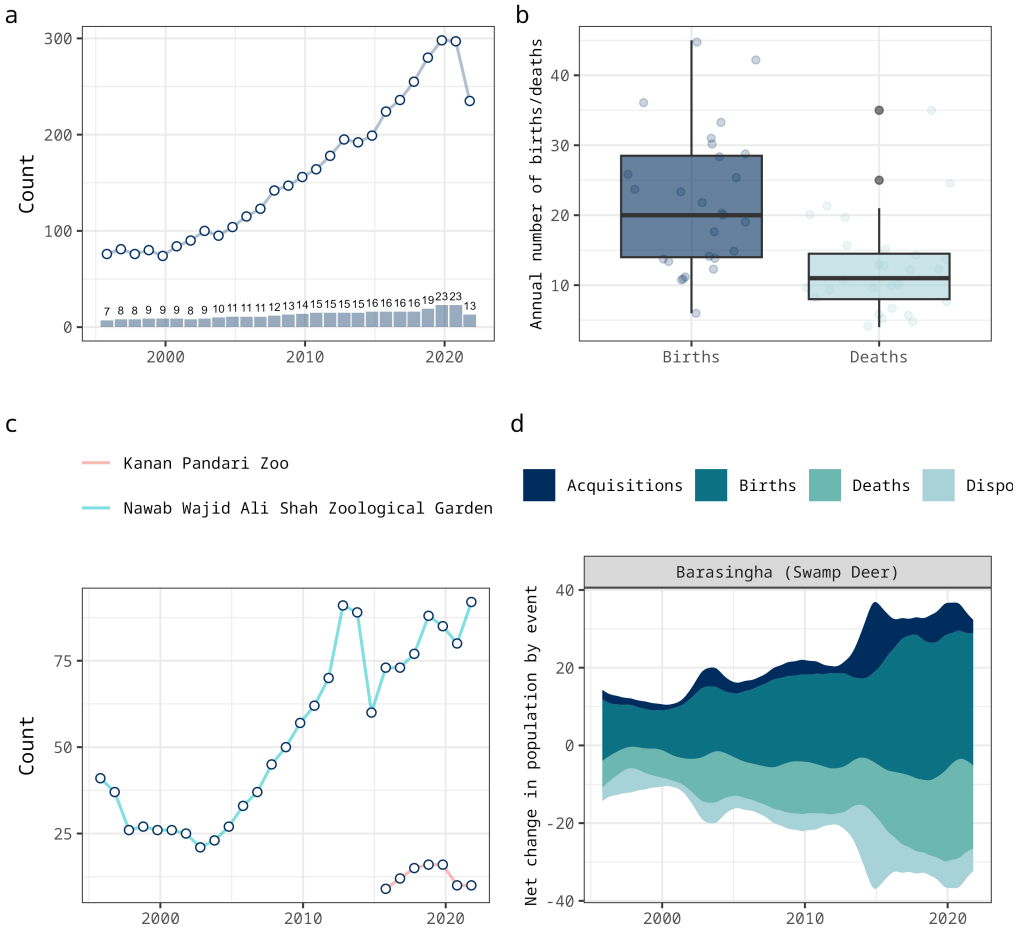


Figure A-2: Population trends and vital statistics of *R.duvaucelii ssp* in select zoos.(a) Population size over time, with bars indicating the number of holding institutions and line representing cumulative number of individuals across holding institutions and the general population trajectory. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends of Barasingha at Kanan Pandari Zoo and Nawab Wajid Ali Shah Zoological Garden, highlighting differences in population dynamics between the two zoos. (d) Stacked area chart illustrating net changes in population by event type (acquisitions, births, deaths, disposals) for Barasingha from 1998 to 2023, demonstrating key population drivers.

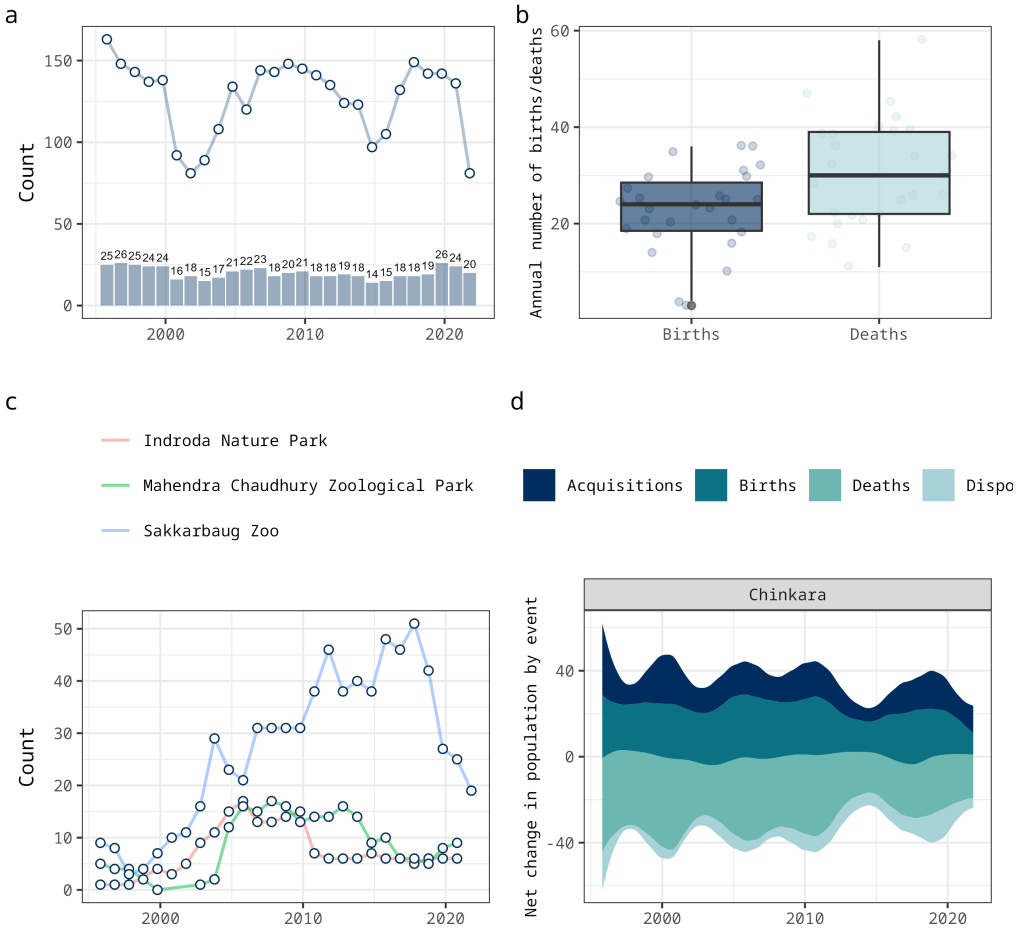


Figure A-3: Population trends and vital statistics of *G.bennettii ssp* in select zoos.(a) Population size over time, with bars indicating the number of holding institutions and line representing cumulative number of individuals across holding institutions and the general population trajectory. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across three zoos: Indroda Nature Park, Mahendra Chaudhury Zoological Park, and Sakkarbaug Zoo, demonstrating differences in management and population dynamics. (d) Stacked area chart illustrating net changes in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, demonstrating key population drivers.

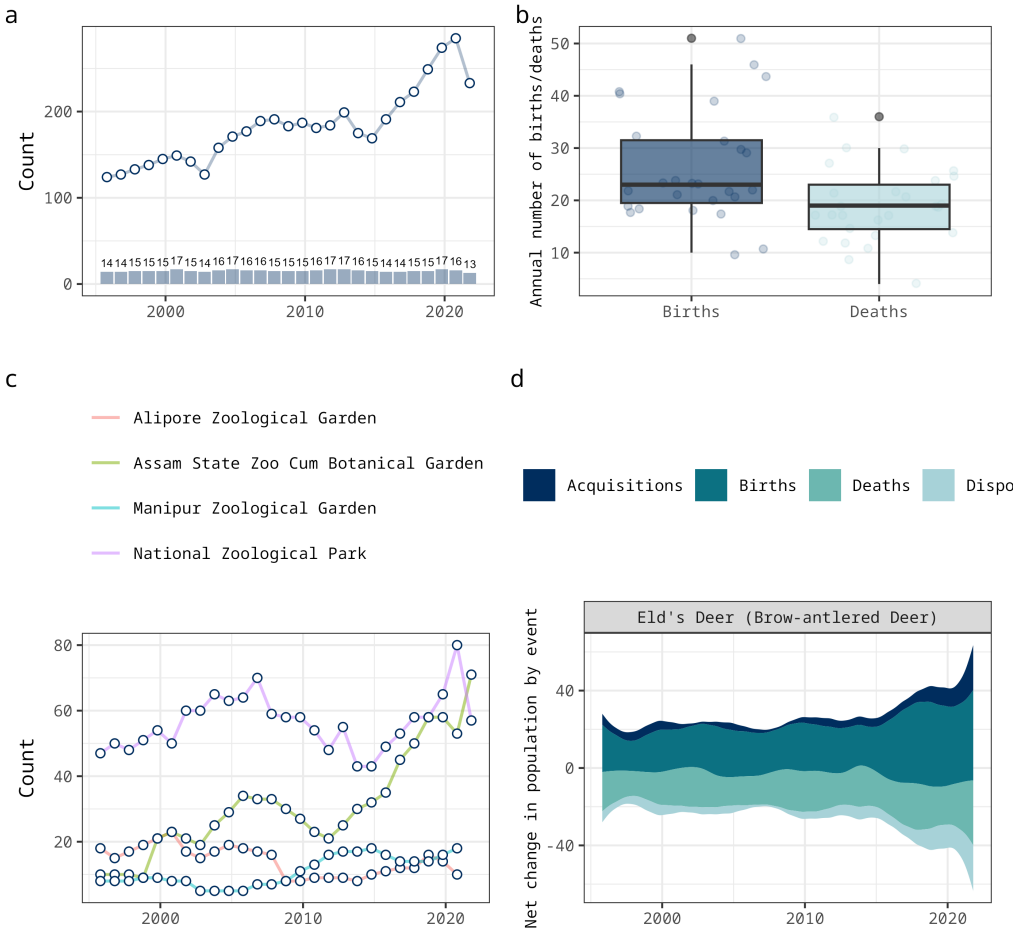


Figure A-4: Population trends and vital statistics of *R.e. eldii* in select zoos.(a) Annual closing population counts of Rucervus eldii from 1998 to 2023, with number of holding institutions as bars below. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across four zoos: Alipore Zoological Garden, Assam State Zoo cum Botanical Garden, Manipur Zoological Garden, and National Zoological Park, illustrating differences in population management. (d) Stacked area chart showing the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insights into the factors influencing population dynamics in captivity.

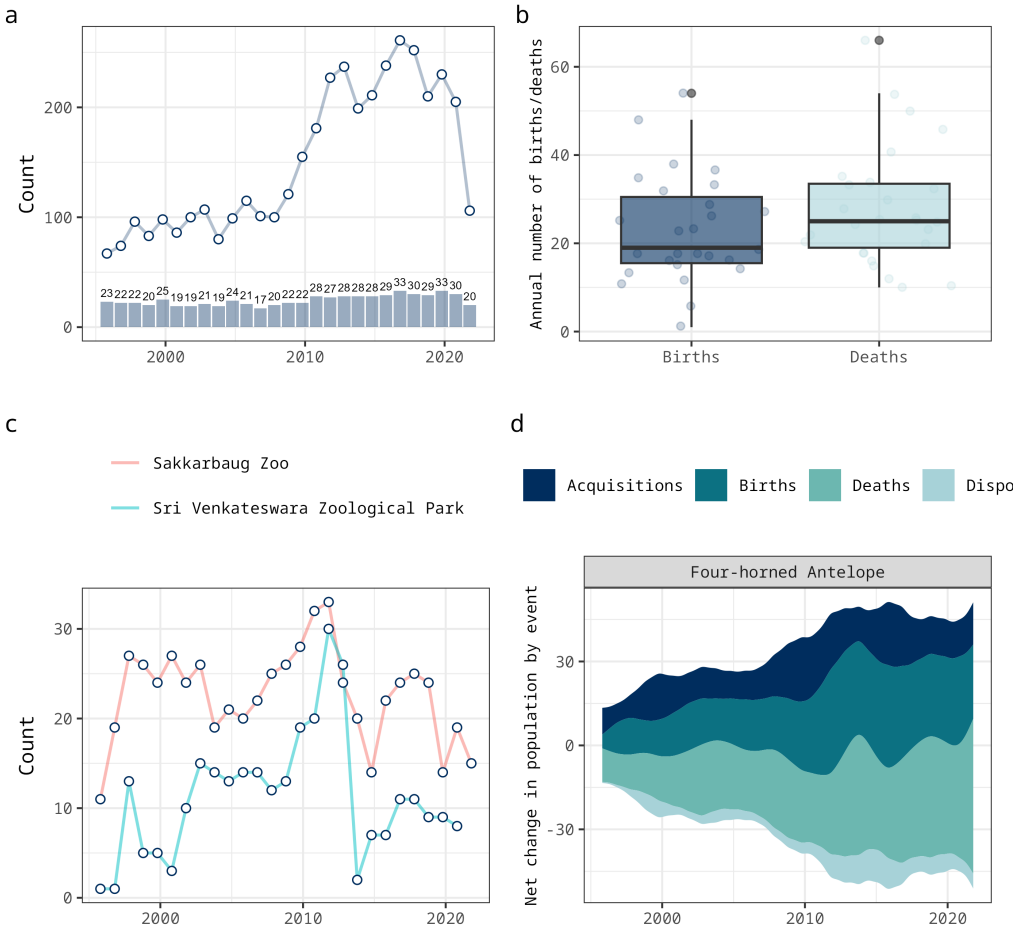


Figure A-5: Population trends and vital statistics of *T.quadricornis ssp.* in select zoos. (a) Annual closing population counts of *T.quadricornis ssp.* from 1998 to 2023, with number of holding institutions as bars below. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends between Sakkarbaug Zoo and Sri Venkateswara Zoological Park, highlighting differences in population management across the two participating zoos. (d) Stacked area chart showing the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insights into the factors influencing population dynamics in captivity.

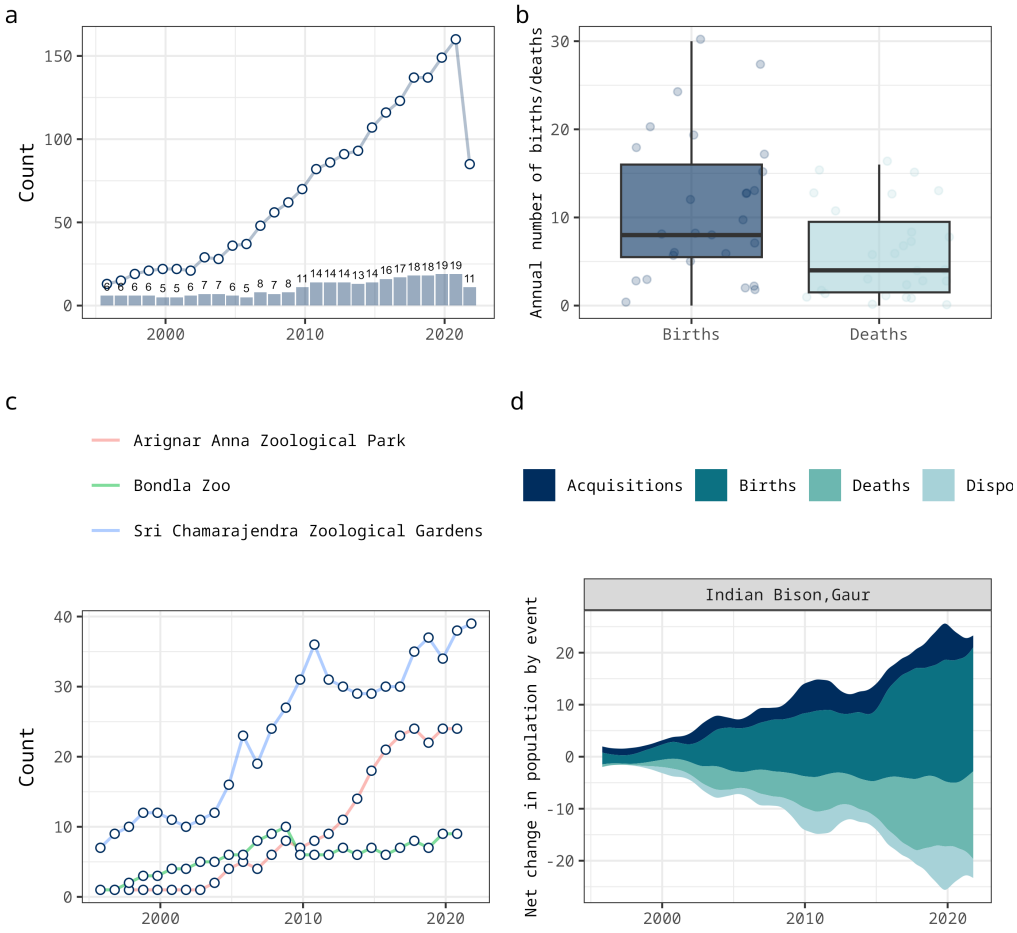


Figure A-6: Population trends and vital statistics of *B.gaurus* in select zoos. (a) Annual closing population counts of *B.gaurus* from 1998 to 2023, with number of holding institutions as bars below. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across three zoos: Arignar Anna Zoological Park, Bondla Zoo, and Sri Chamarajendra Zoological Gardens, showing differences in management and population growth over time. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *B.gaurus* in captivity.

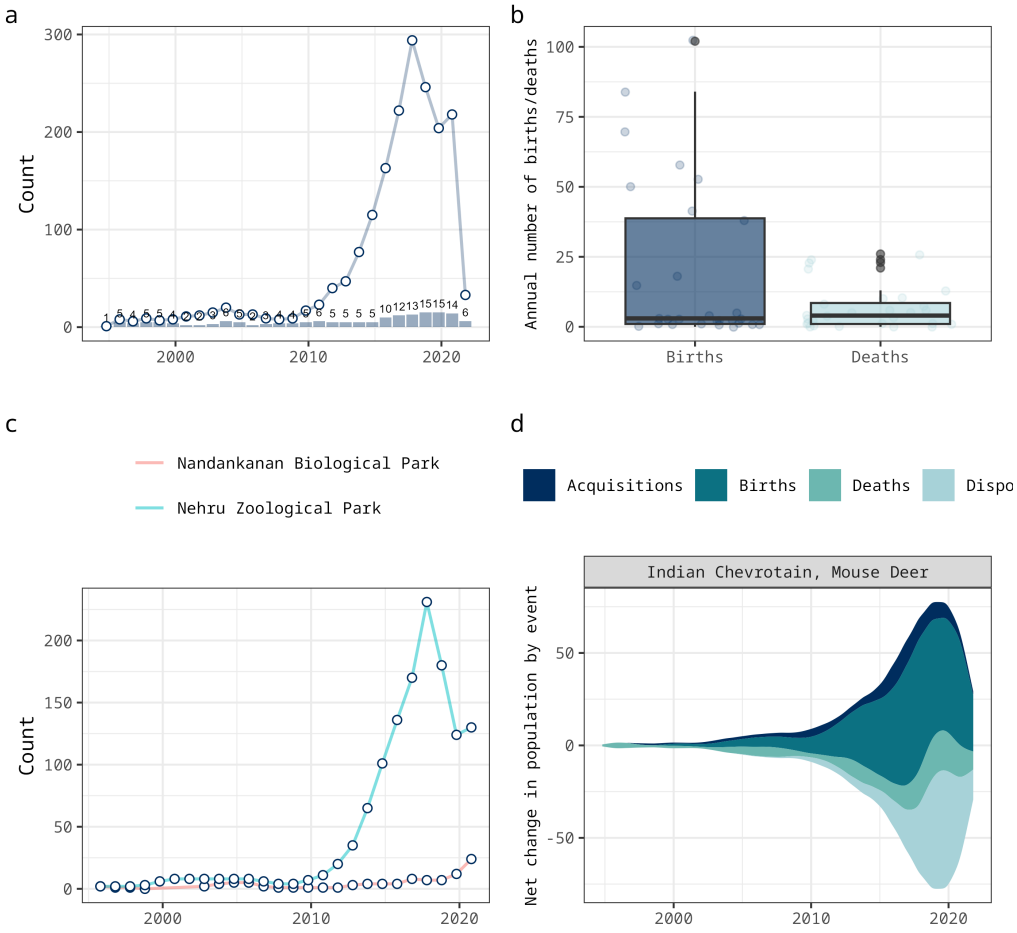


Figure A-7: Population trends and vital statistics of *M.indica* in select zoos. (a) Annual closing population counts of *M.indica* from 1998 to 2023, with number of holding institutions as bars below. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends between Nandankanan Biological Park and Nehru Zoological Park, highlighting differences in population growth across the two zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *M.indica* in captivity.

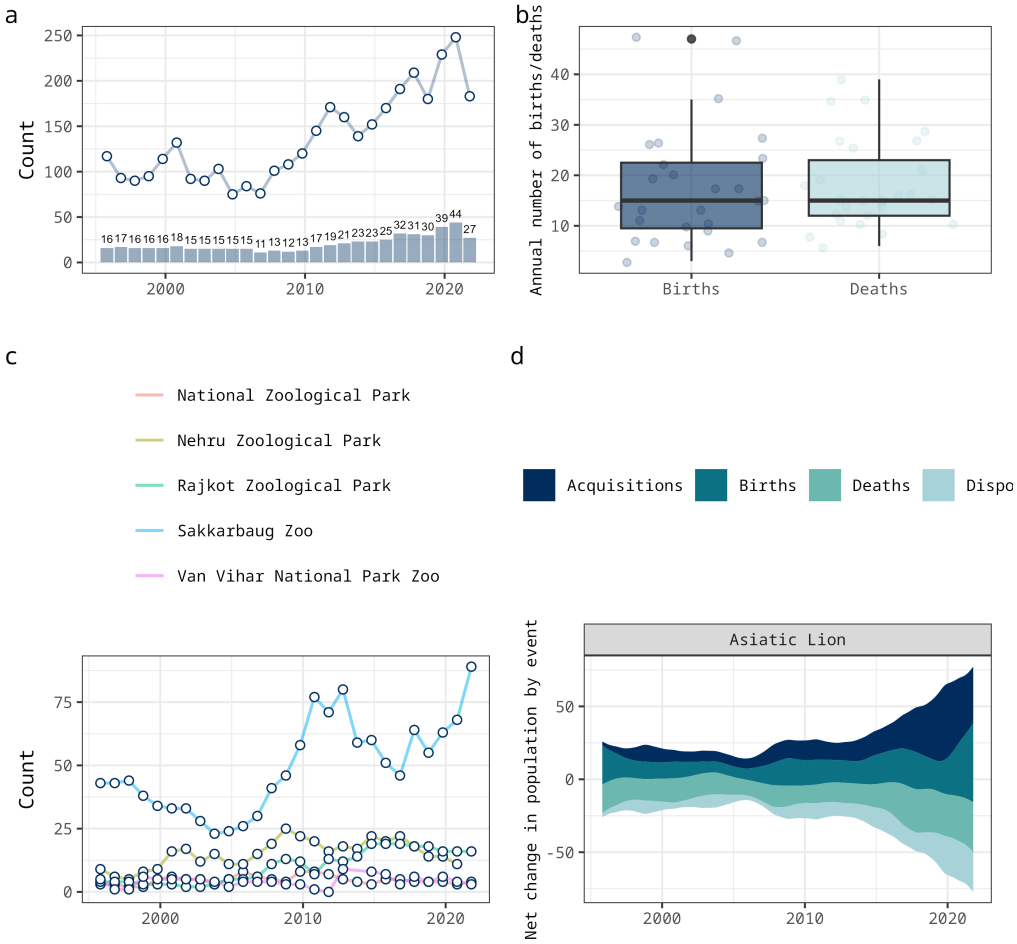


Figure A-8: Population trends and vital statistics of *P.l. persica* in select zoos. (a) Annual closing population counts of *P.l. persica* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across five zoos: National Zoological Park, Nehru Zoological Park, Rajkot Zoological Park, Sakkarbaug Zoo, and Van Vihar National Park Zoo, showing differences in population management and growth. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *P.l. persica* in captivity.

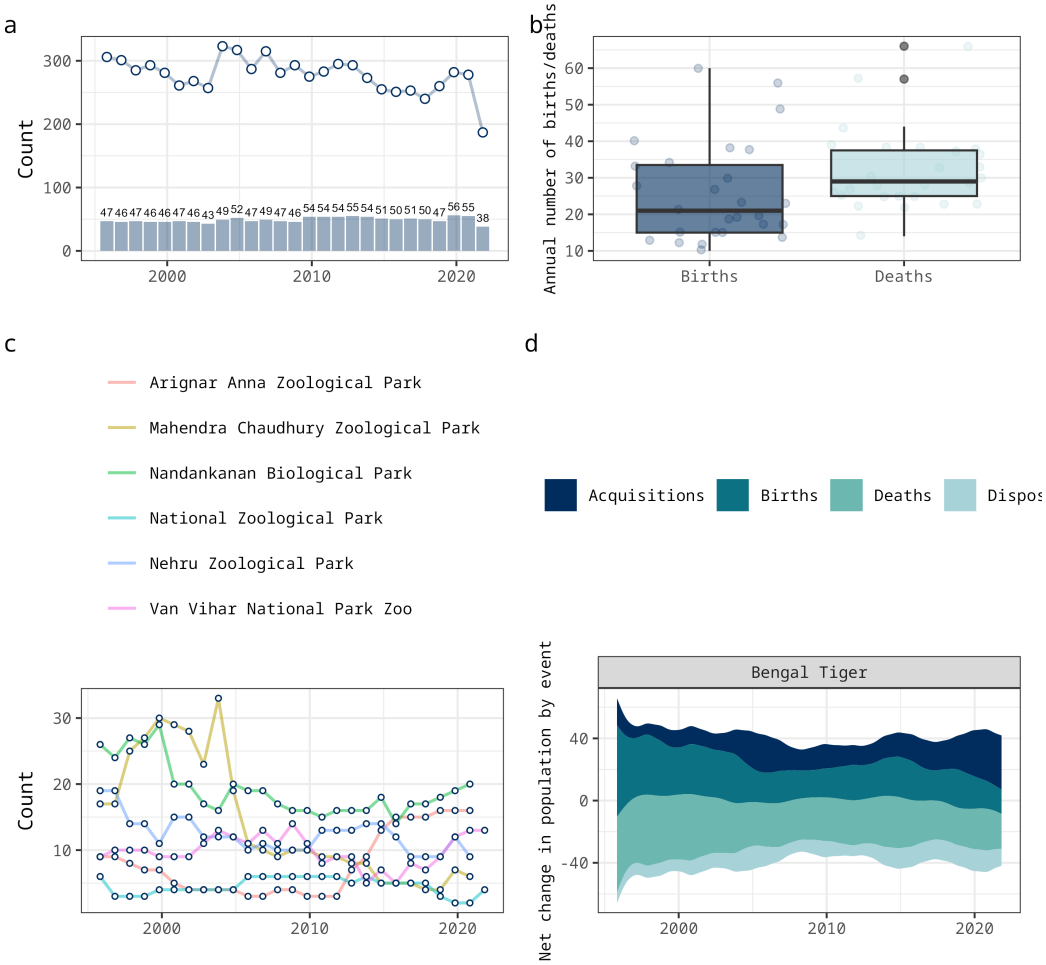


Figure A-9: Population trends and vital statistics of *P.t. tigris* in select zoos. (a) Annual closing population counts of *P.t. tigris* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across six participating zoos: Arignar Anna Zoological Park, Mahendra Chaudhury Zoological Park, Nandankanan Biological Park, National Zoological Park, Nehru Zoological Park, and Van Vihar National Park Zoo, highlighting differences in population management. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *P.t. tigris* in captivity.

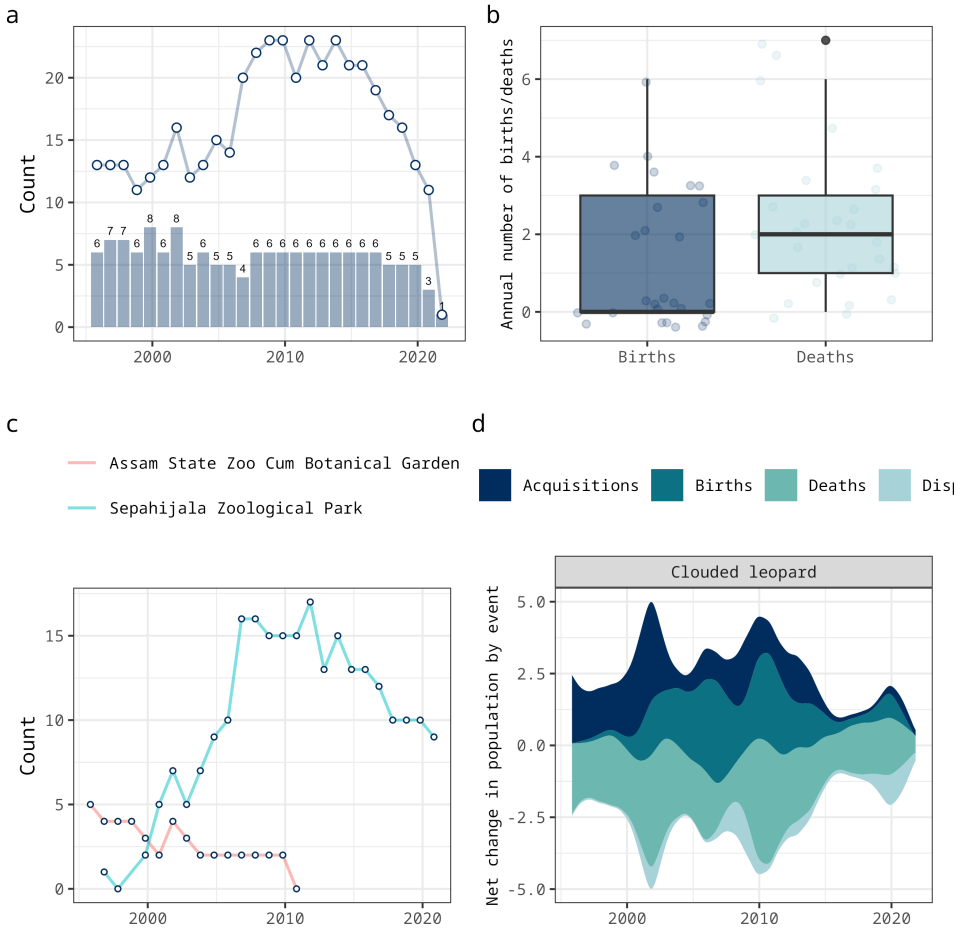


Figure A-10: Population trends and vital statistics of *N.nebulosa* in select zoos. (a) Annual closing population counts of *N.nebulosa* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends between Assam State Zoo cum Botanical Garden and Sepahijala Zoological Park, highlighting differences in population dynamics and management practices across these zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *N.nebulosa* in captivity.

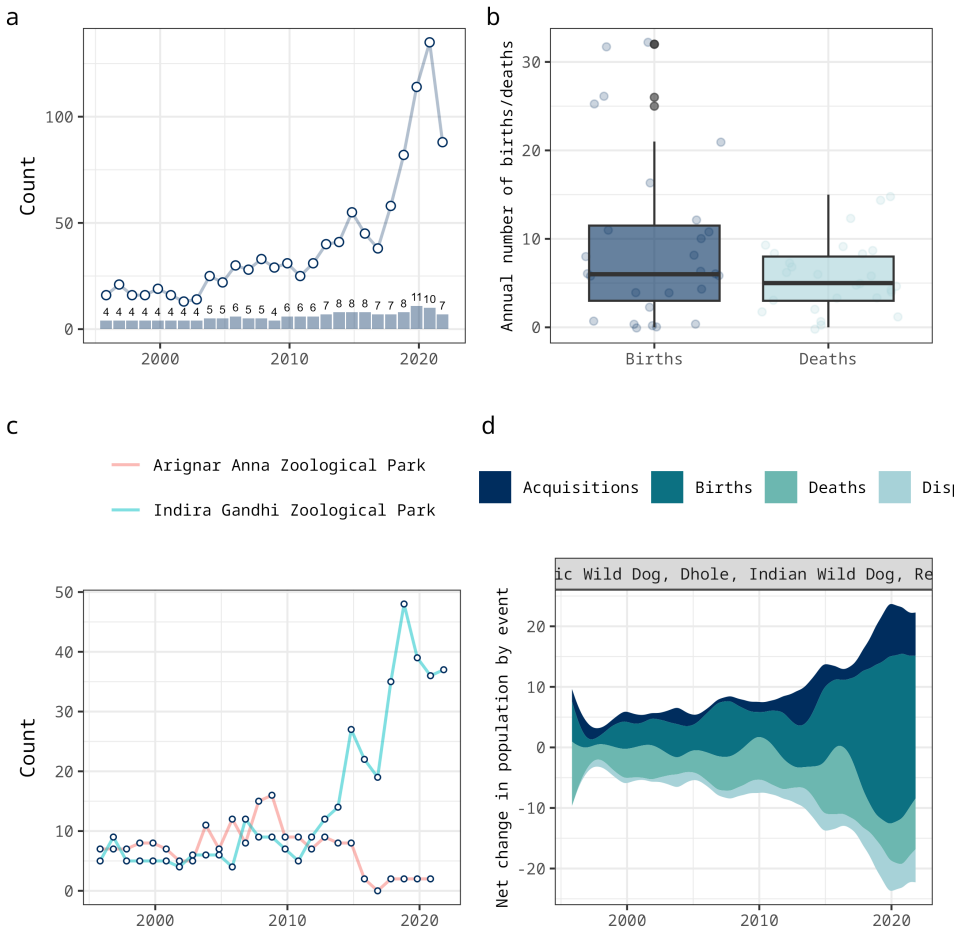


Figure A-11: Population trends and vital statistics of *C.alpinus* in select zoos. (a) Annual closing population counts of *C.alpinus* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends between Arignar Anna Zoological Park and Indira Gandhi Zoological Park, highlighting differences in population dynamics and management across these zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *C.alpinus* in captivity.

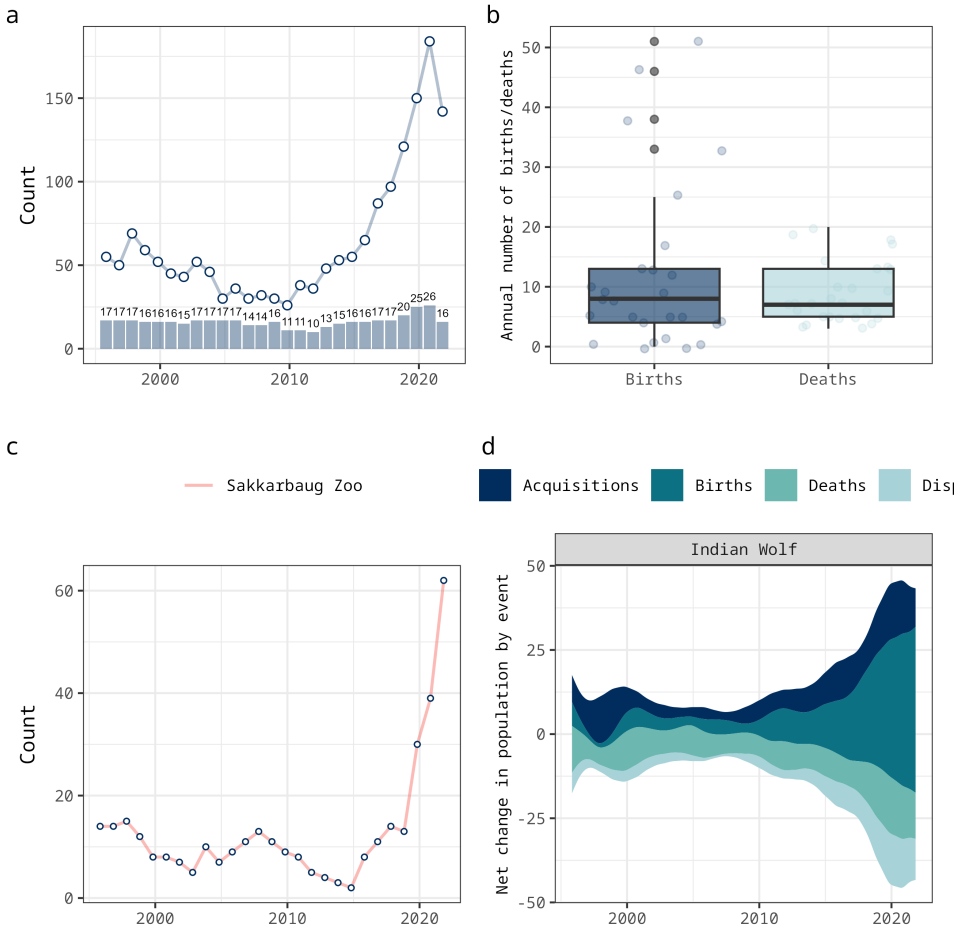


Figure A-12: Population trends and vital statistics of *C.l. pallipes* in select zoos. (a) Annual closing population counts of *C.l. pallipes* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Trend in coordinating zoo - Sakkarbag Zoo. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *C.l. pallipes* in captivity.

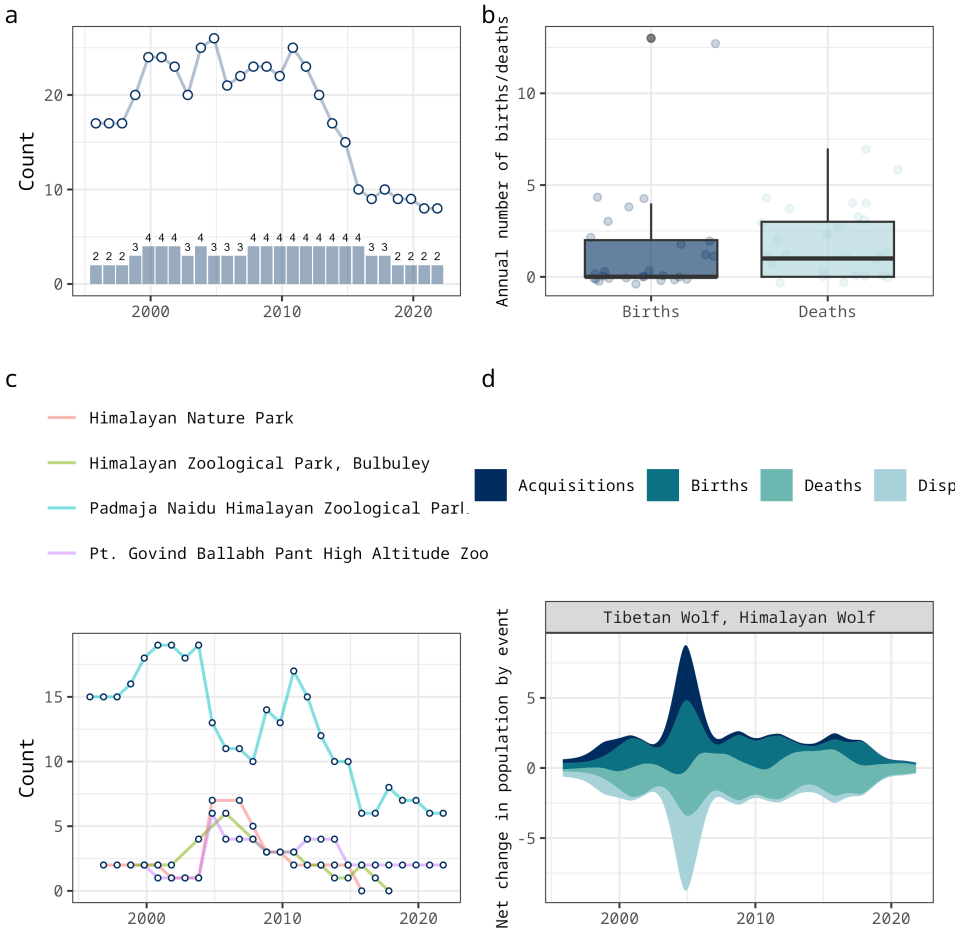


Figure A-13: Population trends and vital statistics of *C.l. chanco* in select zoos. (a) Annual closing population counts of *C.l. chanco* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across four zoos: Himalayan Nature Park, Himalayan Zoological Park (Bulbulay), Padmaja Naidu Himalayan Zoological Park, and Pt. Govind Ballabh Pant High Altitude Zoo. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *C.l. chanco* in captivity.

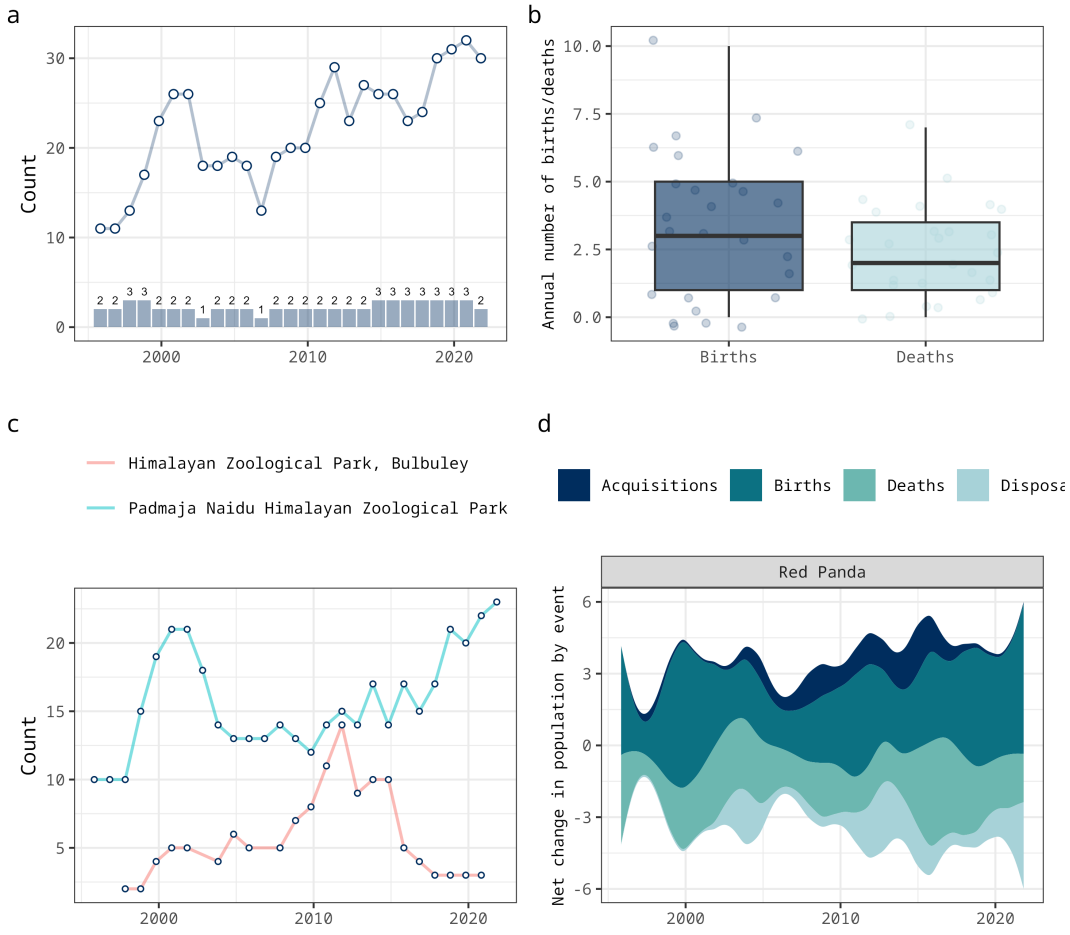


Figure A-14: Population trends and vital statistics of *A.f. fulgens* in select zoos. (a) Annual closing population counts of *A.f. fulgens* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends between Himalayan Zoological Park (Bulbulay) and Padmaja Naidu Himalayan Zoological Park. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *A.f. fulgens* in captivity.

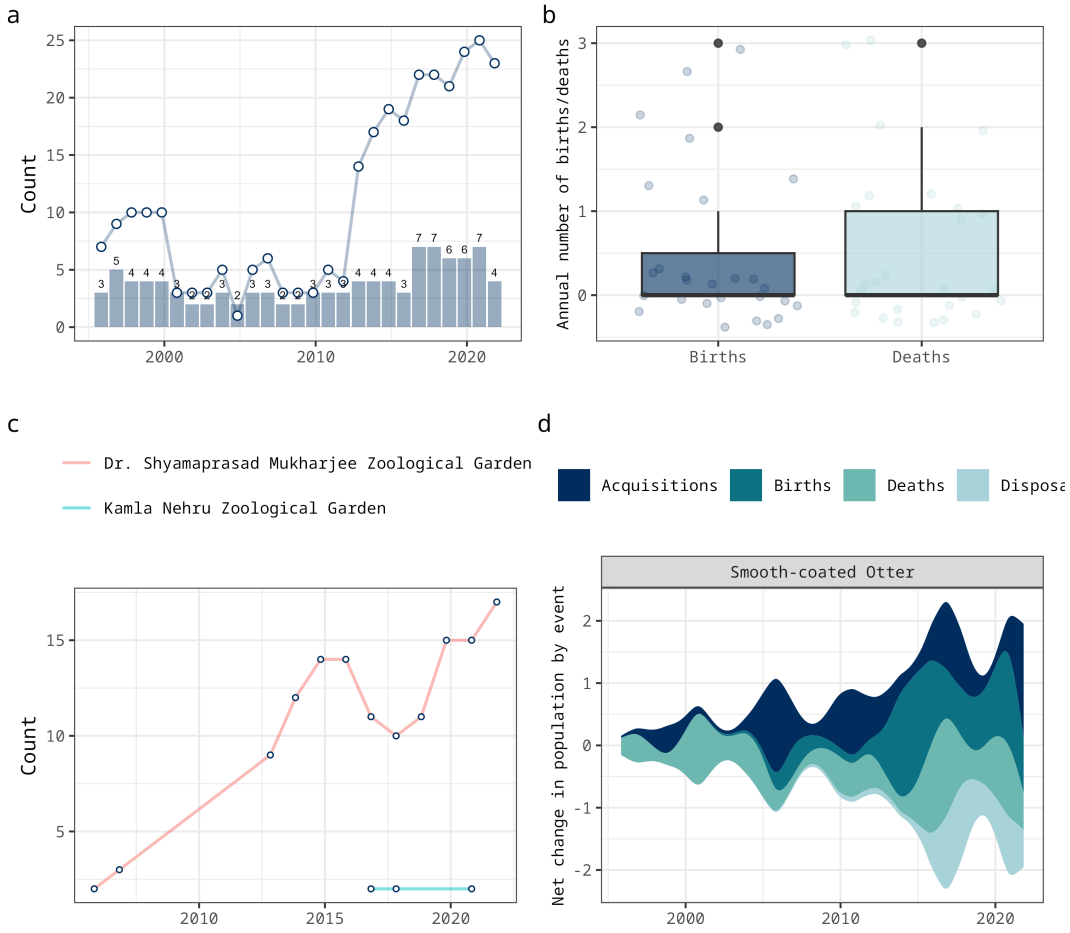


Figure A-15: Population trends and vital statistics of *L.perspicillata* in select zoos. (a) Annual closing population counts of *L. perspicillata* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends between Dr. Shyamaprasad Mukharjee Zoological Garden and Kamla Nehru Zoological Garden. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *L. perspicillata* in captivity.

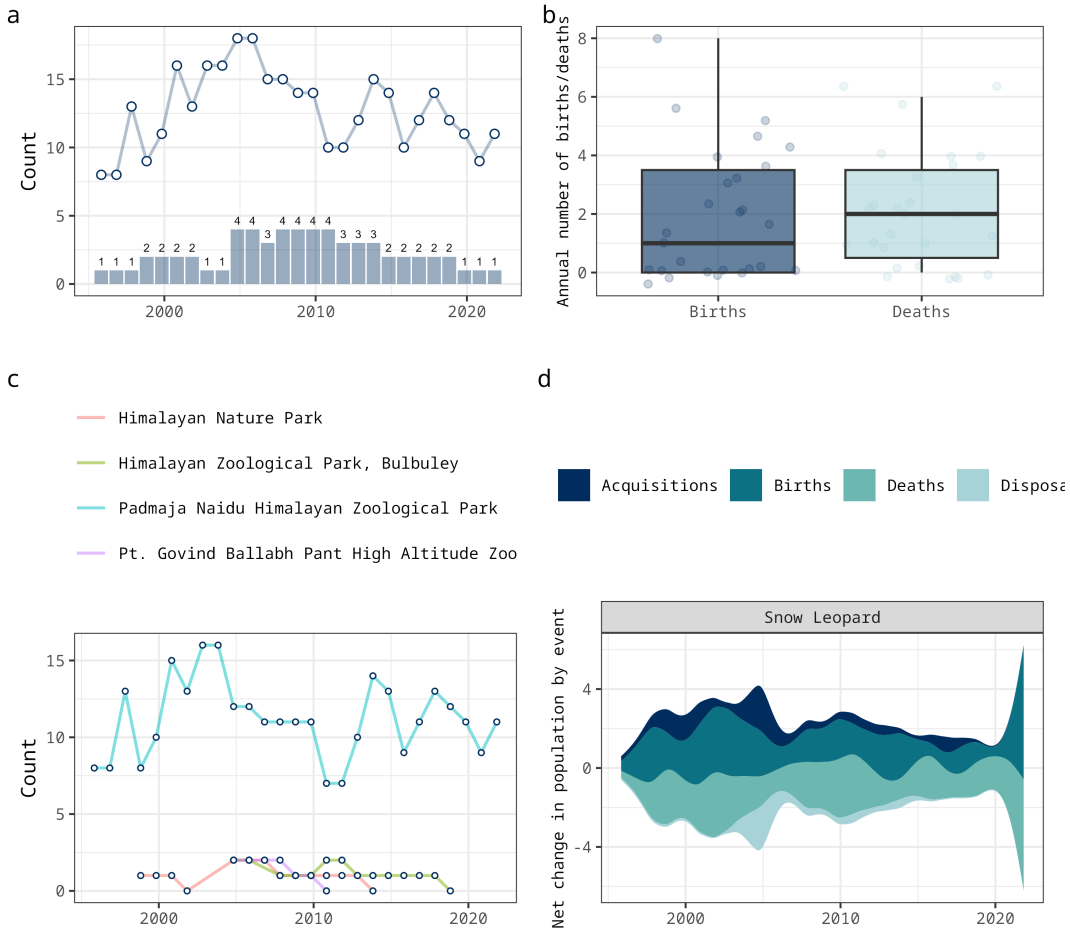


Figure A-16: Population trends and vital statistics of *P. unica* in select zoos. (a) Annual closing population counts of *P. unica* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across four zoos: Himalayan Nature Park, Himalayan Zoological Park (Bulbulay), Padmaja Naidu Himalayan Zoological Park, and Pt. Govind Ballabh Pant High Altitude Zoo. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *P. unica* in captivity.

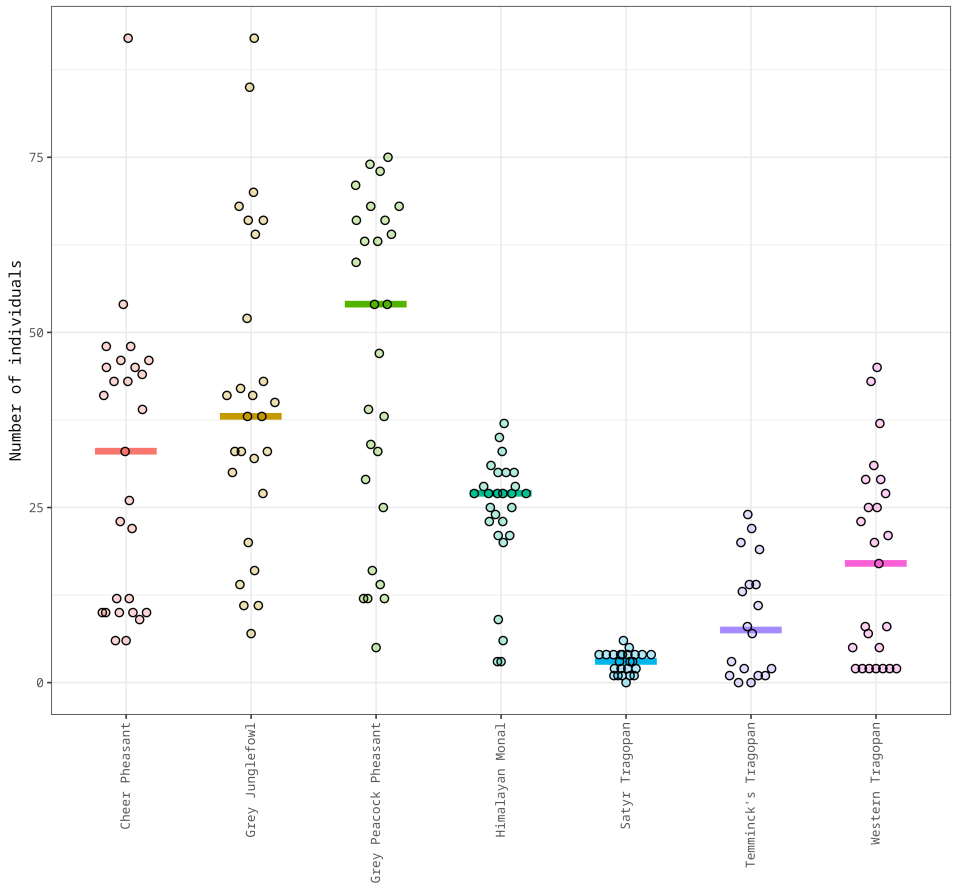


Figure A-17: Population distribution of selected threatened pheasant species in captivity, represented as individual counts across various zoo collections. Each species is depicted with individual data points showing the number of individuals maintained over the years, with horizontal bars indicating median population levels.

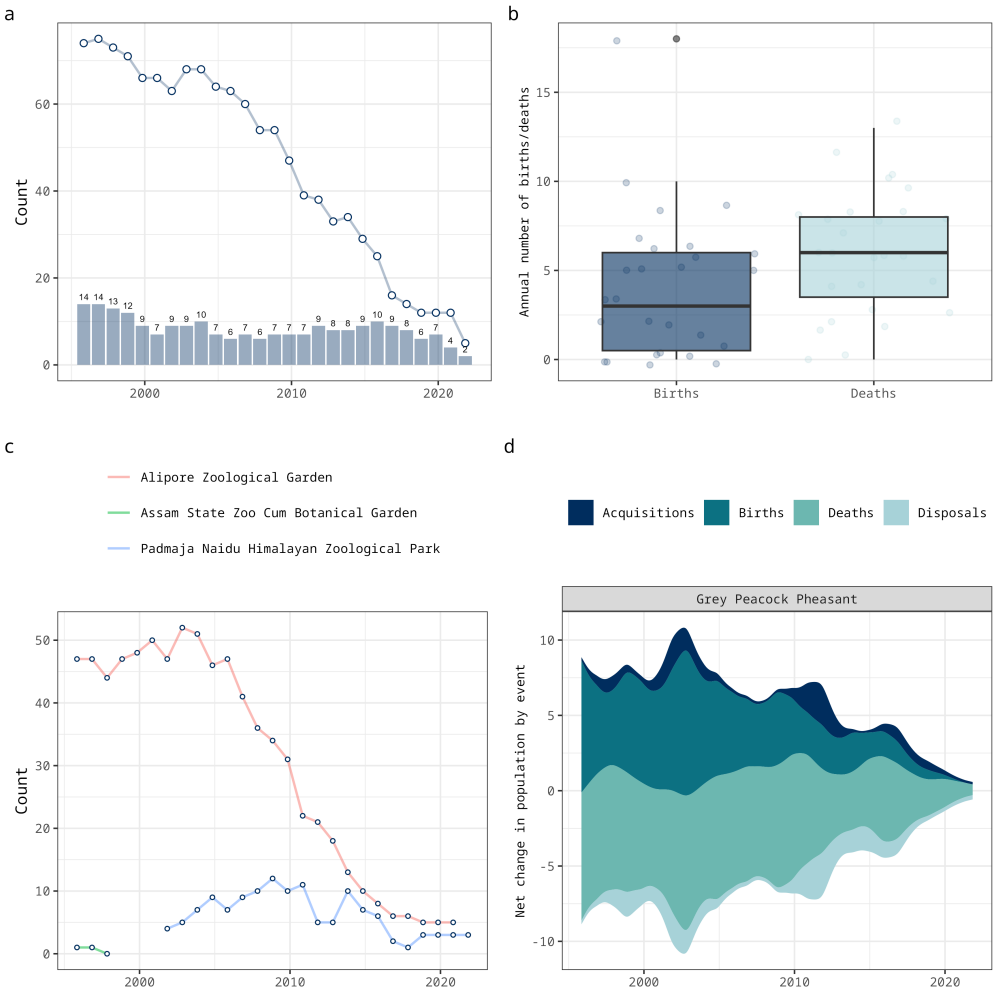


Figure A-18: Population trends and vital statistics of *P.bicalcaratum* in select zoos. (a) Annual closing population counts of *P.bicalcaratum* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *P.bicalcaratum* in captivity.

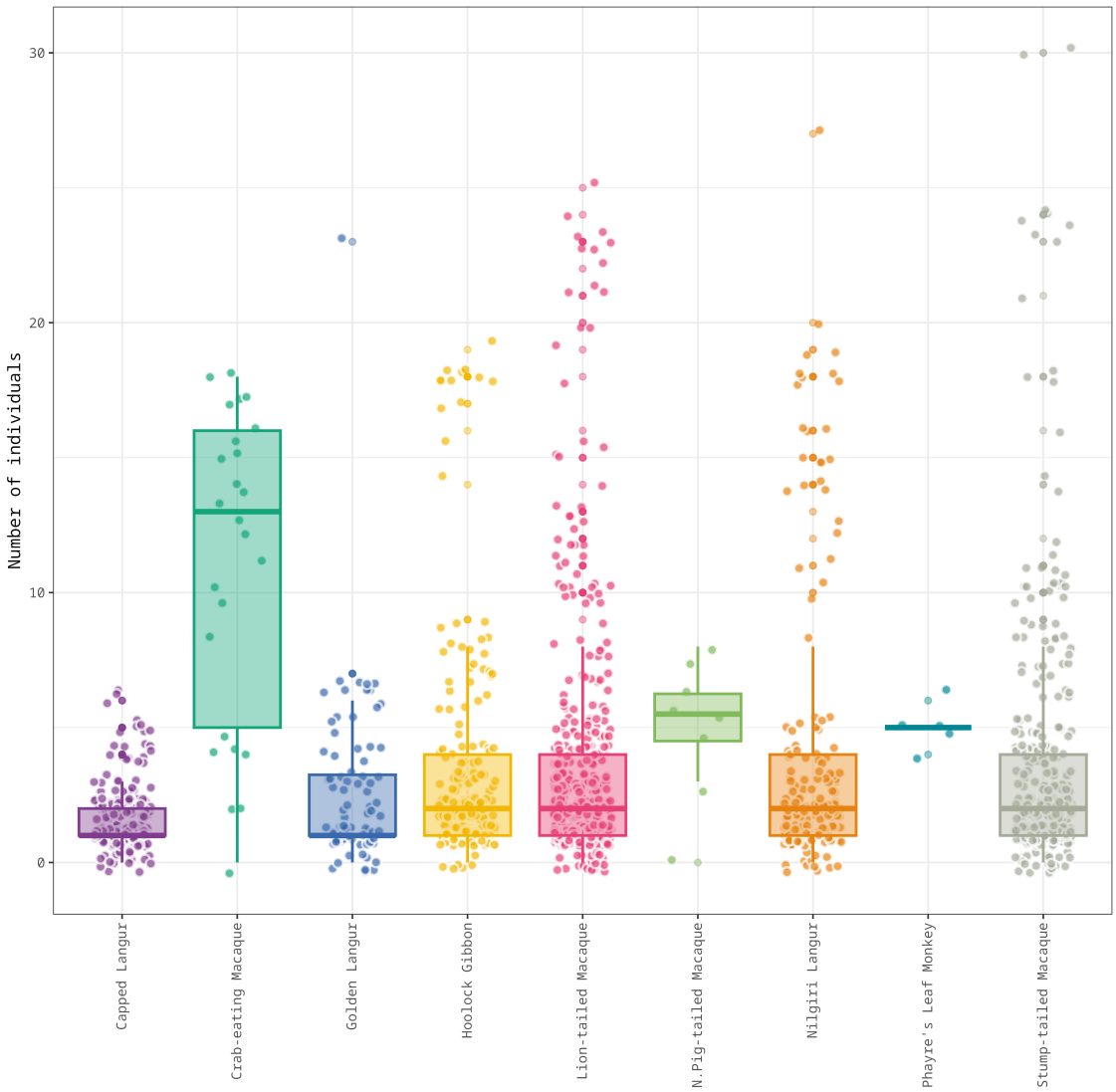


Figure A-19: Distribution of group sizes for different primate species in Indian zoos over multiple years. Each boxplot displays the median, interquartile range, and spread of group sizes for each species. Individual points indicate annual group sizes at different zoos, providing insight into variability across institutions and time.

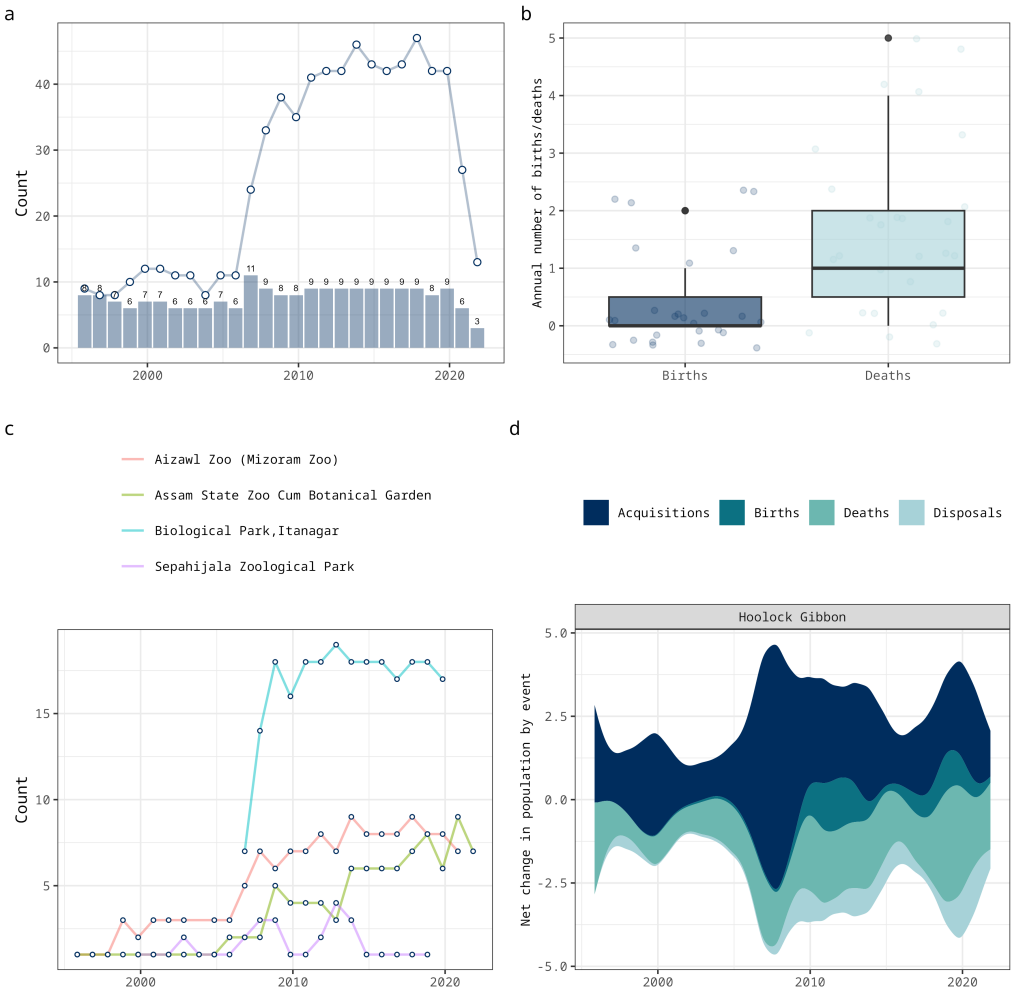


Figure A-20: Population trends and vital statistics of *H.hoolock* in select zoos. (a) Annual closing population counts of *H.hoolock* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *H.hoolock* in captivity.

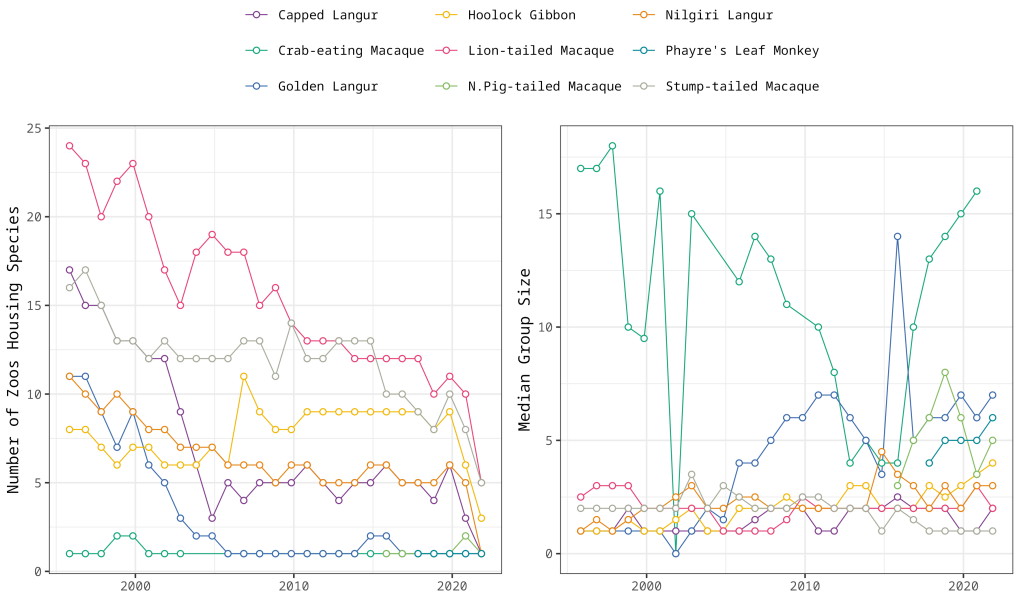


Figure A-21: Trends in the number of zoos housing each primate species (left) and median group sizes over time (right).

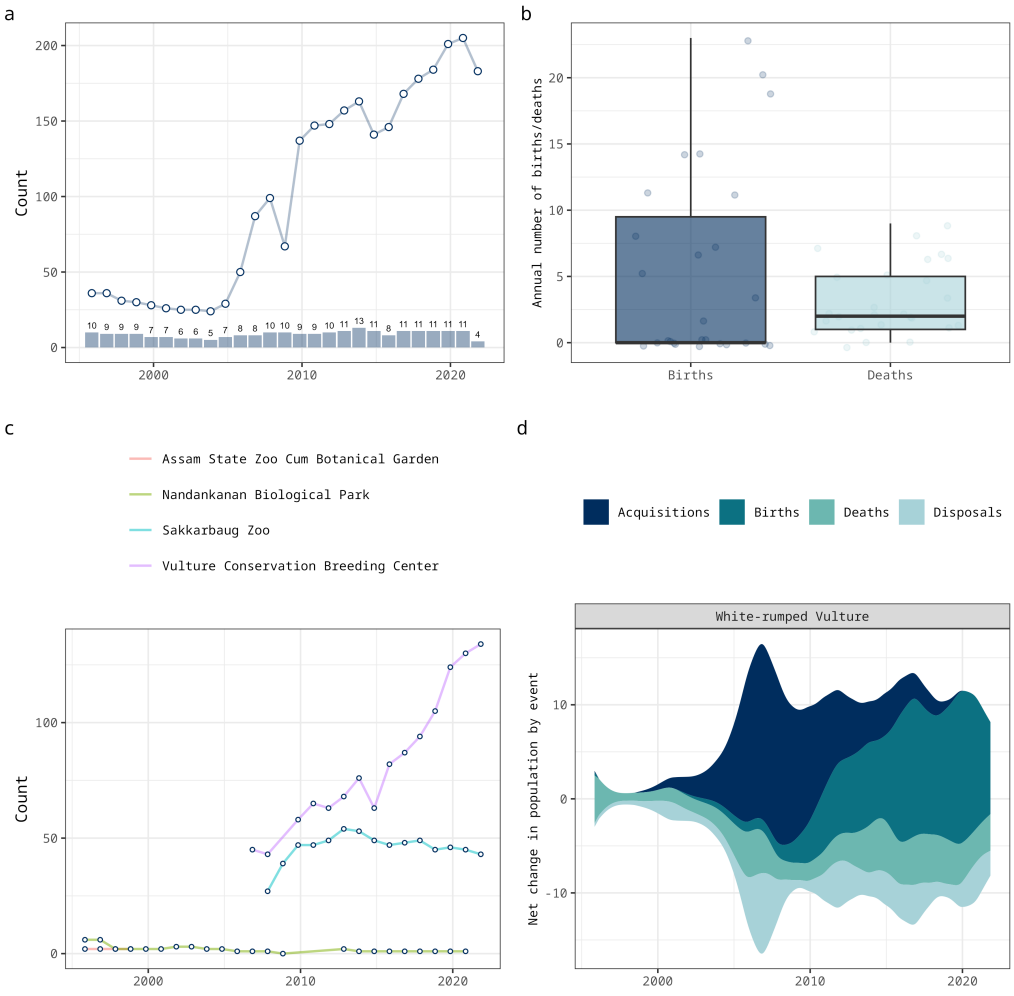


Figure A-22: Population trends and vital statistics of *G.bengalensis* in select zoos. (a) Annual closing population counts of *G.bengalensis* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *G.bengalensis* in captivity.

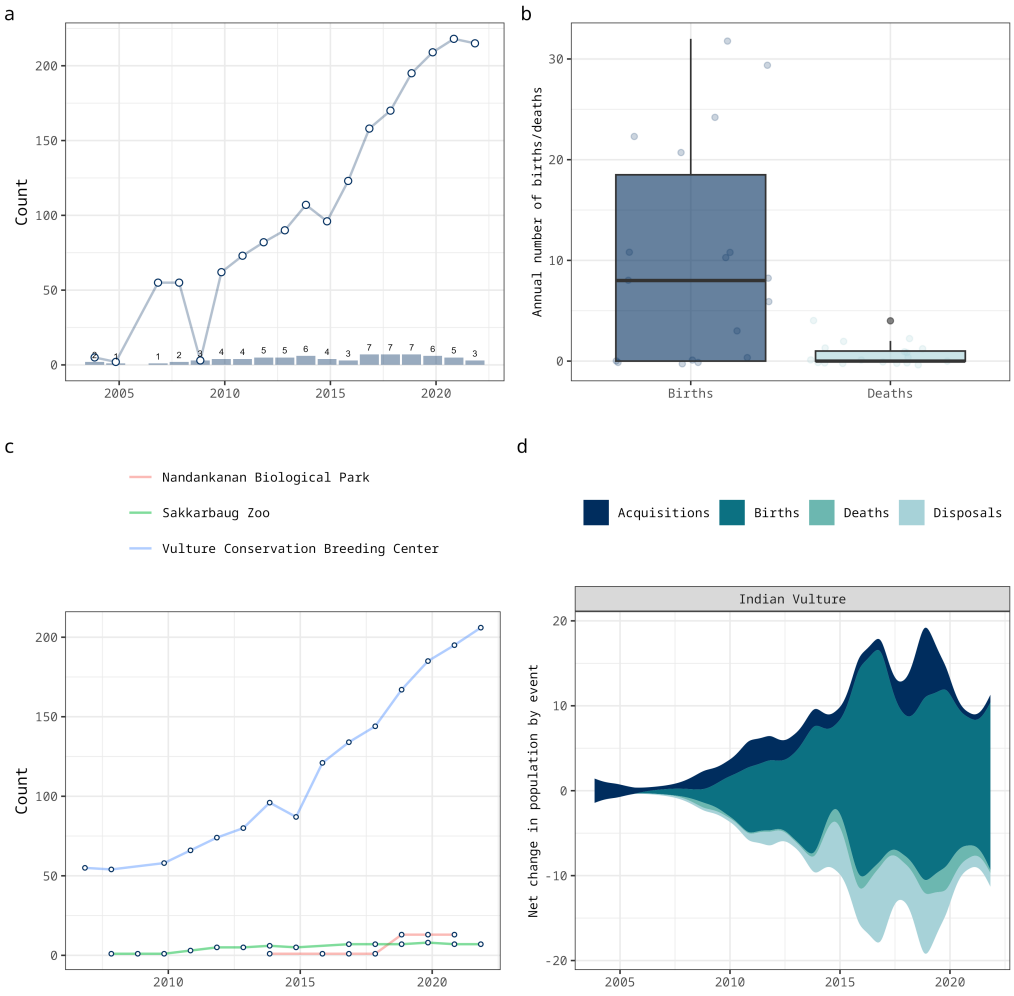


Figure A-23: Population trends and vital statistics of *G.indicus* in select zoos. (a) Annual closing population counts of *G.indicus* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *G.indicus* in captivity.

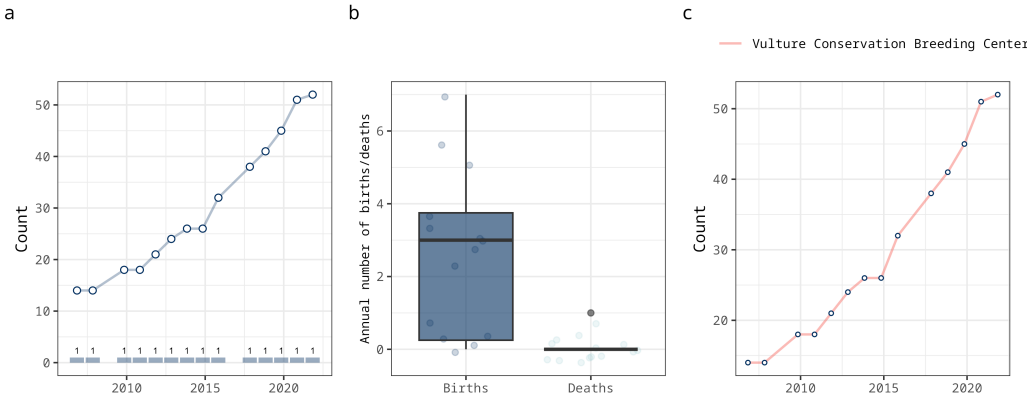


Figure A-24: Population trends and vital statistics of *G.tenuirostris* in select zoos. (a) Annual closing population counts of *G.tenuirostris* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos.

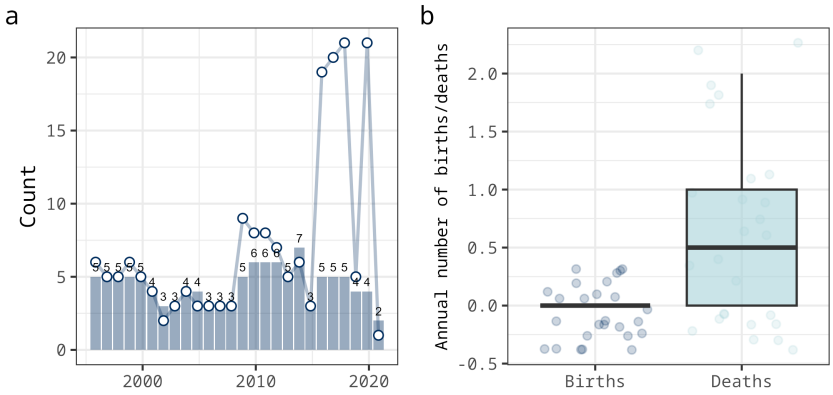


Figure A-25: Population trends and birth-death events for the Malabar Pied Hornbill (*Anthracoceros coronatus*) from 1998 to 2023, with number of holding institutions as bars.

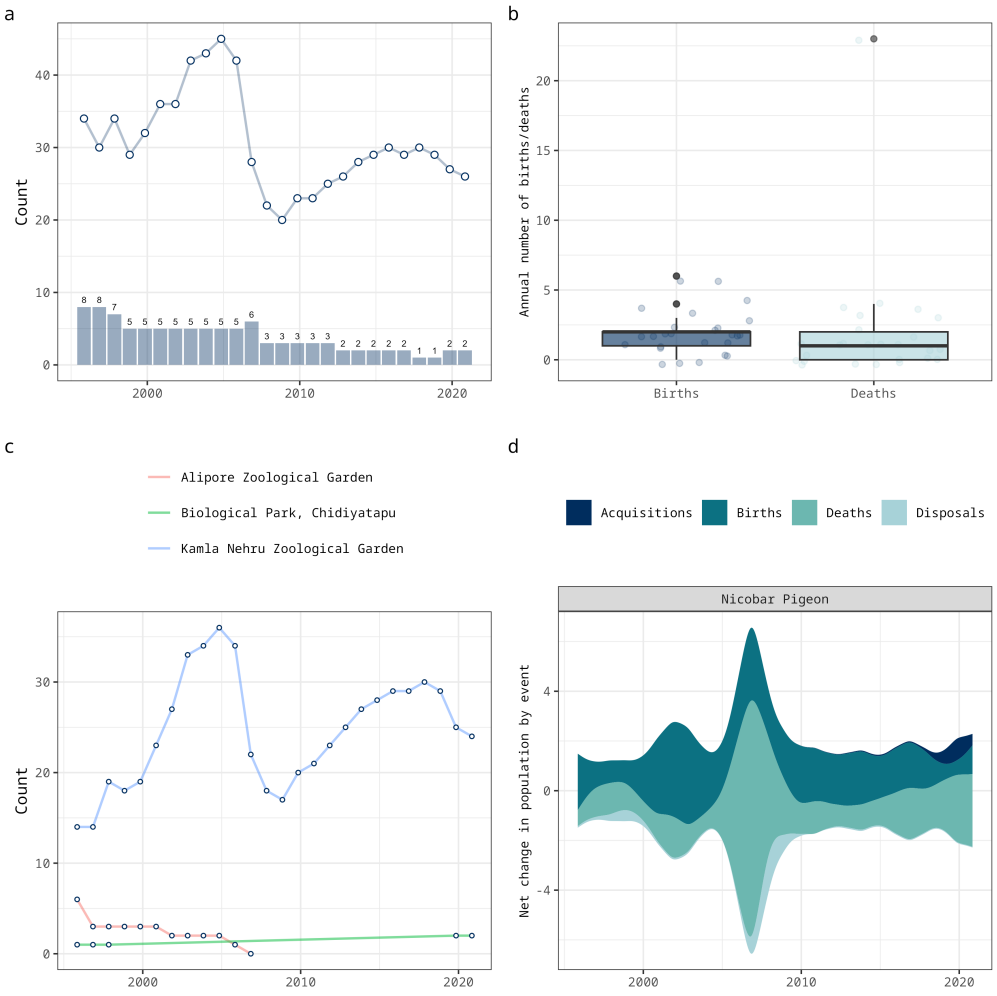


Figure A-26: Population trends and vital statistics of *Caloenas nicobarica* in select zoos. (a) Annual closing population counts of *Caloenas nicobarica* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *Caloenas nicobarica* in captivity.

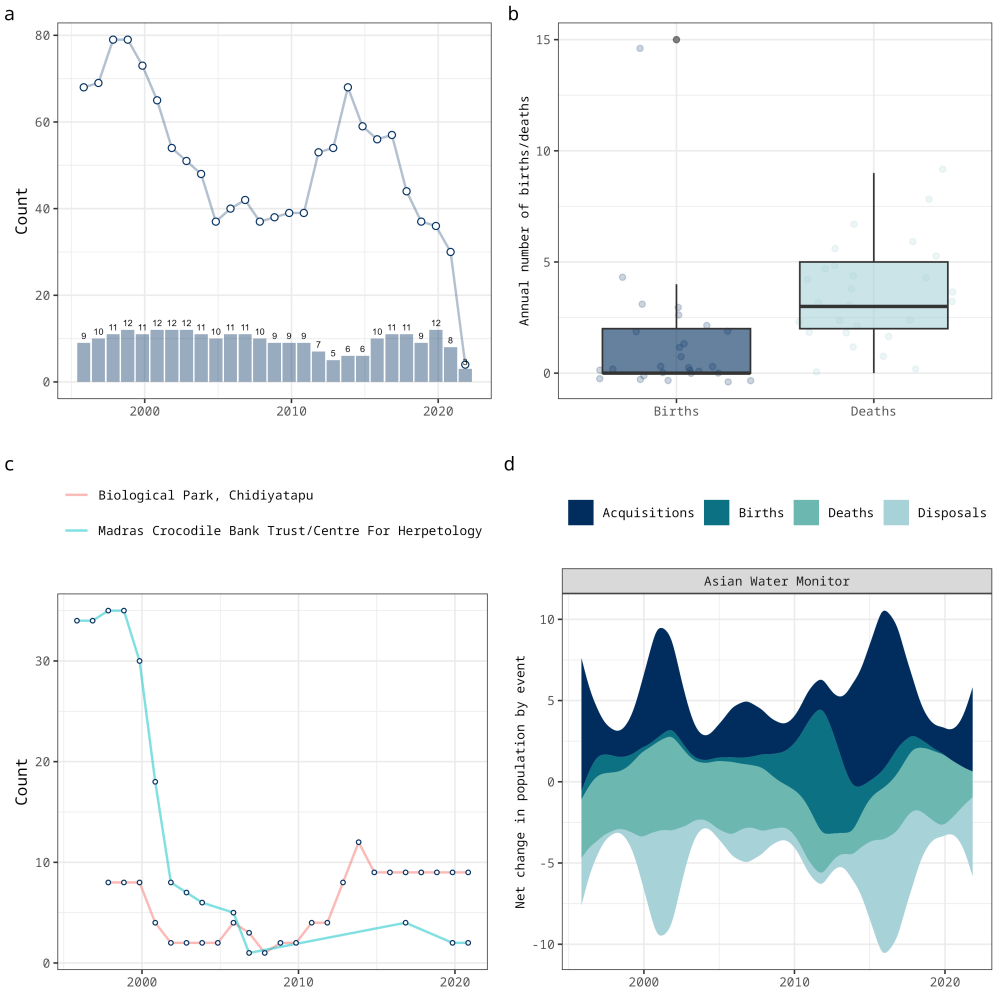


Figure A-27: Population trends and vital statistics of *V.salvator* in select zoos. (a) Annual closing population counts of *V.salvator* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *V.salvator* in captivity.

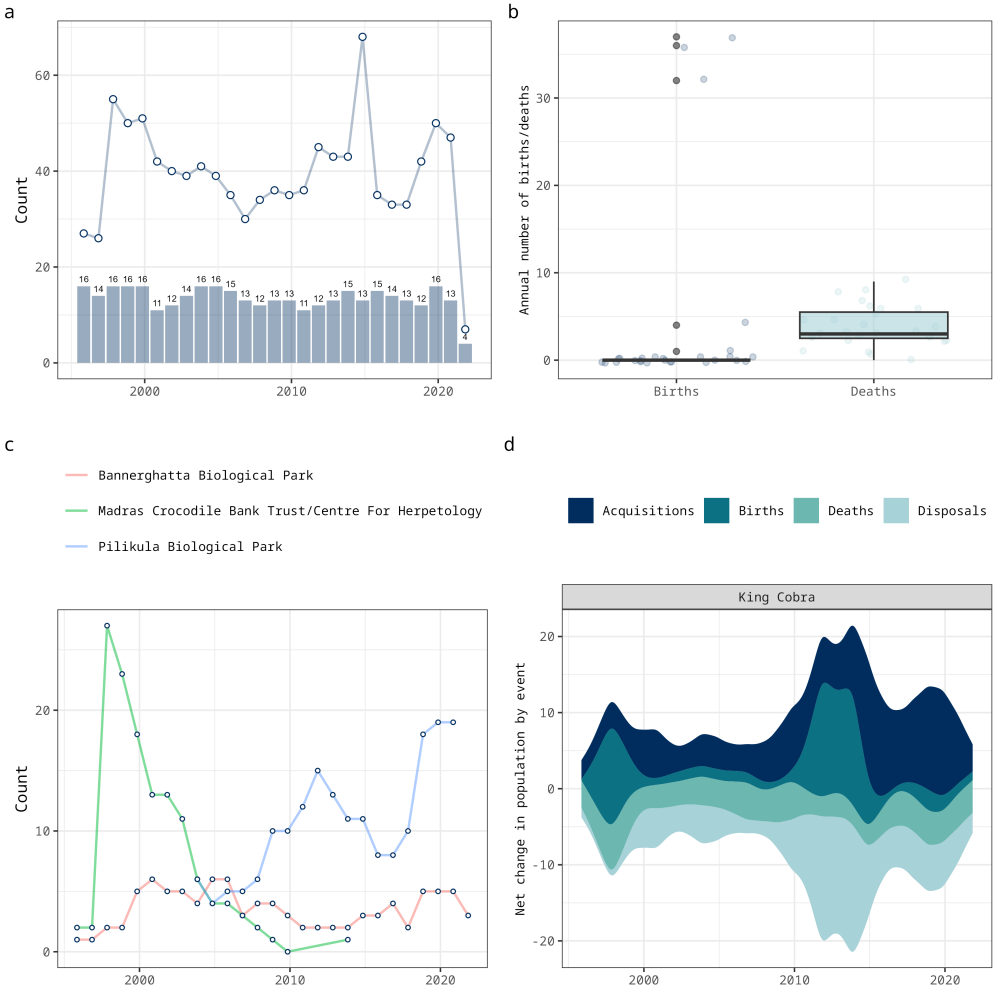


Figure A-28: Population trends and vital statistics of *O.hannah* in select zoos. (a) Annual closing population counts of *O.hannah* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *O.hannah* in captivity.

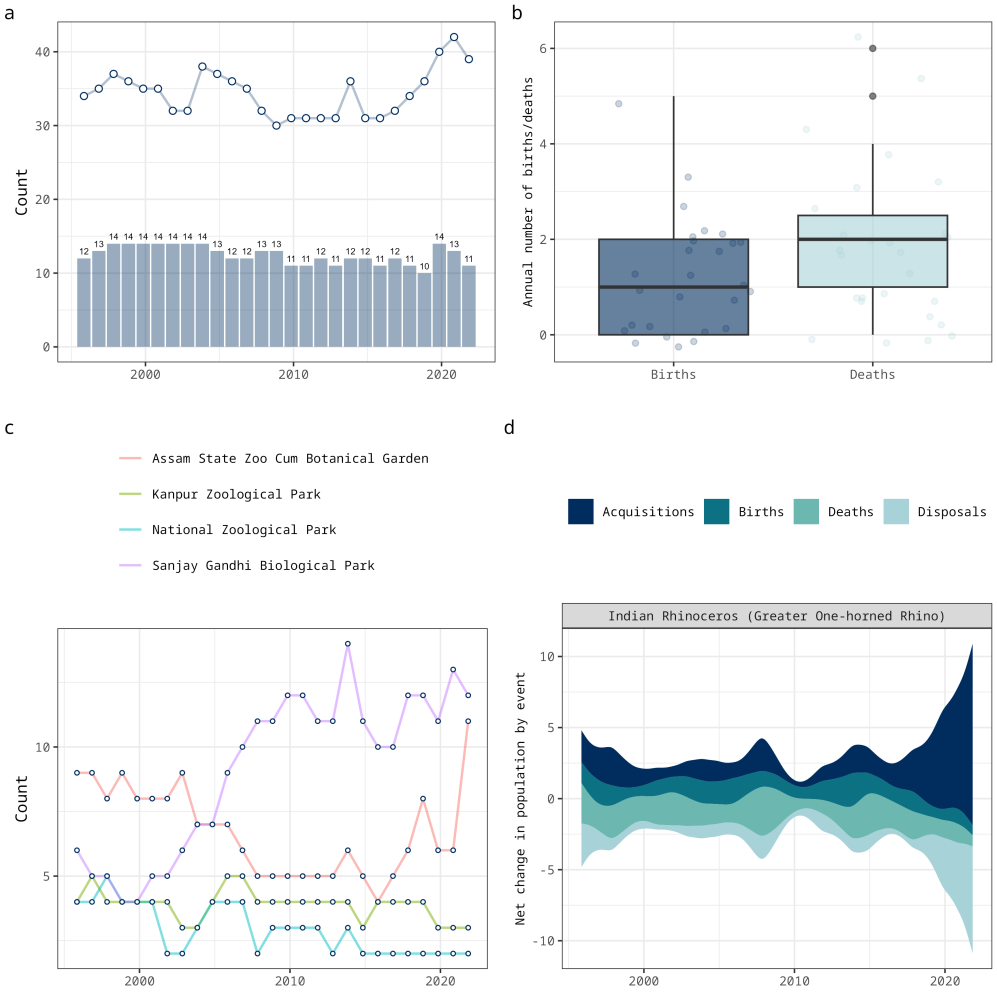


Figure A-29: Population trends and vital statistics of *R.unicornis* in select zoos. (a) Annual closing population counts of *R.unicornis* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *R.unicornis* in captivity.

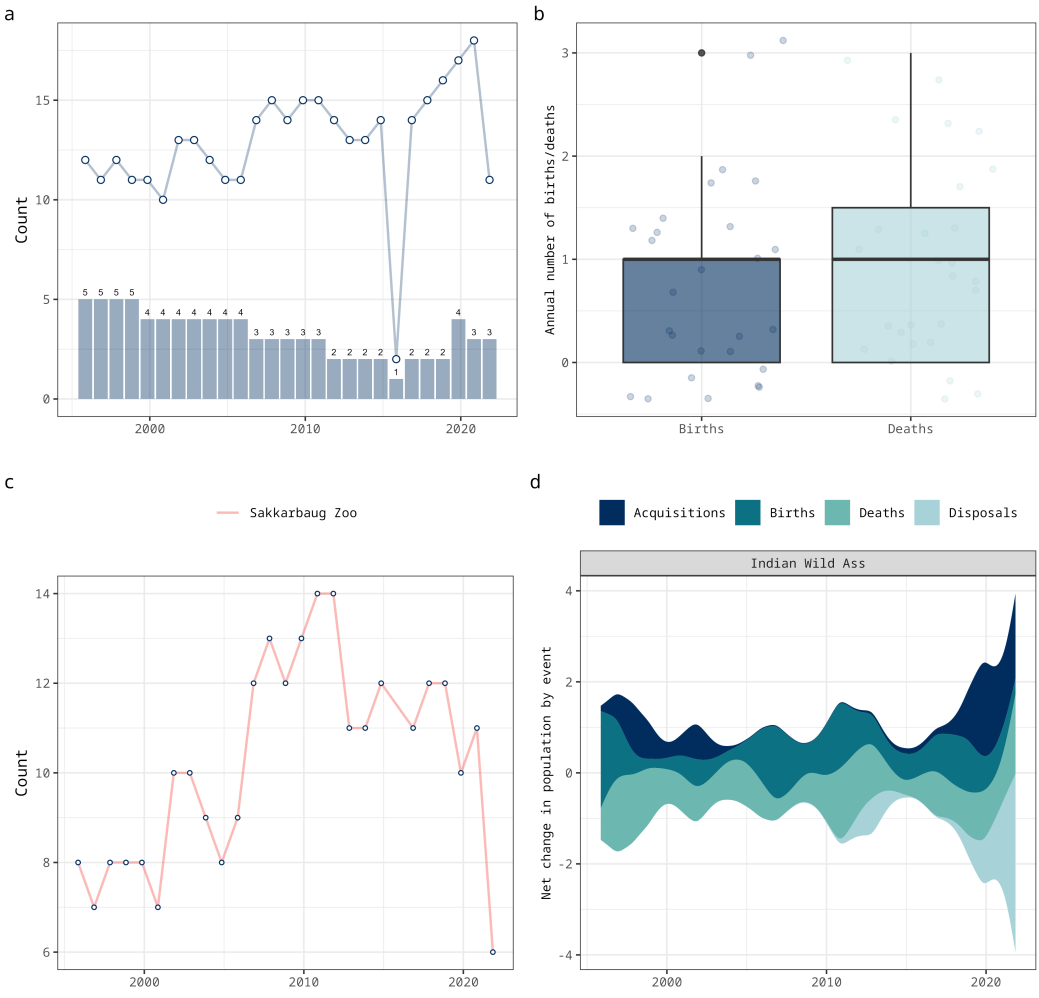


Figure A-30: Population trends and vital statistics of *E.h. khur* in select zoos. (a) Annual closing population counts of *E.h. khur* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *E.h. khur* in captivity.

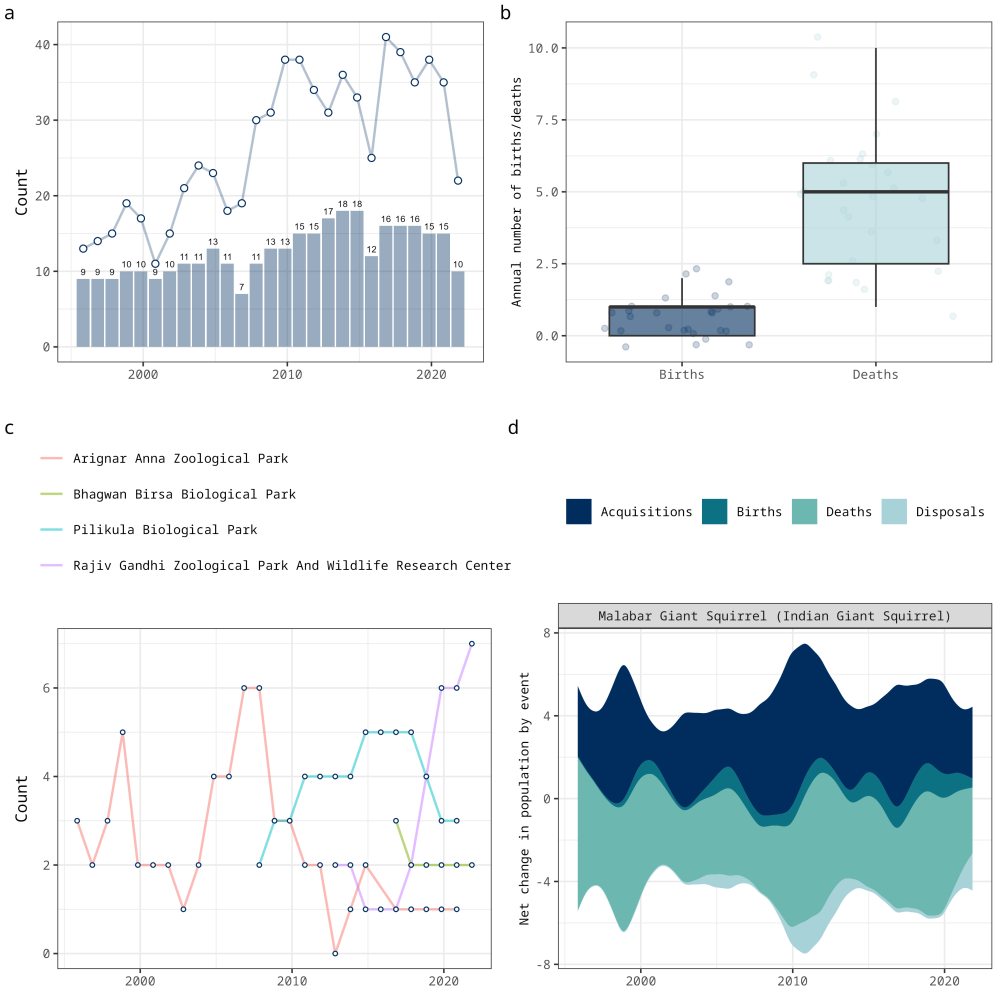


Figure A-31: Population trends and vital statistics of *R.indica* in select zoos. (a) Annual closing population counts of *R.indica* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *R.indica* in captivity.

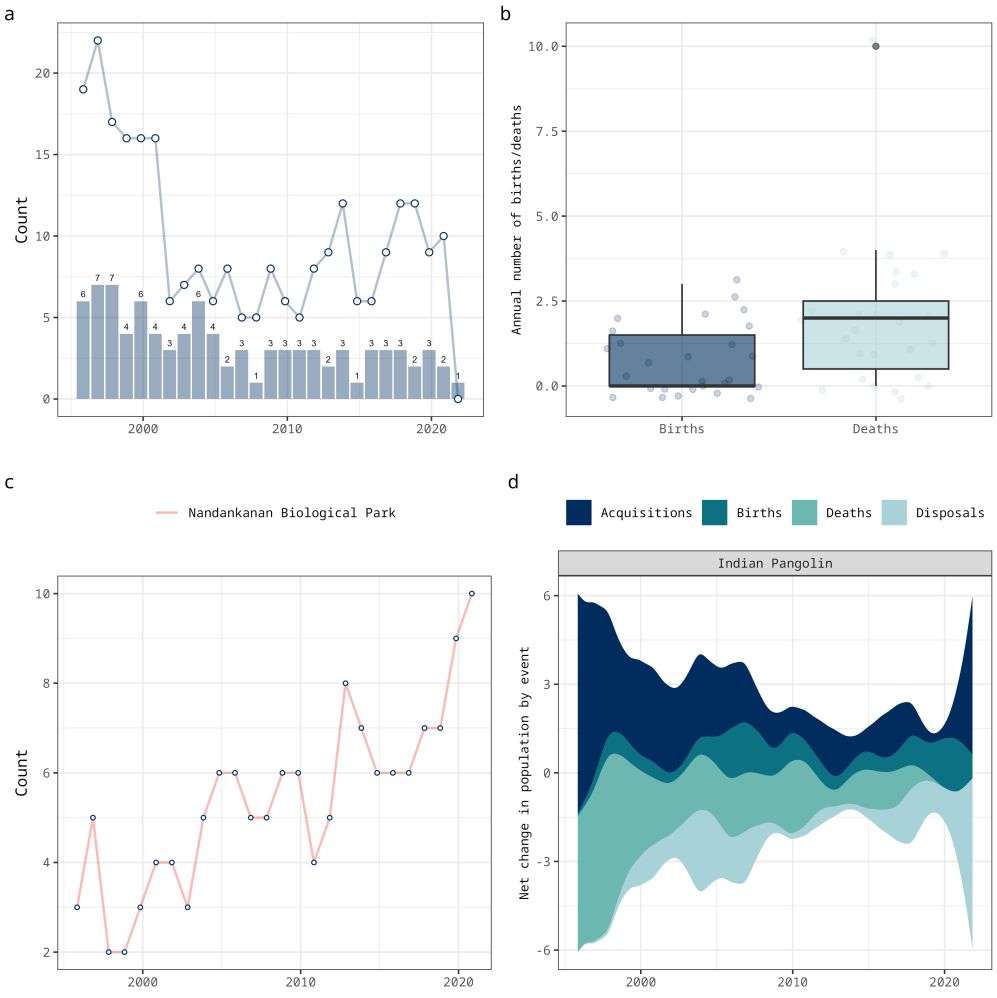


Figure A-32: Population trends and vital statistics of *M.crassicaudata* in select zoos. (a) Annual closing population counts of *M.crassicaudata* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *M.crassicaudata* in captivity.

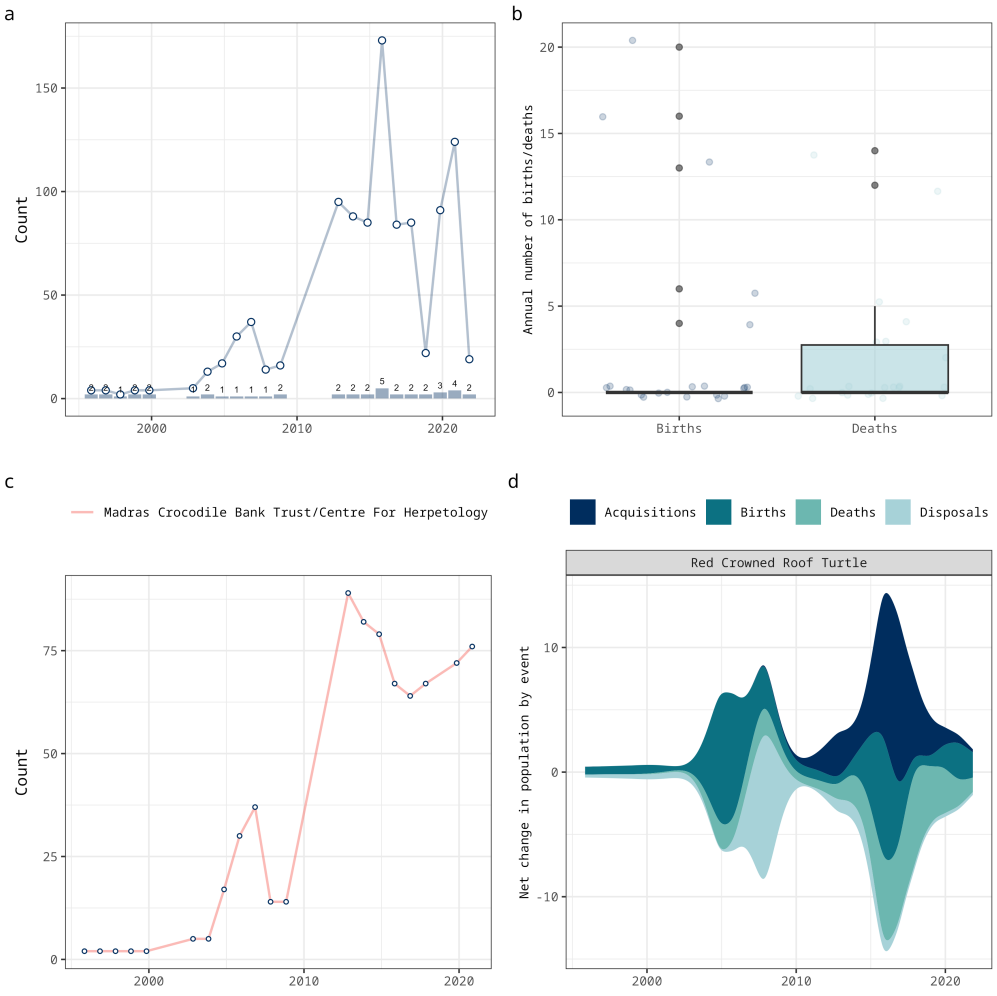


Figure A-33: Population trends and vital statistics of *B.kachuga* in select zoos. (a) Annual closing population counts of *B.kachuga* from 1998 to 2023, with number of holding institutions as bars. (b) Boxplot showing annual numbers of births and deaths recorded across different years. (c) Comparative population trends across coordinating and participating zoos. (d) Stacked area chart depicting the net change in population by event type (acquisitions, births, deaths, disposals) from 1998 to 2023, providing insight into the factors contributing to the overall population dynamics for *B.kachuga* in captivity.

C Prescribed steps for planned breeding of endangered species in India (as per extant guidelines).

1. Identification of species
2. Approximate number of animals of the species in the wild.
3. Number of animals of the species in captivity in Indian Zoos.
4. Identification of coordinating Zoos
5. Identification of participating Zoos
6. Existence of animal enclosures in coordinating, participating and other Zoos.
7. Existence/ creation of off-display enclosure for conservation breeding in coordinating Zoo
8. Identification of founders
9. Marking of founders (transponders, ear tags or rings)
10. Preparation of animal history sheets and animal observation sheets of the identified founders by the Zoos
11. Compilation of Studbook by the National Studbook Keeper.
12. Liaison with the International Studbook Keeper of the species (if any)
13. Possibility of acquiring the founders from foreign Zoos (if required) and details of the Zoos from where founders can be acquired
14. Physical health check-up of the founders using the veterinary hospital in the Zoo as well as National Referral Centre (Indian Veterinary Research Institute, Bareilly)
15. Genetic health check-up of the founders using blood samples or body parts with help from LaCONES, Hyderabad
16. Engagement of Technical Assistant in the coordinating Zoo
17. Preparation of Conservation Breeding Management Plan (CBMP) of the species.

D Proposed format for the preparation of conservation breeding plan.

Template

CONSERVATION BREEDING PLAN

[*Format for the preparation of conservation breeding plan for threatened species*]

Outline

1 Species Information **3**

2 Status in captivity **3**

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4 Purpose, goals and targets **6**

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8 Research **11**

9 Budget and timeline **12**

Notes

1. The Conservation Breeding Plan (CBP) should outline a long-term strategy, spanning at least 10 years. This ensures a sustained commitment to the species' conservation and allows for effective population management.

2. The CBP should not be a standalone document but rather an integral part of the zoo's overarching Master Plan. This ensures that breeding activities are aligned with the zoo's broader goals, resource allocation, and infrastructure development plans.

3. Only species that have been identified by the Central Zoo Authority (CZA) as priorities for planned breeding programs are eligible for inclusion in a CBP. This ensures the program complements the national conservation efforts.

4. The completed CBP for the target species must be submitted to the CZA for review and approval prior to the commencement of the program. An approved CBP is a prerequisite for receiving financial assistance from the CZA.

5. In case of species which have already been selected for undertaking planned breeding programs or a program is already ongoing, a retrospective application of the IUCN's five-step decision-making framework is necessary. This evaluation will rigorously assess the species' current ex-situ efforts, identify specific needs for ex-situ management, and ensure that the program's goals are precisely aligned with conservation requirements.

6. Given that reintroduction may not be the immediate goal for all breeding programs, the CBP format focuses on establishing a robust captive population that has the potential to support future species restoration efforts, including potential reintroduction. If deemed necessary, specific considerations related to reintroduction may be incorporated into the plan. However, it's important to recognize that detailed reintroduction planning would ideally be addressed in a subsequent, dedicated plan that builds upon the foundation laid by the CBP.

7. The essential aspects outlined under each section of the conservation breeding plan are indicative and not exhaustive. If additional relevant points warrant inclusion, they should be incorporated, ensuring their appropriateness within the overall context of the plan and the specific needs of the species.

1 Species Information

i) Common Name & Synonyms –

ii) Scientific name – `Use internationally accepted sources of nomenclature such as ICZN or Catalogue of Life/IUCN`

iii) Taxonomic class, order & family –

iv) Any known sub-species – `Subspecies information shall be derived from reliable sources such as ICZN or Catalogue of Life/IUCN`

v) Wild Life (Protection) Act, 1972 Schedule –

vi) IUCN Red List Status –

vii) CITES Appendix[1] – `NL for species not listed in any appendices`

viii) Distribution – `Natural distributional range of the species, list range countries or localities, include sub-species distribution as appropriate.`

ix) Key ecological traits of the species –

x) Key ecological role of the species –

xi) Threats in the wild – `List major factors contributing to the species' decline`

xii) Population status – `Population estimate or trend in the wild from IUCN including assessment year or other reliable scientific studies.`

2 Status in captivity

i) Current number of individuals in recognised zoos [M.F.U] –

ii) Current number of holding zoos –

iii) Current number of individuals managed in planned breeding programs [M.F.U] –

iv) Current number of recognised zoos undertaking planned breeding programs –

v) Current number of individuals managed by foreign regional associations/accredited zoos [M.F.U] & number of holding institutions – `Sources from ZIMS/AZA/EAZA or other reliable sources`

[1] https://cites.org/eng/app/appendices.php

vi) Inventory of the species in captivity – Annexe a table detailing the captive population's sex ratio, ideally from the time the species was first kept in captivity.
Else, provide data for at least the past 10 years, citing a reliable source.

vii) Studbook – Annexe a copy of the latest version of the studbook available for the species.

viii) Population details of individuals managed in planned breeding program – If an up-to-date studbook is not available at the time of preparing this conservation breeding plan, please furnish the following details encompassing the entire period the species has been kept in recognized zoos:

- Annex a table with individual-wise details including local id (to identify individual such as name), sex, birth date, death date, sire details, dam details, origin (captive- or wild-born), marking type and ID, in case of wild-born individuals provide location of capture and approximate age or life-stage at acquisition, indicate sire and dam as wild, management details (whether managed as part of planned breeding program in off exhibit or on display). Leave blanks where information is not available, but list all the individuals kept in captivity.

3 IUCN Five-step process

To promote a holistic conservation approach, the IUCN advocates for the "One Plan Approach," emphasizing collaborative conservation planning across all populations of a species. In alignment with this and the IUCN's guidelines on ex-situ management[2], ex-situ conservation efforts, like conservation breeding, should be implemented only when stakeholders are confident that the anticipated benefits for the species outweigh any potential risks or negative impacts on the local ecosystem. This involves carefully assessing the potential net positive impact, considering factors such as expertise, resources, and uncertainties.

A transparent, five-step decision-making process (refer to Figure 1) should be followed to evaluate the appropriateness of ex-situ management and define its specific form, ensuring

[2]https://portals.iucn.org/library/node/44952

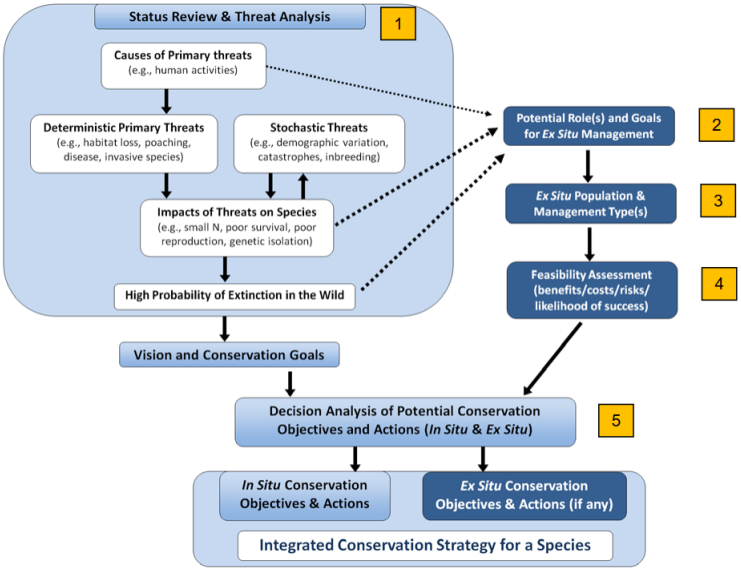

Figure 1: IUCN Five-step decision making process to determine if *ex situ* management is an appropriate conservation tool.

that such actions are a judicious use of resources and contribute effectively to the species' conservation.

To support informed decision-making, this conservation breeding plan shall include a detailed assessment of the target species using the IUCN's five-step framework:

1. Compile a status review of the species, including a threat analysis
2. Define the role(s) that ex situ management will play in the overall conservation of the species.
3. Determine the characteristics and dimensions of the ex situ population needed to fulfil the identified conservation role(s).
4. Define the resources and expertise needed for the ex situ management programme to meet its role(s) and appraise the feasibility and risks.
5. Critically evaluate the necessity of ex-situ measures for the species and articulate the specific benefits they could offer for its conservation.

For a detailed workflow and further guidance on each step, refer to the IUCN SSC *Guidelines on the Use of Ex situ Management for Species Conservation* using the link in the footnote.

4 Purpose, goals and targets

To enhance conservation effectiveness, conservation breeding programs require explicitly defined levels of population management[3]. Provide the following with respect to the target species:

i) Purpose: Broad, qualitative goals that define the purpose of applying management, such as sustaining a population to meet zoo exhibition needs or generating a sufficient number of animals for release into the wild. For *e.g.* To sustain a genetically diverse, demographically robust population able to sustain a harvest of animals for release.

ii) Goals: Quantifiable demographic and genetic measures that answer the questions *how much*(genetic diversity), *how many* (animals) and *for how long*. For *e.g.* Maintain 95% of wild- source heterozygosity for 25 years. Maintain population size at 100 (to allow a harvest of 20 animals per year for release).

iii) Targets: Parameters directly influenced by routine or annual program management of individual animals and which, over time, will determine whether population goals are met. For *e.g.* Maintain breeding rate at 40 births per year; maintain inbreeding at or below f = 0.125.

5 Population management

5.1 Demography

Provide a comprehensive overview of the population's demographic management strategy, encompassing historical practices, current status, and future plans. Connect this demographic assessment to the overarching goals of the conservation breeding plan. Utilize tables, graphs, or charts to visually represent demographic data, enhancing clarity and interpretation. Ensure all demographic data sources are clearly cited and verified for reliability and current relevance. Consider these essential aspects when compiling the demographic information:

[3]Ballou, J. D., Lees, C., Faust, L. J., Long, S., Lynch, C., Bingaman Lackey, L., and Foose,T. J. (2010). Demographic and genetic management of captive populations. Wild mammals in captivity: principles and techniques for zoo management, 219.

- Population size for breeding: Specify the total number of individuals intended for inclusion in the planned breeding program.
- Population summary: Provide a concise summary of the population's origin (wild caught, captive bred), age-sex classes, sex ratios, and the percentage of individuals considered suitable for breeding.
- Captive-bred individuals: Include details about captive-bred individuals, such as their source, historical management practices (including whether they were kept on display), and any relevant breeding history.
- Previous management & recommendations: Summarize any past breeding recommendations or management actions that have influenced the current population structure.
- Founder & descendant details: Provide specifics on wild-born animals that have bred (founders) and their descendants. Additionally, outline any plans for introducing new founders into the population.
- Historical demographic trends: Present historical data on population size, sex ratios at birth, birth rates versus death rates, generation time, age at first reproduction and other pertinent demographic parameters.
- Challenges & opportunities: Identify existing or potential demographic challenges, such as small population size, skewed sex ratios, aging individuals, or low reproductive rates. Propose potential solutions to address these challenges.
- Breeding recommendations: Based on the demographic assessment, provide specific breeding recommendations. This may include identifying over-represented individuals, suggesting pairings for wild-origin animals, or providing general pairing or group recommendations to achieve conservation breeding goals.
- Long-term projections: Consider incorporating population viability analysis or modeling to project future demographic trends and assess the long-term sustainability of the breeding program.
- Collaboration: Explore opportunities to collaborate with other institutions to enhance the demographic health of the captive population through animal exchanges or shared breeding programs.

5.2 Genetics

Provide a comprehensive overview of the genetic management strategy for the captive population, encompassing historical practices, current status, and

future plans. Clearly articulate how the genetic assessment connects to the broader conservation goals outlined in the breeding plan. Utilize tables, graphs, or charts to visually represent genetic data, enhancing clarity and interpretation. Ensure all genetic data sources are clearly cited and verified for reliability and current relevance. Consider these essential aspects when compiling the genetic information:

- Current level of genetic diversity within the captive population.
- Compare the captive population's diversity to that of wild populations, if data is available.
- Current and potential levels of inbreeding within the captive population.
- Pedigree analysis & identify any individuals or lineages at risk of high inbreeding.
- Degree of relatedness between individuals in the population using a kinship matrix.
- Genetic management goals such as maintaining or increasing genetic diversity, minimize inbreeding, maintaining evolutionary potential.
- Breeding recommendations
- Use of molecular genetic techniques
- Periodic evaluation of genetic health of the captive population.

5.3 Behaviour

Provide a detailed overview of the behavioral considerations relevant to the conservation breeding program. Connect the behavioral assessment to the overall breeding goals and management strategies outlined in the plan. Consider using ethograms or other visual aids to effectively present behavioral data and observations. Focus on these essential aspects when compiling behavioral information:

- Identify and describe key behaviors relevant to successful breeding such as foraging ecology, courtship and mating rituals, nesting or denning behaviors, parental care, social interactions and group dynamics.
- Behavioral challenges that might impact breeding success or animal welfare such as stereotypies, aggression accompanied by social incompatibility, difficulty with natural breeding.

- Design of enclosures and enrichment to promote expression of species-specific behaviours.
- Other strategies to promote natural behaviours such as social grouping, housing strategies, conditioning to facilitate interactions with keepers and veterinary staff.
- Addressing specific behavioural issues with targeted intervention.
- Behavioural monitoring.

5.4 Health

Provide a comprehensive overview of the health management strategies for the captive population, incorporating historical health records, current protocols, and future plans. Clearly articulate how the health assessment contributes to the successful implementation of the conservation breeding plan. Consider these essential aspects when compiling health information:

- Review historical health records for the captive population, if available.
- Any recurring health issues, prevalent diseases, or patterns that may impact breeding success.
- Current preventive health care measures in place such as physical examination, vaccinations, parasite control, quarantine of new acquisitions.
- Specific health concerns such as infectious diseases, genetic predispositions to certain conditions
- Availability of veterinary facilities.
- Strategies to address known health concerns and promote overall health and well-being such as species-specific health care protocols, biosecurity measures to prevent disease transmission and advanced diagnostic and treatment options.
- Evaluate the potential for future reintroduction of captive-bred individuals into the wild. Identify and assess the risks of disease transmission between captive and wild populations, and outline strategies to mitigate these risks (e.g., disease screening, vaccination protocols, quarantine procedures).

6 Husbandry and welfare

Provide a comprehensive outline of the husbandry and welfare practices that will be implemented to ensure the physical and psychological well-being of the animals involved in the conservation breeding program. Connect these practices to the overall goals of the plan, highlighting their contribution to animal health, breeding success, and the long-term sustainability of the captive population. Consider these essential aspects when detailing husbandry and welfare provisions:

- Enclosures or captive habitats where the animals will be housed, ensuring they meet or exceed the species-specific needs and promote natural behaviors.
- Enclosure design to facilitate optimal social management.
- Diverse and dynamic enrichment program to enhance the animals' psychological well-being and encourage natural behaviors.
- Detail the species-specific dietary needs and outline feeding protocols to ensure optimal nutrition and expression of natural foraging behaviours.
- Training (such as the use of positive reinforcement techniques) and handling procedures that will be used to facilitate positive interactions with keepers and minimize stress during veterinary care.
- Record keeping for population management and evaluating effectiveness of husbandry.
- Staff training.
- Evaluation and improvement.

7 Infrastructure

Provide a detailed assessment of the current infrastructure and any modifications or upgrades necessary to support the successful implementation of the conservation breeding plan. Consider both existing facilities and potential new infrastructure needs. Connect the infrastructure assessment to the specific requirements of the species and the goals of the breeding program. Consider these essential aspects when detailing infrastructure considerations:

- Overview of the existing facilities available for the breeding program such as enclosures, holding, off-exhibit spaces, quarantine, food preparation and storage.
- Suitability of the existing infrastructure for the target species and the breeding program's goals.
- Additional infrastructure that may be required to support the breeding program.
- Carrying capacity of the existing and proposed enclosures or habitats.
- Sustainability aspects when planning infrastructure, such as energy efficiency, water conservation, and the use of environmentally friendly materials.
- Timeline for implementing any necessary infrastructure changes.

8 Research

Outline a comprehensive research plan that aligns with the goals of the conservation breeding program and contributes to broader conservation efforts for the species. Clearly articulate the research priorities and identify potential opportunities for collaboration and knowledge advancement. Consider these essential aspects when detailing the research plan:

- Identify key research questions and areas of focus that directly support the breeding program and species conservation. This might include:
  - Reproductive biology (e.g., breeding seasonality, hormonal cycles, assisted reproductive techniques)
  - Behavior (e.g., social dynamics, mating systems, parental care)
  - Genetics (e.g., population genetics, genomics, conservation genetics)
  - Nutrition (e.g., dietary requirements, optimizing health and reproduction)
  - Animal health (e.g., disease surveillance, novel treatments, preventative medicine)
  - Welfare assessment and enhancement
  - Reintroduction biology
- Broadly outline the research methods that will be employed to address the identified research questions.

- Identify potential collaborators, such as universities, research institutions, and other zoos.
- Consider how research activities can contribute to capacity building within the zoo and the broader conservation community.

9 Budget and timeline

Develop a detailed budget that covers all aspects of the conservation breeding program, ensuring financial sustainability and resource allocation for its successful implementation. The budget should be transparent, realistic, and aligned with the goals and activities outlined in the plan. Consider these essential aspects when preparing the budget:

- Personnel -- for staff directly involved in the breeding program, including keepers, veterinarians, biologists/researchers and their training and professional development.
- Animal care -- Food, veterinary care, supplements, enrichment, transport and quarantine.
- Infrastructure -- Capital costs for new construction, renovations, equipment and maintenance.
- Research -- Laboratory supplies, genetic testing, health assessments, data management and analysis.
- Administrative and operational costs including contingency funds.

Additional considerations:

- Develop a multi-year budget that reflects the projected costs over the duration of the conservation breeding plan.
- Identify potential funding sources, such as government grants, private donations, corporate sponsorships, or revenue generated from zoo admissions or educational programs.
- Develop strategies to ensure the long-term financial sustainability of the breeding program.

E Species with no breeding program ongoing in recognised zoos.

Species	Zoo Name and Role
Otidiformes	
Asian Houbara (*Chlamydotis macqueenii*)	Not assigned
Bengal Florican (*Houbaropsis bengalensis*)	Not assigned
Lesser Florican (*Sypheotides indicus*)	Not assigned
Great Indian Bustard (*Ardeotis nigriceps*)	Not assigned
Carnivora	
Asiatic Cheetah (*Acinonyx jubatus venaticus*)	Sakkarbaug Zoo, Coordinating
Sun Bear (*Helarctos malayanus*)	Aizawl Zoo, Coordinating
Galliformes	
Blood Pheasant (*Ithaginis cruentus*)	Himalayan Zoological Park, Coordinating
Mrs. Hume's Pheasant (*Syrmaticus humiae*)	Aizawl Zoo, Coordinating
Sclater's Monal (*Lophophorus sclateri*)	Not assigned
Tibetan Eared-pheasant (*Crossoptilon harmani*)	Not assigned
Artiodactyla	
Tibetan Antelope (Chiru) (*Pantholops hodgsonii*)	Not assigned
Ganges River Dolphin (*Platanista gangetica gangetica*)	Sanjay Gandhi Biological Park, Coordinating
Hangul (Kashmiri Stag) (*Cervus hanglu hanglu*)	Not assigned
Markhor (*Capra falconeri*)	Not assigned
Nilgiri Tahr (*Nilgiritragus hylocrius*)	Not assigned
Wild Water Buffalo (*Bubalus arnee*)	Nandanvan Jungle Safari, Coordinating
Alpine Musk Deer (*Moschus chrysogaster*)	Not assigned
Himalayan Serow (*Capricornis sumatraensis tahr*)	Assam State Zoo, Coordinating
Bucerotiformes	
Malabar Grey Hornbill (*Ocyceros griseus*)	Nehru Zoological Park, Participating
Lagomorpha	
Hispid Hare (*Caprolagus hispidus*)	Not assigned
Falconiformes	
Shaheen Falcon (*Falco peregrinus peregrinator*)	Mahendra Chaudhury Zoological Park, Coordinating

F Summary of population metrics for selected species with ongoing breeding programs.

Species	Mean Pop. Size	n	SD	IQR	Range
Blyth's Tragopan *T. blythii*	7.0	2	1.4	1.0	6–8
Asian Golden Cat *C. temminckii*	2.5	27	1.2	2.0	1–5
Malayan Sun Bear *H. malayanus*	2.9	26	1.6	2.0	0–7
Satyr Tragopan *T. satyra*	2.9	24	1.5	2.2	0–6
Western Tragopan *T. melanocephalus*	16.8	25	14.1	25.0	2–45
Indian Vulture *G. indicus*	106.6	18	73.1	110.2	2–218
Capped Langur *T. pileatus*	12.1	27	6.5	5.0	2–30
Bengal Tiger *P. tigris tigris*	277.5	27	27.9	32.5	187–323
Barasingha *R. duvaucelii sp.*	159.1	27	73.5	119.0	74–298
Blue Sheep *P. nayaur*	8.3	21	7.0	14.0	0–18
Lion-tailed Macaque *M. silenus*	58.1	27	11.1	11.0	15–75
Clouded Leopard *N. nebulosa*	7.0	27	2.9	3.0	3–11
Indian Bison *B. gaurus*	59.7	27	23.8	40.0	18–106
Malabar Giant Squirrel *R. indica*	26.5	27	9.5	16.5	11–41
Indian Wild Ass *E. hemionus khur*	12.9	27	3.0	3.5	2–18
Red Panda *A. fulgens*	22.1	27	6.1	8.0	11–32
Indian Wolf *C. lupus pallipes*	64.1	27	40.7	30.0	26–184
King Cobra *O. hannah*	39.3	27	11.1	9.5	7–68
Smooth-coated Otter *L. perspicillata*	10.9	27	8.1	15.0	1–25
Snow Leopard *P. uncia*	12.7	27	2.9	4.5	8–18
Cheer Pheasant *C. wallichii*	30.9	27	20.7	35.0	6–92
Crab-eating Macaque *M. fascicularis*	12.0	23	5.5	7.0	0–20
Indian Pangolin *M. crassicaudata*	9.7	27	5.1	6.0	0–22
Four-horned Antelope *T. quadricornis*	149.6	27	65.6	112.0	67–261
Asian Water Monitor *V. salvator*	50.2	27	16.9	23.5	4–79
Markhor *C. falconeri*	4.8	16	3.1	5.2	0–11
Chinkara *G. bennettii*	127.4	27	22.9	29.0	81–163
Indian Chevrotain *M. indica*	66.0	28	89.6	77.5	1–294
Red Junglefowl *G. gallus*	267.3	27	162.6	286.0	52–536
Himalayan Monal *L. impejanus*	24.0	27	9.0	7.0	3–37
Temminck's Tragopan *T. temminckii*	9.0	18	8.3	12.8	0–24

Species	Mean Pop. Size	n	SD	IQR	Range
Nicobar Pigeon *C. nicobarica*	30.7	26	6.7	7.8	20–45
Golden Langur *T. geei*	8.0	27	5.7	2.0	3–28
Indian Rhinoceros *R. unicornis*	34.4	27	3.2	4.5	30–42
Asiatic Lion *P. leo persica*	135.8	27	48.4	76.5	75–248
Tibetan Wolf *C. lupus chanco*	18.0	27	6.1	10.5	8–26
Phayre's Leaf Monkey *T. phayrei*	5.0	5	0.7	0.0	4–6
Asian Wild Dog *C. alpinus*	40.0	27	31.0	23.0	13–135
Himalayan Tahr *H. jemlahicus*	7.7	27	5.4	8.0	2–19
White-rumped Vulture *G. bengalensis*	101.9	27	67.1	129.5	24–205
Red-crowned Roof Turtle *B. kachuga*	46.2	22	48.3	78.0	2–173
Stump-tailed Macaque *M. arctoides*	45.3	27	9.5	5.5	12–61
Indian Vulture *G. indicus*	106.6	18	73.1	110.2	2–218
Nilgiri Langur *T. johnii*	26.0	27	7.6	3.0	3–54
Hoolock Gibbon *H. hoolock*	26.3	27	15.4	31.0	8–47
Grey Junglefowl *G. sonneratii*	41.2	27	22.7	29.5	7–92
Himalayan Newt *T. himalayanus*	24.8	18	12.2	14.8	9–50
Binturong *A.binturong*	9.5	27	3.6	6.0	1–15
Northern Pig-tailed Macaque *M.leonina*	5.7	7	1.6	1.5	3–27
Grey Peacock Pheasant *P.bicalcaratum*	45.7	27	23.4	39.0	5–75

G Subjective assessment and categorisation of the species based on the proposed scenarios.

	Species	Order
1	Asian Houbara *Chlamydotis macqueenii*	Otidiformes
2	Asiatic Cheetah *Acinonyx jubatus venaticus*	Carnivora
3	Bengal Florican *Houbaropsis bengalensis*	Otidiformes
4	Blood Pheasant *Ithaginis cruentus*	Galliformes
5	Tibetan Antelope *Pantholops hodgsonii*	Artiodactyla
6	Ganges River Dolphin *Platanista gangetica gangetica*	Artiodactyla
7	Great Indian Bustard *Ardeotis nigriceps*	Otidiformes
8	Hangul *Cervus hanglu hanglu*	Artiodactyla
9	Alpine Musk Deer *Moschus chrysogaster*	Artiodactyla
10	Himalayan Serow *Capricornis thar/sumatraensis*	Artiodactyla
11	Hispid Hare *Caprolagus hispidus*	Lagomorpha
12	Lesser Florican *Sypheotides indicus*	Otidiformes
13	Malabar Grey Hornbill *Ocyceros griseus*	Bucerotiformes
14	Mrs. Hume's Pheasant *Syrmaticus humiae*	Galliformes
15	Nilgiri Tahr *Nilgiritragus hylocrius*	Artiodactyla
16	Shaheen Falcon *Falco peregrinus peregrinator*	Falconiformes
17	Sclater's Monal *Lophophorus sclateri*	Galliformes
18	Tibetan Eared-pheasant *Crossoptilon harmani*	Galliformes
19	Wild Water Buffalo *Bubalus arnee*	Artiodactyla

Table 4: **Scenario 1**: No Program Initiated [Yellow]

	Species	Order
1	Asiatic Golden Cat *Catopuma temminckii*	Carnivora
2	Binturong *Arctictis binturong*	Carnivora
3	Blue Sheep *Pseudois nayaur*	Artiodactyla
4	Blyth's Tragopan *Tragopan blythii*	Galliformes
5	Gee's Golden Langur *Trachypithecus geei*	Primates
6	Himalayan Tahr *Hemitragus jemlahicus*	Artiodactyla
7	Indian Pangolin *Manis crassicaudata*	Pholidota
8	Malabar Pied Hornbill *Anthracoceros coronatus*	Bucerotiformes
9	Markhor *Capra falconeri*	Artiodactyla
10	Northern Pig-tailed Macaque *Macaca leonina*	Primates
11	Phayre's Leaf Monkey *Trachypithecus phayrei*	Primates
12	Pygmy Hog *Porcula salvania*	Artiodactyla
13	Rusty-spotted Cat *Prionailurus rubiginosus*	Carnivora
14	Satyr Tragopan *Tragopan satyra*	Galliformes
15	Sun Bear *Helarctos malayanus*	Carnivora
16	Temminck's Tragopan *Tragopan temminckii*	Galliformes

Table 5: **Scenario 2**: Persistent Small Populations and Limited Growth [Blue]

	Species	Order
1	Brown Bear *Ursus arctos*	Carnivora
2	Capped Langur *Trachypithecus pileatus*	Primates
3	Cheer Pheasant *Catreus wallichii*	Galliformes
4	Clouded Leopard *Neofelis nebulosa*	Carnivora
5	Common Water Monitor *Varanus salvator*	Squamata
6	Dhole *Cuon alpinus*	Carnivora
7	Greater One-horned Rhino *Rhinoceros unicornis*	Perissodactyla
8	Grey Junglefowl *Gallus sonneratii*	Galliformes
9	Grey Peacock-pheasant *Polyplectron bicalcaratum*	Galliformes
10	Himalayan Monal *Lophophorus impejanus*	Galliformes
11	Himalayan Salamander *Tylototriton himalayanus*	Caudata
12	Himalayan Wolf *Canis lupus chanco*	Carnivora
13	Indian Giant Squirrel *Ratufa indica*	Rodentia
14	Indian Wild Ass *Equus hemionus khur*	Perissodactyla
15	King Cobra *Ophiophagus hannah*	Squamata
16	Nicobar Crab-eating Macaque *Macaca fascicularis*	Primates
17	Nicobar Pigeon *Caloenas nicobarica*	Columbiformes
18	Nilgiri Langur *Trachypithecus johnii*	Primates
19	Red Panda *Ailurus fulgens*	Carnivora
20	Red-crowned Roof Turtle *Batagur kachuga*	Testudines
21	Slender-billed Vulture *Gyps tenuirostris*	Accipitriformes
22	Smooth-coated Otter *Lutrogale perspicillata*	Carnivora
23	Snow Leopard *Panthera uncia*	Carnivora
24	Stump-tailed Macaque *Macaca arctoides*	Primates
25	Western Hoolock Gibbon *Hoolock hoolock*	Primates
26	Western Tragopan *Tragopan melanocephalus*	Galliformes

Table 6: **Scenario 3**: Sub-optimal Demographic and Genetic Correlates [Green]

	Species	Order
1	Asiatic Lion *Panthera leo leo*	Carnivora
2	Barasingha *Rucervus duvaucelii*	Artiodactyla
3	Bengal Tiger *Panthera tigris tigris*	Carnivora
4	Chinkara *Gazella bennettii*	Artiodactyla
5	Eld's Deer *Rucervus eldii eldii*	Artiodactyla
6	Four-horned Antelope *Tetracerus quadricornis*	Artiodactyla
7	Gaur *Bos gaurus*	Artiodactyla
8	Grey Wolf *Canis lupus*	Carnivora
9	Indian Chevrotain *Moschiola indica*	Artiodactyla
10	Indian Vulture *Gyps indicus*	Accipitriformes
11	Lion-tailed Macaque *Macaca silenus*	Primates
12	Red Junglefowl *Gallus gallus*	Galliformes
13	White-rumped Vulture *Gyps bengalensis*	Accipitriformes

Table 7: **Scenario 4**: Large Populations but Misaligned Conservation Priorities [Pink]

H Framework for assessment of planned breeding programs.

Recommendations from the 106th Technical Committee Meeting and approval from the 40th CZA Meeting:

1. Collate demographic and genetic status of each species identified for planned breeding programs using inventory and studbook data.

2. Collate husbandry information, housing facilities available, personnel (technical and other frontline staff) for each species in zoos assigned coordinating/participating roles or where the species are housed through consultative meetings and questionnaires.

3. Identify threatened native species that may warrant support through ex situ conservation using the IUCN Five-step decision process through consultative meetings and data analysis. Correspondingly, identify potential zoos based on housing facilities, personnel and husbandry experience to undertake conservation breeding of such species.

4. Collate information on international regional programs ongoing for the target species through literature review and consultative meetings. Further, identify potential international regional programs (e.g. EAZA Ex situ Programs (EEP), Species Survival Programs (SSP) etc.) housing the target species and exploring possible collaborations.

5. Based on the collated data, determine the relative success of the ongoing planned breeding programs with reference to parameters including but not exclusive to sustainability & viability of the captive stocks, reproductive success, husbandry expertise, availability of optimal housing and its potential to support in situ conservation.

6. Prepare a budget outlay and potential funding sources to support the said breeding programs.

7. Taking lead from the ongoing programs and policies thereof, prepare a *perspective plan* (at least for 10 years) for conservation-oriented captive breeding programs in India which is inclusive of the advances in zoo science (e.g. population management, reintroduction biology, capacity of personnel etc.) and which would serve as guiding document.

8. Prepare a *monitoring plan* (including targets and verifiable measures of success) to periodically assess the efficacy of the breeding programs to meet the overall goal outlined in the *perspective plan* and to complement national conservation plans.

I Framework for evaluation of conservation breeding programs

Housing Facility Evaluation Checklist

1. **General Enclosure Design and Layout**

   → Is the enclosure dedicated exclusively for conservation breeding?
   (Yes/No. If No, explain shared usage.)

   → Does the enclosure reflect the species' ecological and behavioral needs?
   (Yes/No. Provide details of any mismatches.)

   → Is the facility located within the species' natural distribution range or designed to mimic natural climatic conditions?
   (Yes/No. Describe.)

   → Is the enclosure designed to accommodate breeding behavior (e.g., mating areas, nesting sites)?
   (Yes/No. If No, suggested improvements.)

   → What is the total area of the enclosure, and is it sufficient for the species' social structure and group dynamics?
   (Record enclosure area and evaluator's assessment of adequacy.)

2. **Environmental Complexity and Enrichment**

   → Does the enclosure provide sufficient horizontal and vertical complexity?
   (Yes/No. List features like vegetation, substrates, or climbing structures.)

   → Are there natural or artificial hiding spaces, resting areas, or escape zones?
   (Yes/No. Provide examples or deficiencies.)

   → Are environmental enrichment practices in place?
   (Yes/No. List types, frequency, and effectiveness.)

3. **Access to Private and Public Zones**

   → Are there off-display zones for breeding animals to retreat?
   (Yes/No. If Yes, describe their design and accessibility.)

   → For on-display areas, do animals have the option to move to a non-visible area?
   (Yes/No. Provide details.)

4. **Climatic and Seasonal Adjustments**

→ Does the facility provide mechanisms for temperature control (e.g., heating, cooling, shaded/covered areas)?
(Yes/No. Describe systems in place.)

→ How is the facility adapted for seasonal variations (e.g., monsoons, extreme winters/summers)?
(Describe adaptations or lack thereof.)

5. **Feeding Areas**

→ Are feeding areas isolated and designed to minimize stress during feeding?
(Yes/No. Describe setup.)

→ Are feeding practices aligned with natural foraging behaviors?
(Yes/No. Provide examples or deficiencies.)

6. **Breeding-Specific Infrastructure**

→ Are breeding-specific features present (e.g., nesting boxes, mate-separation areas)?
(Yes/No. List features.)

→ Are there designated areas for pregnant/lactating females or juveniles?
(Yes/No. Describe.)

→ Are there designated facilites for care of young available and well-maintained?
(Yes/No. Provide details.)

7. **Biosecurity and Hygiene**

→ Are there biosecurity measures to prevent disease transmission (e.g., foot baths, restricted access, enclosure disinfection, susbtrate change)?
(Yes/No. List measures.)

→ Is waste management adequate to maintain hygiene?
(Yes/No. Describe system.)

8. **Maintenance and Repairs**

→ Is the enclosure well-maintained and free of structural hazards?
(Yes/No. Note any required repairs or upgrades.)

→ Are records kept of regular maintenance and inspections?
(Yes/No. Assess record quality.)

9. **Animal Monitoring and Management**

→ Is there adequate provision for monitoring individual animals (e.g., camera systems, tagging)?
(Yes/No. Describe.)

→ Is there provision for safe animal handling or intervention in emergencies?
(Yes/No. List tools and procedures.)

10. **Evaluator's Recommendations**

→ Overall suitability of the facility for conservation breeding purposes:
(Satisfactory/Needs Improvement/Unsuitable. Provide justification.)

→ Key recommendations for improvement:
(List actionable steps with priority levels.)

Diet and Feeding Evaluation Checklist

1. **Diet Composition**

→ Is the diet tailored to the species' natural dietary requirements?
(Yes/No. Provide details on the type of food provided.)

→ Is the diet designed to replicate the nutritional content and diversity of natural foraging?
(Yes/No. Note any significant deviations.)

→ Are seasonal variations in diet incorporated, reflecting natural availability in the wild?
(Yes/No. Provide examples.)

2. **Feeding Practices**

→ Are feeding times consistent with the species' natural feeding schedules (e.g., nocturnal, diurnal)?
(Yes/No. Describe.)

→ Is food presentation designed to encourage natural foraging behaviors (e.g., scatter feeding, hanging browse)?
(Yes/No. Provide examples or deficiencies.)

→ Are feeding areas designed to minimize competition or aggression among animals?
(Yes/No. Describe setup.)

3. **Diet Quality and Monitoring**

→ Is the diet fresh, free of contaminants, and stored under appropriate conditions?
(Yes/No. Describe storage facilities and practices.)

→ Are food items tested for nutritional quality or contamination regularly?
(Yes/No. Provide details on testing frequency and protocols.)

→ Is there provision for monitoring individual feeding habits and intake?
(Yes/No. Describe methods.)

4. **Special Diets and Supplements**

→ Are dietary supplements provided for specific needs (e.g., vitamins, minerals, calcium for breeding females)?
(Yes/No. List supplements and their purpose.)

→ Are there special diets or protocols for specific life stages (e.g., juveniles, lactating females, elderly animals)?
(Yes/No. Describe.)

→ Are there provisions for adjusting diets in response to veterinary recommendations?
(Yes/No. Provide examples.)

5. **Feeding Infrastructure and Hygiene**

→ Are feeding areas clean, well-maintained, and easy to sanitize?
(Yes/No. Describe cleanliness standards and practices.)

→ Are feeding tools (e.g., bowls, troughs, dispensers) species-appropriate and regularly cleaned?
(Yes/No. Note any deficiencies.)

→ Is water supply clean and easily accessible to all individuals in the enclosure?
(Yes/No. Provide details on water sources and maintenance.)

6. **Feeding Records and Monitoring**

→ Are feeding records maintained, including details of diet composition, quantities, and feeding schedules?
(Yes/No. Evaluate record quality.)

→ Are there protocols to monitor and address changes in body condition, weight, or health related to diet?
(Yes/No. Describe protocols.)

7. **Behavioral Observations**

   → Are animals displaying natural feeding behaviors (e.g., browsing, grazing, hunting)?
   (Yes/No. Describe observations.)

   → Are there signs of stereotypic behaviors or stress during feeding?
   (Yes/No. Provide details.)

8. **Evaluator's Recommendations**

   → Overall adequacy of diet and feeding practices:
   (Satisfactory/Needs Improvement/Unsuitable. Provide justification.)

   → Key recommendations for improvement:
   (List actionable steps with priority levels.)

Behavioral Management Evaluation Checklist

1. **Natural Behavior Expression**

   → Are enclosures designed to facilitate natural behaviors such as foraging, hunting, climbing, or burrowing?
   (Yes/No. Provide examples or deficiencies.)

   → Are animals observed engaging in species-typical behaviors?
   (Yes/No. List observed behaviors and any notable absences.)

   → Are social structures (e.g., group, pair, solitary) maintained in line with species-specific requirements?
   (Yes/No. Describe social organization.)

2. **Behavioral Enrichment**

   → Are behavioral enrichment programs implemented regularly?
   (Yes/No. Provide examples of enrichment items or activities.)

   → Do enrichment activities target natural behaviors such as problem-solving, exploration, or physical exercise?
   (Yes/No. List targeted behaviors.)

   → Are enrichment items rotated to maintain novelty and engagement?
   (Yes/No. Describe frequency and type of rotation.)

3. **Stress Indicators**

→ Are there signs of stereotypic behaviors (e.g., pacing, overgrooming, repetitive motions)?
(Yes/No. Provide observations and frequency.)

→ Do animals exhibit signs of chronic stress, such as lethargy, aggression, or changes in appetite?
(Yes/No. Describe observed stress indicators.)

→ Are there strategies in place to mitigate stress (e.g., hiding spaces, reducing noise levels, hormonal assessment)?
(Yes/No. Provide details.)

4. **Social Behavior**

→ Are group dynamics monitored to ensure compatibility among individuals?
(Yes/No. Describe monitoring methods.)

→ Are social structures consistent with natural behavior (e.g., alpha-dominant, pair-bonded)?
(Yes/No. Provide observations.)

→ Are protocols in place to manage conflicts or aggression within groups?
(Yes/No. Describe conflict resolution methods.)

5. **Training and Conditioning**

→ Are operant conditioning or positive reinforcement techniques used for veterinary or management purposes?
(Yes/No. Provide examples, such as training for health checks.)

→ Are animals responsive to basic training cues that reduce stress during handling or medical interventions?
(Yes/No. Describe effectiveness.)

6. **Reproductive Behaviors**

→ Are mating behaviors observed and consistent with species' natural patterns?
(Yes/No. Provide examples or note deficiencies.)

→ Are there facilities to support prenatal and postnatal behaviors, such as nesting or rearing of offspring?
(Yes/No. Describe adequacy of facilities.)

7. **Behavioral Records and Monitoring**

→ Are behavioral observations recorded regularly?
(Yes/No. Describe frequency and quality of records.)

→ Are significant changes in behavior tracked and investigated (e.g., illness, stress, aggression)?
(Yes/No. Provide examples.)

→ Are behavioral monitoring systems (e.g., CCTV, time budgets) in place to collect data on individual and group behaviors?
(Yes/No. Describe systems used.)

8. **Release Readiness**

→ Are behaviors critical for survival in the wild (e.g., predator avoidance, foraging) observed and encouraged?
(Yes/No. Describe readiness and any gaps.)

→ Are animals exposed to environmental stimuli that mimic wild conditions (e.g., sounds, vegetation)?
(Yes/No. Provide examples.)

→ Are there measures to minimize human habituation in individuals intended for release?
(Yes/No. Describe strategies.)

9. **Evaluator's Recommendations**

→ Overall adequacy of behavioral management:
(Satisfactory/Needs Improvement/Unsuitable. Provide justification.)

→ Key recommendations for improvement:
(List actionable steps with priority levels.)

Health Management Evaluation Checklist

1. **Health Screening and Records**

→ Are individual health records maintained for all animals, including medical history, treatments, and vaccinations?
(Yes/No. Provide observations on record-keeping.)

→ Are pre-acquisition health screenings conducted for new arrivals?
(Yes/No. Describe procedures.)

→ Is there a routine schedule for health checks and veterinary examinations?
(Yes/No. Specify frequency and coverage.)

→ Are necropsies conducted for all deceased animals?
(Yes/No. Provide details on documentation and findings.)

2. **Veterinary Facilities and Expertise**

→ Is there an on-site veterinary facility with appropriate diagnostic and treatment equipment?
(Yes/No. Provide details on equipment and resources.)

→ Are veterinary professionals with species-specific expertise available on-site or on-call?
(Yes/No. Describe qualifications and availability.)

→ Are collaborations with external experts or veterinary institutions in place for specialized care?
(Yes/No. List partnerships.)

3. **Preventive Care and Monitoring**

→ Are prophylactic healthcare measures, such as vaccinations, deworming, and parasite control, regularly implemented?
(Yes/No. Provide details and schedule.)

→ Are animals regularly monitored for signs of disease, injury, or other health issues?
(Yes/No. Describe monitoring protocols.)

→ Is quarantine enforced for new arrivals and animals showing signs of illness?
(Yes/No. Provide quarantine duration and practices.)

4. **Disease Management**

→ Are disease outbreaks recorded and managed effectively?
(Yes/No. Describe recent incidents and responses.)

→ Are biosecurity measures in place to prevent the spread of diseases within and between enclosures?
(Yes/No. Describe measures.)

→ Are diagnostic equipment (e.g. spot test kits) available to identify and manage diseases promptly?
(Yes/No. List available tools and their usage.)

5. **Reproductive Health**

   → Are reproductive health checks conducted for breeding individuals?
   (Yes/No. Specify frequency and methods.)

   → Are assisted reproductive technologies (e.g., artificial insemination, hormone therapy) employed when natural breeding fails?
   (Yes/No. Provide examples.)

   → Are prenatal and postnatal health care measures implemented for pregnant females and offspring?
   (Yes/No. Describe measures.)

6. **Nutrition and Its Impact on Health**

   → Are diet plans tailored to the species' nutritional requirements and reviewed for health impacts?
   (Yes/No. Provide details.)

   → Are weight and body condition regularly monitored to identify malnutrition or obesity?
   (Yes/No. Describe procedures.)

   → Are special diets provided for individuals with health issues (e.g., geriatric, pregnant, or ill animals)?
   (Yes/No. Provide examples.)

7. **Stress and Its Health Implications**

   → Are measures in place to minimize stress-related health issues (e.g., noise control, visitor interactions)?
   (Yes/No. Describe measures.)

   → Are animals showing signs of stress-related illnesses monitored and treated?
   (Yes/No. Provide examples.)

8. **Health Monitoring Technology**

   → Are technological tools, such as microchipping, radiology, or blood tests, used for health monitoring?
   (Yes/No. List tools and applications.)

   → Are health monitoring systems integrated with population management databases (e.g., ZIMS)?
   (Yes/No. Describe integration.)

9. **Evaluator's Recommendations**

   → Overall adequacy of health management:
   (Satisfactory/Needs Improvement/Unsuitable. Provide justification.)

   → Key recommendations for improvement:
   (List actionable steps with priority levels.)

Record-Keeping Evaluation Checklist

1. **Individual Animal Records**

   → Are individual animal records maintained for all species?
   (Yes/No. Provide details on record format and accessibility.)

   → Do records include basic details such as unique ID, sex, age, acquisition details, and origin?
   (Yes/No. Specify completeness.)

   → Are detailed life-history records maintained, including reproductive history, health history, and transfer details?
   (Yes/No. Highlight any gaps.)

2. **Breeding Records**

   → Are breeding records kept, documenting pairings, mating behaviors, reproductive success, and outcomes?
   (Yes/No. Provide examples of recorded details.)

   → Is information on parentage (e.g., dam, sire, offspring) maintained and verifiable?
   (Yes/No. Highlight any inconsistencies.)

   → Are unproductive pairings documented, with reasons and follow-up actions?
   (Yes/No. Provide observations.)

3. **Health Records**

   → Are comprehensive health records maintained for each individual, including medical treatments, vaccination history, and diagnostic results?
   (Yes/No. Describe the format and frequency of updates.)

   → Are necropsy reports recorded for all deceased animals?
   (Yes/No. Specify how these reports are used for future management decisions.)

4. **Demographic Data**

→ Is demographic data, such as births, deaths, transfers, and acquisitions, consistently recorded?
(Yes/No. Indicate any gaps or inconsistencies.)

→ Are population-level trends (e.g., birth-to-death ratio, growth rates) derived from records and analyzed regularly?
(Yes/No. Specify frequency and use.)

5. **Genetic Records**

→ Are pedigree records maintained to track founder representation and inbreeding coefficients?
(Yes/No. Indicate whether molecular techniques are integrated.)

→ Are genetic data used to guide breeding decisions?
(Yes/No. Highlight gaps or missed opportunities.)

6. **Behavioral Records**

→ Are behavioral observations recorded, including social interactions, mating behaviors, and stress indicators?
(Yes/No. Describe the frequency and detail of records.)

→ Are behavioral records integrated with health and breeding data to provide a comprehensive view?
(Yes/No. Provide examples.)

7. **Data Accessibility and Integration**

→ Are records maintained in a centralized database, such as ZIMS (Zoological Information Management System)?
(Yes/No. Specify whether data is digital or manual.)

→ Are historical records easily retrievable and consistently updated?
(Yes/No. Highlight any limitations in access.)

→ Is record-keeping integrated with population management strategies (e.g., studbooks, breeding plans)?
(Yes/No. Provide observations.)

8. **Documentation Practices**

→ Are records periodically audited for accuracy and completeness?
(Yes/No. Specify frequency and responsible personnel.)

→ Are standardized templates or formats used for recording key data?
(Yes/No. Provide examples of templates, if available.)

→ Are backups maintained for physical and digital records?
(Yes/No. Specify how backups are stored and updated.)

9. **Training and Oversight**

→ Are staff members trained in record-keeping practices, including data entry and maintenance?
(Yes/No. Highlight any gaps in training.)

→ Is oversight provided to ensure that records are accurate and updated regularly?
(Yes/No. Specify the role of supervisors or mentors.)

10. **Evaluator's Recommendations**

→ Overall adequacy of record-keeping:
(Satisfactory/Needs Improvement/Unsuitable. Provide justification.)

→ Key recommendations for improvement:
(List actionable steps with priority levels.)

Studbook Information Checklist

(a) **Basic Identification**

→ House name (Enclosure name/ID): _____

→ Local name: _____

→ National studbook number: _____

→ International studbook number: _____

(b) **Animal Details**

→ Sex: _____

→ Sire: _____

→ Dam: _____

→ Birth date: _____
(Provide date range if wild-born specimen)

→ Birth location: _____

→ Death date: _____
(Provide date range if unknown death date)

→ Death location: _____

→ Cause of death: _____

(c) **Acquisition and Transfer Details**

→ Acquisition date: _____
(For wild-born specimens)

→ Acquisition location (Source of animals): _____

→ Transfer date: _____

→ Transfer location: _____

→ Transfer type (To zoo/Release in the wild): _____

(d) **Marking Details**

→ Marking type: _____

→ Marking ID: _____

Evaluator's Observations:

→ Completeness of studbook data: _____

→ Key gaps identified: _____

→ Recommendations for improvement: _____

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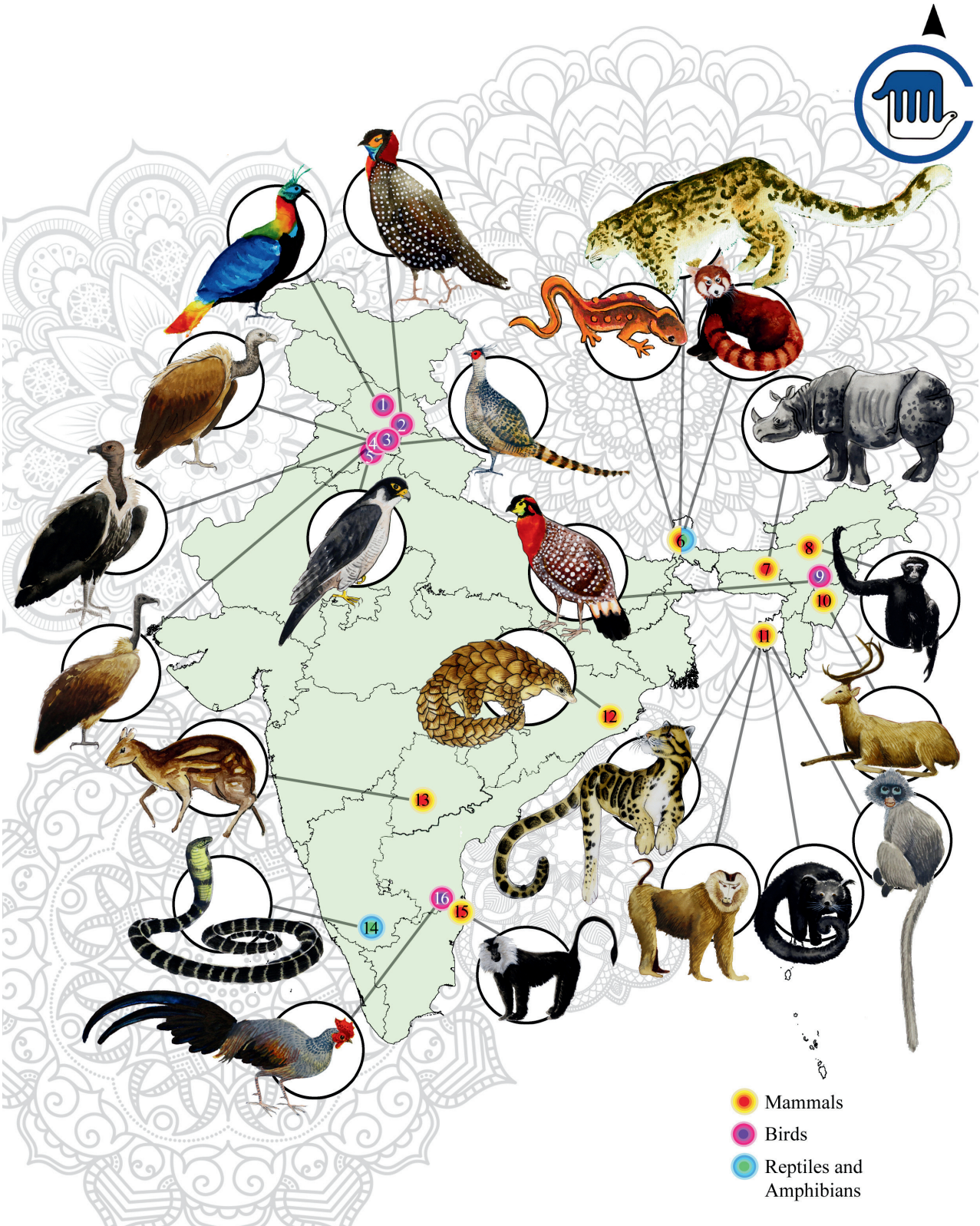
CONSERVATION BREEDING MAP OF INDIA



1. Nehru Pheasantry: Himalayan Monal; **2. Sarahan Pheasantry:** Western Tragopan; **3. Chail Pheasantry:** Cheer Pheasant; **4. Vulture Conservation Breeding Centre:** Indian Vulture, White-rumped Vulture, Slender-billed Vulture; **5. Mahendra Chaudhury Zoological Park:** Peregrine Falcon; **6. Padmaja Naidu Himalayan Zoological Park:** Himalayan Salamander, Red Panda, Snow Leopard; **7. Assam State Zoo-cum-Botanical Garden:** Greater One-horned Rhino; **8. Biological Park, Itanagar:** Western Hoolock Gibbon; **9. Nagaland Zoological Park:** Blyth's Tragopan; **10. Manipur Zoological Garden:** Eld's Deer; **11. Sepahijala Zoological Park:** Binturong, Clouded Leopard, Northern Pig-tailed Macaque, Phayre's Leaf Monkey; **12. Nandankanan Zoological Park:** Indian Pangolin; **13. Nehru Zoological Park:** Indian Chevrotain; **14. Dr. Shivaram Karanth Pilikula Biological Park:** King Cobra; **15. Arignar Anna Zoological Park:** Lion-tailed Macaque; **16. Sri Venkateswara Zoological Park:** Grey Junglefowl.