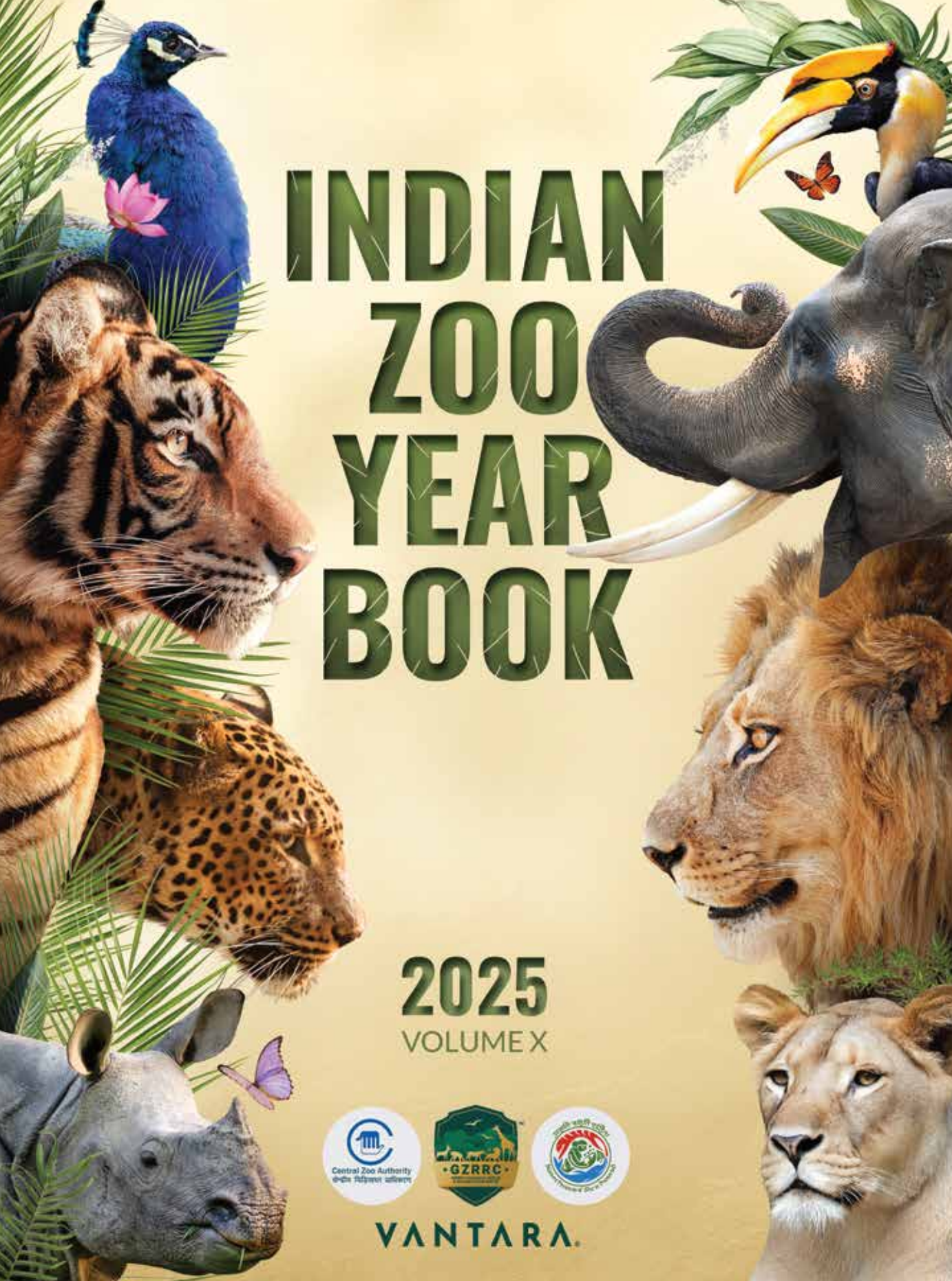


INDIAN ZOO YEAR BOOK

2025

VOLUME X

Central Zoo Authority

GZRRC

VANTARA

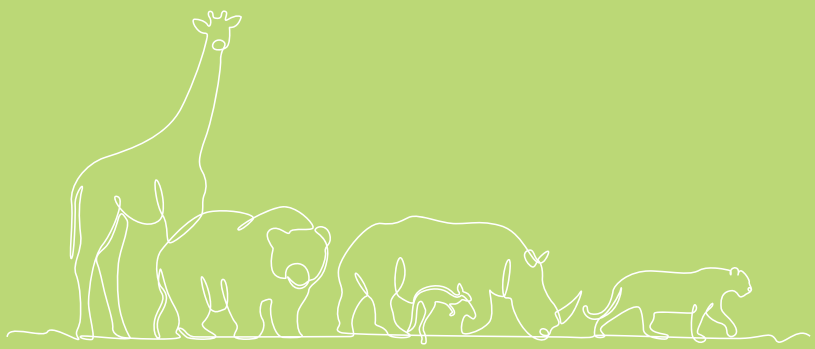
INDIAN ZOO YEAR BOOK
VOLUME - X, 2025

Editors

Dr. Sanjay Kumar Shukla,
Ms. Akanksha Mahajan,
Sh. R Hemanth Kumar,
Dr. Manoj V Nair,
Dr. Parag Nigam,
Dr. Karthikeyan Vasudevan,
Dr. Brij Kishor Gupta,
Dr. Devender Kumar,
Dr. Prudhvi Raj Gunturu and
Dr. Natasha Sethi

Published by

CENTRAL ZOO AUTHORITY
&
GREENS ZOOLOGICAL RESCUE & REHABILITATION CENTRE



Designed by: JUGGNOO - Design Studio

Suggested citation: (an article of IZYB as example)
Gupta, B. K. & Raj, P. (2025) Fostering Conservation Breeding of cheetahs in India: A Greens Zoological, Rescue And Rehabilitation Centre Initiative. Indian Zoo Year Book. Vol. X: 1-10.

VANTARA

FOREWORD

I am honoured to introduce the Indian Zoo Yearbook Volume X, an illustrious compilation that stands as a testament to the collective dedication and collaborative spirit driving the advancement of captive wildlife management within Indian Zoos. Since its inception in 1996, the Indian Zoo Yearbook has served as a beacon of knowledge, illuminating the path toward best practices in the care and conservation of captive wildlife. Volume X represents the culmination of years of diligent research, innovation, and commitment to the welfare of zoo animals across the nation. In this milestone volume, I am particularly delighted to acknowledge the pivotal role played by the Greens Zoological Rescue and Rehabilitation Centre in shaping the discourse surrounding wildlife conservation. Established in 2019 amidst the tranquil environment of Jamnagar, Gujarat, the centre has emerged as a shining example of excellence in zoological care and conservation. At the heart of the centre's ethos lies an unwavering commitment to the well-being of its animal residents, many of whom have found refuge within its walls after being rescued from perilous situations worldwide. With meticulous attention to detail and a steadfast dedication to animal welfare, the centre has earned acclaim as one of the foremost institutions of its kind in the country.

Noteworthy among its achievements is the establishment of cutting-edge facilities, including the largest wildlife hospital and conservation genetics lab in Asia, underscoring the centre's commitment to pushing the boundaries of scientific inquiry in the service of conservation. Moreover, with the distinction of operating the largest leopard rescue facility globally, the centre sets a gold standard for compassionate care and rehabilitation. Through its pioneering conservation breeding programs aimed at safeguarding endangered species such as the Okapi, Greater one-horned rhinoceros, Spix macaw, and Asiatic lion, the centre exemplifies the critical role that zoos play in preserving biodiversity and promoting stewardship of our natural heritage.

As we embark on this journey of discovery and enlightenment with Volume X of the Indian Zoo Yearbook, let us pause to celebrate the tireless efforts of zoo managers, veterinarians, curators, and biologists who dedicate their lives to the noble cause of wildlife conservation. May the insights gleaned from these pages serve as a beacon of inspiration, guiding us toward a future where humans and wildlife coexist harmoniously.

On behalf of the Indian Zoo Directors Association and the Central Zoo Authority, I extend my heartfelt gratitude to all those who have contributed to the success of this volume. Together, let us continue to champion the cause of wildlife conservation, ensuring a brighter tomorrow for generations to come.

(Dr. Brij Kishor Gupta)
Director
Greens Zoological Rescue and Rehabilitation Centre

GOVERNMENT OF INDIA
भारत सरकार

MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय

Central Zoo Authority
केंद्रीय चिड़ियाघर प्राधिकरण

PREFACE

Zoos, with their living collections, play a pivotal role in global wildlife conservation, particularly through ex-situ management. These institutions, dedicated to the well-being of captive animals, strike a balance between the animals' needs and the educational and recreational requirements of the public. The increasing coordination of research efforts in wildlife biology and behaviour is a crucial component of advancing conservation goals. Collaborative research, shared across institutions and aligned with global species conservation strategies, plays a pivotal role in this endeavour.

Zoos have evolved significantly from their early days of simply exhibiting exotic animals for public entertainment. Today, they are centers of conservation, education, and research. Ex-situ conservation, which involves the management of species outside their natural habitats, is one of the primary conservation strategies implemented by zoos. By maintaining genetically diverse populations and participating in breeding programmes, zoos contribute to the preservation of species. Zoos provide visitors with the opportunity to learn about animal behaviour, habitats, and the challenges faced by wildlife. Educational programmes, interactive exhibits, and informative signage help to foster a greater appreciation for biodiversity. Additionally, zoos offer recreational experiences that connect people with nature, promoting a sense of responsibility towards wildlife conservation. Research is a cornerstone of modern zoos, with studies focusing on various aspects of wildlife biology, behaviour, and health. Collaborative research initiatives, involving partnerships with universities, conservation organizations, and other zoos, enhance our understanding of animal needs and conservation strategies. These efforts are aligned with global species conservation plans, ensuring that research findings contribute to the broader goals of preserving biodiversity.

Research on animal behaviour and breeding techniques has led to successful breeding programmes for critically endangered species. Indian zoos have increasingly recognized the value of outreach and education in engaging the public about wildlife conservation. Through educational programmes for schools, community engagement activities, and partnerships with local organizations, these zoos focus on raising awareness about endangered species and highlighting the importance of preserving their ecosystems. Capacity-building programmes and workshops for zoo staff ensure that these institutions continuously enhance their ability to provide welfare for animals while involving the community in conservation efforts.

This publication aims to promote the adoption of scientific rigor in zoo animal management across India, encouraging evidence-based research that informs conservation strategies. By disseminating research findings and sharing best practices, the publication seeks to strengthen the scientific foundation of wildlife management in Indian zoos. Scientific research is essential for understanding the needs of captive animals, developing effective breeding programmes, and improving animal welfare. This publication celebrates the progress made in advancing conservation through scientific research, public engagement, and capacity building, showcasing the critical role that zoos play in safeguarding future of wildlife. It underscores the vital role that zoos play in ensuring the long-term survival of species and the preservation of biodiversity. By bridging the gap between conservation science and public awareness, Indian zoos contribute significantly to global efforts aimed at protecting our planet's precious wildlife.We extend our heartfelt thanks to all the contributors to the Zoo Yearbook for their invaluable articles and research papers. Your insights and dedication have greatly enriched this publication, and we deeply appreciate your efforts in advancing our understanding of wildlife conservation. Thank you for sharing your knowledge and passion with us. We sincerely thank to GZRRC for stepping up and taking on the responsibility of publishing the zoo yearbook. Your effort and dedication are greatly appreciated!

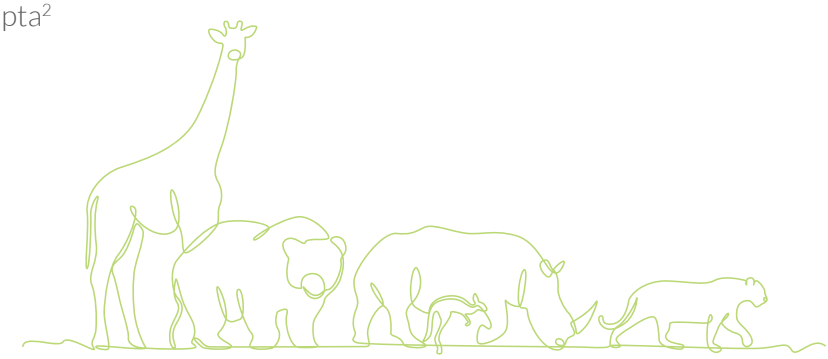
(Dr. Sanjay Kumar Shukla)
Member Secretary

B-1 Wing, 6th Floor, Pt. Deendayal Antyodaya Bhawan, C.G.O. Complex, Lodhi Road, New Delhi – 110003
बी- 1 विंग, 6 तल, पं.दीनदयाल अंत्योदय भवन, सी॰जी॰ओ. कॉम्प्लेक्स, लोधी रोड, नई दिल्ली – 110003
दूरभाष (Tel)0 : 11-24367846, 24367851, 24367852 फ़ैक्स (Fax) :011-24367849
ईमेल (Email) :cza@nic.in, वेबसाइट (Website) :http://www.cza.nic.in

CONTENT

Indian Zoo Year Book - Volume X

2025



1

Fostering Conservation Breeding of cheetahs in India: A Greens Zoological, Rescue And Rehabilitation Centre Initiative

[1]Dr. Brij Kishor Gupta and [2]Dr. Prudhvi Raj,
[1]Director, Greens Zoological Rescue and Rehabilitation Centre, Jamnagar and [2]Compliance Officer, Greens Zoological Rescue and Rehabilitation Centre, Jamnagar 361 142, Gujarat

Email: gzrrc@outlook.com, bkgupta.brij@gmail.com

INTRODUCTION

Captive breeding initiatives are becoming increasingly vital for species conservation endeavours, however breeding endangered species in captivity is fraught with some unique challenges related to species biology and captive husbandry practices. The survival of the Cheetah *(Acinonyx jubatus)* hinges on comprehensive conservation planning that incorporates both in-situ and ex-situ strategies (Bartels et al. 2002). According to the recent update from the IUCN Red List of Threatened Species (2023), the global cheetah population in the wild is currently estimated to range between 6,517 and 7,000 individuals, with a classification of "vulnerable," indicating a high risk of extinction in their natural habitat. Habitat loss, human-wildlife conflict, and poaching have all significantly contributed to the decline in the cheetah population and local extinction in much of its former distribution range. Faced with the imminent threat of extinction, concerted efforts are being made in both wild conservation and captive breeding programs to safeguard their survival. Research conducted on captive cheetahs offers valuable insights into strategies for protecting their counterparts in the wild. There is potential to enhance wild populations by reintroducing captive-bred cheetahs into their native habitats.

However, only a small percentage, approximately 20%, of cheetahs successfully reproduce in captivity, partly due to reduced genetic diversity and ongoing efforts to gain a better understanding of their requirements.

CAPTIVE BREEDING CHEETAHS IN INDIA: CHALLENGES AND PERSPECTIVES

The etymology of the term "cheetah" can be traced back to the Sanskrit word "Chitraka," which translates to "spotted." This nomenclature aptly describes the characteristic spotted coat of these magnificent creatures. Cheetahs had a wide geographical distribution in the Indian subcontinent, as evidenced by the plethora of cave paintings scattered throughout its arid hinterlands. These ancient depictions serve as a testament to the enduring fascination that cheetahs have invoked among humans since time immemorial. However, it was during the Mughal era that they gained significant prominence. During the reign of the Mughal emperors, particularly Emperor Akbar, cheetahs garnered immense attention. They were sought after for their prowess in hunting and were often captured from the wild and trained for royal hunting expeditions. Akbar's royal menagerie boasted an impressive collection of 1,000 cheetahs, highlighting the cultural and historical significance of these majestic cats.

The association between cheetahs and the Mughal dynasty is immortalized in numerous artworks and historical texts, including the renowned Akbarnama and Shah Jahannama. However, despite their prominence, the cheetah population in India began to face significant challenges from the mid-17th century onwards. The burgeoning human population led to widespread habitat loss, particularly the grasslands crucial for the cheetah's survival and its prey base. As agricultural activities expanded, vast swathes of cheetah habitat were cleared, diminishing their natural range. By the end of the 19th

century, the cheetah population had dwindled drastically from an estimated 10,000 to just a few hundred individuals. The colonial period further compounded the cheetah's decline, with practices such as rewarding individuals for killing cheetahs exacerbating their plight. Despite attempts to bolster captive populations through imports from Africa, the species was never sustainable since captive breeding of the species remained elusive. By 1952, cheetahs had vanished from the Indian landscape, and by 1997, they were declared extinct across the entire Indian subcontinent, primarily due to habitat loss and hunting pressures.

In the early 2000s, hopes for cheetah conservation were buoyed by scientific advancements in cloning technology. The Centre for Cellular and Molecular Biology (CCMB) proposed plans to clone Asiatic cheetahs, leveraging these breakthroughs. However, logistical challenges, including reluctance from Iran regarding the transfer of Asiatic cheetahs, hindered the realization of these ambitious plans. While historical records indicate a single instance of captive breeding success of the species during the Mughal era, subsequent centuries saw no progress in this regard. Post-independence, various attempts were made to breed cheetahs in Indian zoos, but these efforts were plagued by challenges such as inadequate husbandry practices and diseases. Between the 1970s and 1990s, six Indian zoos, including Nehru Zoological Park in Hyderabad, National Zoological Park in New Delhi, Sri Chamarajendra Zoological Gardens in Mysore, Kanpur Zoological Park in Kanpur, Zoological Garden in Alipore, Kolkata, and Zoological Garden in Thiruvananthapuram, imported a total of 35 cheetahs. Unfortunately, all these animals perished by 1995, largely due to inadequate husbandry practices and diseases. Despite concerted efforts to facilitate captive breeding, challenges such as dietary changes, environmental factors, and other breeding constraints thwarted success. Renewed efforts to breed cheetahs within Indian zoos commenced in the 2000s with the importation of 14 cheetahs by four zoos, including Nehru Zoological Park in Hyderabad, Sri Chamarajendra Zoological Gardens in Mysore, Sakkarbaug Zoological Gardens in Junagadh, and Indira Gandhi Zoological Park in Visakhapatnam. Among these institutions, only Sri Chamarajendra Zoological Gardens in Mysore achieved successful breeding outcomes, attributed to improved husbandry practices and dedication to conservation efforts. Despite these efforts, breeding cheetahs in captivity remained a formidable challenge, with many animals succumbing to various factors.

Recent years have seen a resurgence in conservation initiatives, with institutions like Sri Chamarajendra Zoological Gardens and Greens Zoological Rescue and Rehabilitation Centre (GZRRC) leading the charge to breed cheetahs in captivity, offering hope for the preservation of this endangered species. Needless to say, this phenomenon is something that is not restricted to Indian zoos. Most zoos around the world faced similar challenges.

Captive breeding challenges: Most of the known large and medium sized felids are known to do well in captivity, however, captive cheetah populations were never self-sustaining given their unusually high mortality rates. Though the species reproduces very well in the wild, cheetahs were found to be difficult to breed in captivity as the species exhibit unique social and mating behaviours. In

the past, zoos in India as with zoos around the world followed husbandry practices similar to other large felids. These practiced are to be blame for poor breeding success rates and high juvenile mortality. Out of the 14 animals that arrived at various zoos in India and of the 19 cubs that were born in five litters at Sri Chamarajendra Zoological Gardens from late 2000's to mid-2010's, 23 cheetahs died due neurological disorders characterized by hindlimb paralysis, 4 animals died due to renal related issues, one animal due to myocardial infarction, and the rest due to senility and unknown reasons. Though cheetahs were kept in Indian zoos for a long time, little focus was placed on to understand the cheetah's reproductive biology and husbandry practices. Unlike other large felids that are commonly found in various zoological institutions in India and the breeding biology of these species well studied, relatively little was known on the cheetahs reproductive biology until recently. Similar situation prevailed globally and until recently very few zoos were successful in breeding the species in captivity. Many of the enclosure designs and husbandry practices followed in Indian zoos for cheetah were based on information from other felids. There are still significant gaps in the knowledge of captive cheetahs' behaviour (Wielebnowski 1998).

NAVIGATING HEALTH CHALLENGES IN CAPTIVE CHEETAHS

Insights and Considerations:

In captivity, cheetahs face a multitude of health challenges, encompassing both non-infectious disorders and infectious diseases, which significantly impact their well-being and longevity. Despite considerable advancements in the husbandry practices implemented within zoos and other captive environments worldwide, cheetahs continue to grapple with a range of medical issues that are seldom encountered in other captive feline species. These health concerns span a broad spectrum, including gastritis, various kidney ailments, liver abnormalities, fibrosis of the heart muscle, and an assortment of neurological disorders. The prevalence of such conditions underscores the complexity of maintaining the health and welfare of cheetahs in captivity, despite efforts to optimize their living conditions. Among the most alarming health risks faced by captive cheetahs is Systemic Amyloid A (AA) amyloidosis, an inflammatory disorder that manifests with alarming frequency due to the chronic elevation of cortisol, a stress hormone prevalent in captive settings (Ashley et al. 2016). This condition poses a significant threat to cheetah populations, contributing to increased mortality rates among captive individuals.

In addition to systemic disorders, cheetahs are highly susceptible to a myriad of infectious agents, including various viruses such as Feline calicivirus, Feline herpesvirus (FHV), Feline parvovirus, Feline coronavirus, Feline leukemia virus, Canine distemper virus, and Rabies virus. Furthermore, they are vulnerable to blood-borne protozoans like *Toxoplasma gondii*, *Babesia* spp., and *Leptospira* spp. These pathogens can wreak havoc on the health of captive cheetahs, leading to debilitating illnesses and compromising their overall immune function. Moreover, cheetahs exhibit a predisposition to a diverse array of hepatic, gastric, and renal diseases, further complicating their health management in captivity. These conditions necessitate comprehensive veterinary care and diligent monitoring to mitigate their impact on cheetah

populations. Furthermore, diseases affecting the central nervous system (CNS), such as encephalomyelopathy, pose a formidable challenge for cheetahs in captivity, representing a significant threat to their neurological health and overall survival. The intricate interplay of environmental stressors, genetic predispositions, and infectious agents underscores the multifactorial nature of these neurological disorders in captive cheetahs.

Post-mortem examinations conducted on cheetahs housed in captive facilities across different regions, including North America and South Africa, have revealed alarming findings. Over 90% of these individuals exhibited some degree of gastritis at the time of death, highlighting the pervasive nature of gastrointestinal disorders among captive cheetah populations. Similarly, kidney disease affected more than two-thirds of captive cheetahs, underscoring the prevalence of renal pathology in these individuals. In stark contrast, such diseases are exceedingly rare in their wild counterparts, emphasizing the profound impact of captivity on the health and well-being of cheetahs. Efforts to address these health challenges require a holistic approach, encompassing advancements in veterinary medicine, improvements in captive management practices, and heightened conservation efforts aimed at preserving wild cheetah populations and their natural habitats.

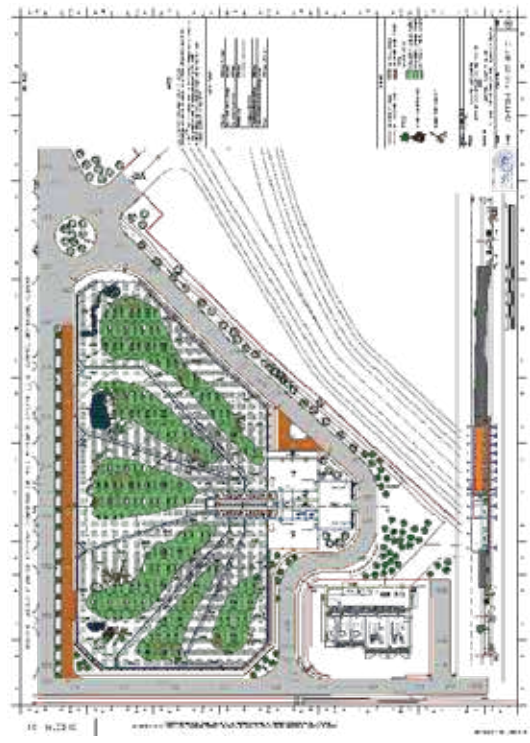


Image 1. Site plan of Somali cheetah breeding area at GZRRC

OPTIMIZING CAPTIVE CHEETAH NUTRITION

Insights and Challenges:

In recent years, significant advancements have been made in enhancing captive husbandry practices. In their natural habitat, cheetahs primarily prey on small antelope, consuming the entire carcass, including skin, bones, and internal organs. However, until recently, captive cheetahs in India and worldwide were commonly fed mainly muscle meat from domestic species such as cattle and chickens, lacking the essential minerals and vitamins crucial for a cheetah's health. These captive diets provided to cheetahs are notably deficient in collagen, which is a rich source of glycine. Glycine plays a crucial role in various physiological functions, particularly in collagen synthesis, and its deficiency could lead to numerous negative health effects. Glycine levels are low in the muscle meat diets and in captivity, cheetahs are not fed with skin, cartilage, or body organs, that contain higher amounts of glycine.

Captive cheetahs are known to excrete high levels of phenolic acids in urine due to the presence of undigested proteins in their large intestine. Phenolic acids can negatively affect dopamine production, which plays a vital role in gut and kidney function, potentially contributing to the prevalence of renal-related problems among cheetahs. Research on various metabolites in cheetahs has revealed that captive individuals tend to exhibit high levels of polyunsaturated fatty acids in their blood compared to their wild counterparts, who typically have lower levels (Visser 2002; Franklin et al 2015). Recent studies suggest that feeding cheetahs whole carcasses can lead to improved stool consistency, increased production of beneficial fatty acids, and reduced production of some toxic compounds in the colon. However, this feeding method is costly in captivity. Overall, nutrition is crucial for the survival of cheetahs in captivity, and their diet should be carefully planned to meet their specific requirements. It's essential to consider the nutritional needs of the species to ensure their health and well-being in captivity.

REVOLUTIONIZING CAPTIVE CHEETAH BREEDING

Insights from Natural Behaviour:

Over the years, the endeavour to breed cheetahs in captivity has faced considerable challenges, largely stemming from a limited understanding of the intricate nuances of the species' reproductive biology. With cheetah populations dwindling and facing imminent threats, there exists an urgent imperative to bolster their numbers through successful captive breeding programs. The historical setbacks in captive breeding efforts can be traced back to a fundamental misunderstanding of cheetah behaviour. Since the 1950s, numerous attempts have been made to propagate captive cheetah populations through various behavioural methodologies and breeding techniques yet met with modest success at best. One of the prevalent practices involved housing both male and female cheetahs together in zoo environments, where the subtle behavioural cues indicative of female estrus cycles often

went unnoticed (Brown et al. 1996; Brown 2011). This lack of discernment, coupled with prolonged cohabitation, frequently resulted in the formation of sibling bonds between males and females, undermining reproductive efforts (Beekman et al. 1997).

However, recent breakthroughs in cheetah breeding owe much to a deeper comprehension of the species' behaviour in its natural habitat (Caro 1993; Koester 2014). While cheetahs are inherently more social compared to many other felids, it is primarily the males that form coalitions, fostering cooperation in territories and during hunting. Females, on the other hand, typically lead solitary lives, unless they are raising cubs. Moreover, in the wild, females exhibit promiscuous mating behaviour, engaging with multiple males during estruses. These critical behavioural insights have revolutionized the design of cheetah enclosures in captive settings. By emulating the natural social dynamics and reproductive behaviour of cheetahs, enclosures have been tailored to accommodate their specific needs, thereby fostering successful breeding outcomes (Koester 2014). Notably, allowing cheetahs to select their own mates has emerged as a pivotal strategy. Adult female cheetahs demonstrate a remarkable degree of mate selection, exhibiting discernment when choosing a partner. Thus, facilities that house a diverse array of male cheetahs stand a greater chance of facilitating compatible pairings.

Pioneering institutions such as the Ann van Dyk Cheetah Centre in South Africa have spearheaded innovative breeding management approaches. By implementing separate housing for males and females, with no direct visual or physical contact between the sexes, these centres have optimized breeding conditions. Central to this approach is the utilization of designated "lover's lane" walkways, where male cheetahs are strategically released to detect females in estruses based on behavioural cues. The presence of males has been observed to stimulate the initiation of the estrous cycle in females, often resulting in unmistakable displays of estrous behaviour upon interaction (Wielebnowski et al. 2002; Silva et al. 2017). In essence, the success of captive cheetah breeding hinges on a nuanced understanding of the species' natural behaviour and reproductive biology. By aligning captive breeding practices with the ecological and social dynamics observed in the wild, conservationists and zoologists can pave the way for the preservation and proliferation of this magnificent species.

CHEETAH BREEDING AT GZRRC

In a significant stride towards bolstering cheetah conservation efforts, the Greens Zoological Rescue and Rehabilitation Centre (GZRRC) unveiled its expansive 26-acre Cheetah Breeding Facility in December 2023. Meticulously chosen for its tranquil surroundings, the location was carefully selected to mitigate potential disturbances, ensuring an optimal environment for the cheetahs under GZRRC's care. The enclosures' innovative design prioritises the cheetahs' well-being and natural behaviour. Spanning across the facility's expanse are four distinct divisions, each tailored to meet the unique requirements of different cheetah demographics. These divisions encompass dedicated spaces for breeding females, females with cubs, male cheetahs, and juveniles, providing ample room for movement and enrichment activities. Specific enclosures

within the breeding facility cater to various stages of the cheetah's life cycle. Notably, the division dedicated to females with cubs comprises ten spacious enclosures, each boasting a generous 1545 square meters paddock area, fostering a nurturing environment for maternal care and cub development. Additionally, another set of enclosures, totalling ten, is allocated for individual breeding females, offering ample room for solitary repose and reproductive activities within their 2000 square meter enclosures. Furthermore, GZRRC's commitment to cub rearing is exemplified through ten enclosures specifically designed to accommodate mothers and their growing offspring, each providing a sprawling 3700 square meters of space. Complementing these areas, the juvenile section comprises six enclosures, each offering 1250 square meters of paddock area, facilitating young cheetahs' energetic exploration and development.

The enclosure's meticulous design seamlessly integrates natural elements, ensuring minimal disruption to the cheetahs' privacy and fostering a habitat that closely mimics their wild counterparts. Alongside these enclosures, a meandering pathway affectionately referred to as "Lover's Lane" winds its way past the breeding female enclosures, allowing male cheetahs to detect females in oestrus, promoting natural mating behaviours. All cheetahs enrolled in GZRRC's breeding program are housed within this state-of-the-art facility, underscoring its pivotal role in cheetah conservation efforts. Moreover, GZRRC is the sole institution in South and Southeast Asia to spearhead the Cheetah Breeding Centre Coalition, uniting regional stakeholders in a collective endeavour to safeguard this endangered species. Looking ahead, GZRRC aims to forge domestic and international partnerships with institutions, fostering collaborative efforts to establish a self-sustaining captive breeding population of cheetahs in India.

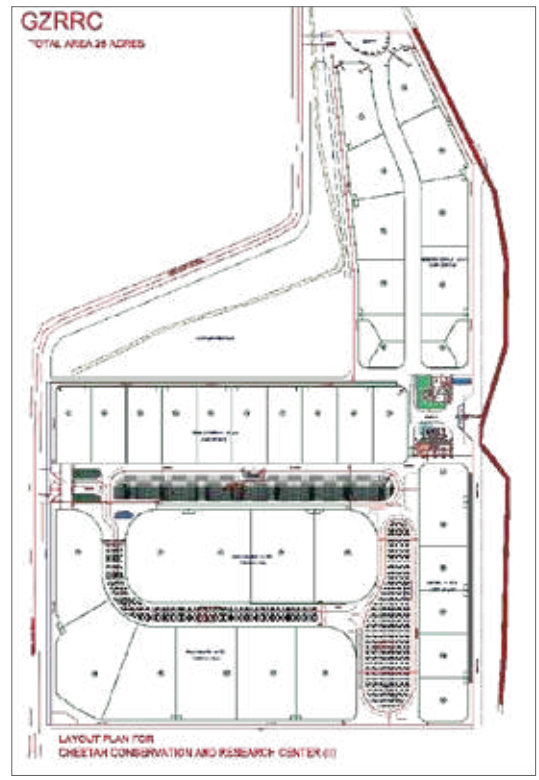


Image 2. Site plan of Cheetah Breeding Centre at GZRRC

Through these concerted endeavours, GZRRC aspires to realise its overarching objective of cultivating a sustainable cheetah population, thereby safeguarding the species from the brink of extinction.

In essence, GZRRC's Cheetah Breeding Facility epitomises a beacon of hope for cheetah conservation, embodying a steadfast commitment to preserving the natural heritage of this iconic species for generations to come.

GZRRC will play a key role in maintaining a healthy ex-situ breeding population and aid in the conservation of cheetahs.

This establishment of this facility has multiple animal management and research objectives, including:

1.Standardising basic cheetah husbandry and breeding techniques

2.Develop a record-keeping system for animal husbandry, nutrition, breeding, pregnancy, and cub survival data, which can be helpful for further research and improvements in captive husbandry of the species.

3.Formulate and provide a nutritionally balanced diet.

4.Assess stress levels measured through blood and faecal cortisol levels.

5.Assess female reproductive status and cyclicity using hormonal metabolites.

6.Create compatible breeding pairs using individual animals' behavioural, genetic, hormonal, and chemical communication attributes.

7.Monitor pregnancy/gestation/parturition using faecal hormones.

8.To maintain a captive population of cheetahs with a higher genetic variability

9.Pairing up genetically viable males and females within the population.

10.Standardising protocols for infant care and improving their survival rates.

11.Identify various health and genetic issues in captive cheetahs and develop a preventative health programme.

12.To help both national and international institutions in cheetah conservation and rewilding programmes

REFERENCE

Ashley, D., Franklin, Anne Schmidt-Küntzel, Karen, A., Terio, Laurie, L. M., Adrienne, E. C. (2016): Serum Amyloid, a protein concentration in blood is Influenced by genetic differences in the Cheetah (*Acinonyx jubatus*), J. Herd. 107 (2): 115–121.

Beekman, S. P. A., de Wit, M., Louwman, J. and Louwman H. (1997): Breeding and Observations on the Behaviour of Cheetah (*Acinonyx Jubatus*) at Wassenaar Wildlife Breeding Centre. Int. Zoo Yearb. 35: 43–50.

Bertschinger, H. J., Meltzer, D. G. A. and van Dyk, A. (2008): Captive Breeding of Cheetahs in South Africa—30 Years of Data from the de Wildt Cheetah and Wildlife Centre. Reprod. Domest. Anim.43:66–73.

Brown, J. L. (2011): Female Reproductive Cycles of Wild Female Felids. Anim. Reprod. Sci. 2011;124:155–162.

Brown, J. L., Wildt, D. E., Wielebnowski, N., Goodrowe, K. L., Graham, L. H., Wells S., Howard J. G. (1996): Reproductive Activity in Captive Female Cheetahs (*Acinonyx Jubatus*) Assessed by Faecal Steroids. J. Reprod. Fertil.106: 337–346.

Caro, T. M. (1993): Behavioral Solutions to Breeding Cheetahs in Captivity: Insights from the Wild. Zoo Biol.12:19–30.

Franklin, A. D., Crosier, A. E., Vansandt, L. M., Mattson, E. and Xiao, Z. (2015): Induction Of Cytokine Production In Cheetah (*Acinonyx jubatus*) Peripheral Blood Mononuclear Cells And Validation Of Feline-Specific Cytokine Assays For Analysis Of Cheetah Serum. J. Zoo. Wildl. Med. 46(2): 306-13.

Koester D. C. (2014): Ph.D. Thesis. George Mason University; Fairfax, VA, USA: The Effect of Environment on the Reproductive Potential of Ex Situ Cheetahs (*Acinonyx jubatus*)

Silva, A. R., Moreira, N., Pereira, A. F., Peixoto, G. C. X., Maia, K. M., Campos, L. B., Borges A. (2017): Estrus cycle monitoring in wild mammals: Challenges and perspectives;

Visser, R. R. C. (2002): Ph.D. Thesis. Stellenbosch University; Stellenbosch, South Africa. Chemical Communication: Chemical Characterization of Volatile Constituents of Urine of the Southern African Cheetah (*Acinonyx jubatus*), Using Headspace Sampling and GC-MS.

Wielebnowski N. and Brown J. L. (1998): Behavioral Correlates of Physiological Estrus in Cheetahs. Zoo Biol. 1998;17: 193–209.

Wielebnowski, N. C., Ziegler, K., Wildt, D. E., Lukas, J., Brown, J. L. (2002): Impact of Social Management on Reproductive, Adrenal and Behavioural Activity in the Cheetah (*Acinonyx Jubatus*) Anim. Conserv. 5:291–301.

2

The Zoological Garden, Alipore- A realm of memory and science

Manabi Paul[1], Silanjan Bhattacharyya[2], Subhankar Sen Gupta1*
[1]Zoological Garden, Alipore, Kolkata, West Bengal, India.
[2]West Bengal State University, Barasat, North 24 Parganas, West Bengal, India.

*Corresponding Author details:
Shri Subhankar Sengupta, IFS, Chief Conservator of Forest &
Director, Zoological Garden, Alipore,

Email: director@kolkatazoo.in, Contact: +91 9433147904

ABSTRACT

Kolkata (formerly called Calcutta) has numerous historical stories to tell that are deeply intertwined with the colonial legacy of the British Empire. The Zoological Garden, Alipore, represents one such architectural gems that has witnessed the transformation of a barren 65 acres of land into a mesmerising animal park that has recently bagged the title of "Kolkata's Grade-I Heritage Property" under the criteria "Park, Waterbody, and Memorial.". During the last 150 years of its journey, Zoological Garden, Alipore has succeeded in maintaining it's architectural elements that have been blended with well with the new structures and landscapes. This article portrays the fascinating history of Zoo-establishment along with its success in captive breeding of Sumatran rhinoceros as early as 1889 under the supervision of Rai Bahadur Ram Brahma Sanyal.

KEYWORDS

Ram Brahma Sanyal, Captive breeding, Sumatran rhinoceros

INTRODUCTION

The fascinating history of establishment: Establishing botanical and zoological gardens had been integral to European colonial expansions (Drayton 2000). Plants and animals, hitherto unknown to Europeans (mainly from the tropics), were collected from the wild or local farms and then acclimatised and bred in the local gardens before their propagules or offspring were sent to the botanical gardens andzoos in Europe. Thus, in 1787, the Royal Botanical Garden was established on the west bank of the Hooghly River under Col. Robert Kyd's leadership. The success of this garden (termed as the best in the tropics by James Hooker in 1848) triggered the urge to have a zoological garden in Calcutta that would augment the glamour of the then capital of British India. Moreover, between 1752 and 1838, Zoological Gardens had been opened in many European cities like Vienna, Paris, Dublin, Bristol, etc., including the London Zoo in 1828. Zookeepers from these zoos wanted to add only animals that were acclimatised to captivity in their climatic regions. Hence, to feed that demand, on 24 September 1875, the Zoological Garden was finally established in Alipore, at the heart of Calcutta, which had a good transportation system and a nearby river shore. The vibrant weekend retreat of the Governor Generals of India during that time at the riverside of Barrackpore, some 30 km north of Alipore, already had a menagerie within it (Fig. 1). Alipore Zoological Garden started its journey with 31 animals of various species obtained from this park and on 6th May 1876, the Garden's gate was opened for the general visitors.

Mr. Ram Brahma Sanyal, an erudite Bengali medical student, was appointed as the Superintendent of the Garden, whose brilliant expertise in animal biology, experienced eyes, and magical touch made a revolutionary makeover of this Garden. Soon, it became one of the most lucrative visiting spots for the royals of British Calcutta.

A FLOURISHING ZOO

Gradually, the garden acquired various animals and birds from different parts of the World, including Egypt, England, and Germany. Simultaneously, the Management Committee of the Garden started to acquire different travelling cages, including a few expensive ones (worth Rs. 102/- in 1896) for the birds. On

Fig. 1 The old menagerie at Barrackpore

11th April 1896, Rai Bahadur R. B. Sanyal mentioned in one of his letters requesting for the availability of such cages, ***"if you have any spare travelling cages in the table for Ostriches & deer that we can get a loan of or if necessary, buy."*** Free railway, ferry, and ship passes were issued not only for the conveyance of animals but also for their keepers from various parts of the world. New enclosures (open, semi-open, and captive) were made to provide the animals with a suitable living ground (Fig. 2). Bit by bit the Garden thus started to flourish and soon became a home for Jaguars, wolves, bears, Long-eared foxes (Fennec foxes), Brow-antlered deer, Sambar, Nilgai, gazelles, Flying squirrels, Pangolins, Emu, Cassowary, Agouti, pythons, vipers, crocodiles, tortoises, and many more. Not only elite-class people but also ordinary visitors stopped by the garden to seek easy access to experience the presence of various exciting animals and birds, most of which were new to them. The Garden used to have a footfall of 200 to 40isitors daily in 1895, which facilitated the economic growth of the Garden Authority. The entrance fee to the Zoo was five rupees per head in 1895, which increased to fifty rupees in 2022.

Fig. 2 Shri. Rai Bahadur Ram Brahma Sanyal; open enclosure at Zoological Garden, Alipore in the late 1800's

THE HISTORICAL ARCHAEOLOGY OF THE GARDEN

The Mullick House: It was the first animal house constructed within the Zoological Garden, Alipore, with the financial help of Raja Rajendra Nath Mullick Bahadur of Chorebagan, Calcutta, and therefore named "Mullick House". Raja Mullick Bahadur was the first Indian donor who came forward to help construct the garden. At the age of sixteen, Raja Mullick began the construction of the famous Marble Palace (Calcutta), where he maintained his private menagerie in 1840, long before the Zoological Garden came into existence. Besides money, Raja offered the newly built-up garden with various birds and animals (including monkeys, fish-eagles, White storks, Black-headed ibis, and Demoiselle

cranes) from his private garden. Initially, this Mullick house was used to keep pheasants and fowls, but it has recently been converted into a zoo museum.

The Burdwan House: Following the Mullick House, the Maharaja of Burdwan donated a lumpsum of Rs. 35000/- to construct the garden. The Burdwan house is famous as an open-air moated lion enclosure (Fig. 3).

The Swarnomoyi House: Maharaja Manindra Chandra Nandy, the nephew and successor of the late Maharani Swarnamoyee of the Cossimbazar Raj estate, contributed to the construction of this house. The main building is surrounded by three extended sides converted to three lofty wire netting aviaries: the Eastern, Western, and Central. These aviaries have natural bushes and trees to simulate the natural home for the birds.

The Murshidabad House: H.H. the Nawab Bahadur of Murshidabad donated the funds to support the construction of this house. The Murshidabad House was a home for exotic birds such as "The Bird of Paradise".

The Buckland Enclosure: This enclosure was built to commemorate the name of Mr. C.T. Buckland, I.C.S., who was the president of Garden for many years and contributed mainly to its welfare in its infancy. This enclosure was built initially for the Rhinoceros and is now inhabited by a Hippopotamus.

The Schwendler House: This house was named after Carl Louis Schwendler (Postmaster to the Govt. of India) in the year 1876. It housed a tiny lake and a tiny little stream was there that was fed by clean pipe water trickled down from a little rockery, with grass plots on one side, and pebbly flats on the other could be seen in the house. On 10th February, 1876 Carl Louis Schwendler donated Siamese Fireback, Monaul, Linn, Wild Common Fowl, Sikkim Horned Pheasant, Guinea Fowl, and Peacock Pheasant. On 12th February, 1876 he donated Lineated Pheasant, Golden Pheasant, and Silver Pheasant.

The Jotindra Mohan Tagore's Library: It is named after the late Maharaja Sir Jotindra Mohan Tagore, K.C.I.E., of Calcutta, who was a constant supporter of the Zoological Garden, and was a recognized leader of Bengal aristocracy. Sir Jotindra Mohan Tagore wished to keep all medical books, related to animal treatments, from all over the world, here in this library. He contributed profuse funds for constructing this library, in 1898. Sir John Edgar, a notable patron of the Garden, donated a handful of bookshelves to this library. Today

Fig. 3 The open-air moated lion enclosure, one of the heritage enclosures at Zoological Garden, Alipore

the Jotindra Mohan Tagore's Library (Fig. 4) is taking care of almost 1400 old and precious books, including the hand-written diaries of Rai Bahadur R. B. Sanyal.

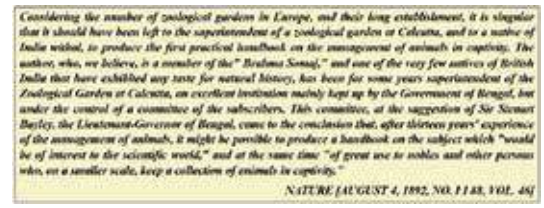
Fig. 4 Jotindra Mohan Tagore's Library at Zoological Garden, Alipore

The Gubbay House: The Gubbay House was built to commemorate the name of Mr. Ellias Gubbay. When it was opened, it was used for keeping the Apes and Monkeys. The enclosure is an oblong brick-made edifice measuring 50 feet long by 30 feet broad by 22 feet high with an arched roof. Currently, the Gubbay House has been recently remodeled into a Nocturnal House.

CAPTIVE BREEDING OF THE SUMATRAN RHINOCEROS

In 1882, the Zoological Garden, Alipore acquired a young female Sumatran rhinoceros of Western subspecies (then called *Rhinoceros lasotis*) and adult males of the Northern Subspecies (then, *R. sumatrensis*). These rhinoceroses had an enclosed area filled with water and mud to bathe and wallow in. A large shade protected them from the sunlight, and the dry ground was used as a promenade. The enclosure was 230 ft. long, 116 ft. broad, surrounded by canopy and bamboo trees. Fig leaves and soaked grams and brans were supplemented with their plant-based diet.

On 30th January 1889, a young (offspring of *R. lasotis* and *R. sumatrensis*) was born within the zoo enclosure under the supervision of Rai Bahadur Ram Brahma Sanyal. Although the newborn was very weak and unsteady when it tried walking, overnight, began suckling and became stable. Soon, the young rhino became lively and playful. The significance of the captive breeding of a highly endangered species could be gauged by the fact that the subsequent successful breeding of the Sumatran Rhino took place in Cincinnati Zoo after 112 years in 2001. This successful incident of captive breeding of Sumatran Rhinoceros was recorded in "A Handbook of the Management of Animals in Captivity in Lower Bengal" by Rai Bahadur R. B. Sanyal himself, along with his observations on various other wild animals kept by him in the Alipore garden. The book had been a pioneering work in the field, and soon it started earning notable accolades as a masterpiece from experts, as the review article published in Nature (No. 1188 vol. 46) on 4th August 1892 indicates (Fig. 5).



Considering the number of zoological gardens in Europe, and their long establishment, it is singular that it should have been left to the superintendent of a zoological garden at Calcutta, and to a native of India withal, to produce the first practical handbook on the management of animals in captivity. The author, who, we believe, is a member of the "Brahmo Somaj," and one of the very few natives of British India that have exhibited any taste for natural history, has been for some years superintendent of the Zoological Garden at Calcutta, an excellent institution mainly kept up by the Government of Bengal, but under the control of a committee of the subscribers. This committee, at the suggestion of Sir Steuart Bayley, the Lieutenant-Governor of Bengal, came to the conclusion that, after thirteen years' experience of the management of animals, it might be possible to produce a handbook on the subject which "would be of interest to the scientific world," and at the same time "of great use to nobles and other persons who, on a smaller scale, keep a collection of animals in captivity."

NATURE [AUGUST 4, 1892, NO. 1188, VOL. 46]

Fig. 5 Extract from the article published on Sumatran rhinoceros in Nature (No. 1188 vol. 46) on 4th August 1892.

CONCLUSION

Conserving Earth's biodiversity is central to contemporary global biodiversity protection where the ex-situ approaches become the predominant ones that contribute considerably to creating a sustainable urban ecosystem. The Zoological Gardens play a pivotal role here in managing as well as maintaining a viable population of threatened species by providing them with required resource supplements. The Zoological Garden, Alipore is not only enhancing the conservation movement but also safeguarding its glorified historical footprints.

The Zoological Garden, Alipore provides an important venue for the conservation of local ecology and biodiversity, as well as for raising social awareness among local people, especially children.

Therefore, besides keeping its tradition of housing a variety of rescued and captive-bred animals and birds from all over the World that serves to create important awareness among the citizens, now the Zoological Garden, Alipore (ZGA) has become a place for various outreach activities. Throughout the year, ZGA conducts a handful of Science Education and Awareness programs. It organizes various training programs on Zoo-Management, where trainees from different Central and Government sectors participate. Throughout the year, the ZGA celebrates several days having ecological and environmental importance, such as Earth Day, Wildlife Day, Environment Day, Wetlands Day, World Rhino Day, International Tiger Day, World Chimpanzee Day, and many more. Here, the Management Authority and the Zoo-Educators organize various activities including popular scientific talks, quiz competitions, short street dramas, tree-plantation drives, workshops, etc. Audiences are expected to be motivated by such incredible tales of these wild, as well as captive animals who have learned to co-exist within urban settlements and come in close contact with humans. The scientific interactions, real stories displaying wildlife, and their daily dependency on urban green spaces and constructions will encourage local people to move forward for conserving urban biodiversity.

REFERENCES

Aronson MFJ et al. A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. Proceedings of Royal Society B. 2014, 281 (art. 20133330).

Donatti, CI, PR Guimaraes, and M, Galetti. 2009. Seed dispersal and predation in the endemic Atlantic rainforest palm *Astrocaryum aculeatissimum* across a gradient of seed disperser abundance. Ecological Research 24:1187-1195.

Drayton, Richard. 2000. Nature's Government: Science, Imperial Britain, and the "Improvement" of the World. Yale University Press.

Dubost, G. and O Henry. 2006. Comparison of diets of the acouchy, agouti and paca, the three largest terrestrial rodents of French Guianan forests. Journal of Tropical Ecology 22:641-651.

Ehrlich, PR, Wilson, EO. Biodiversity studies: Science and policy. Science 1991, 253: 758–762.

Galetti, M, CI Donatti, AS Pires, PR Guimaraes, and P Jordano. 2006. Seed survival and dispersal of an endemic Atlantic Forest palm: the combined effects of defaunation and forest fragmentation. Botanical Journal of the Linnean Society 151:141-150.

Gee, E.P., 1961. The Brow-antlered deer of Manipur. Oryx, 6(2), pp.103-115.

Ives CD et al. Cities are hotspots for

threatened species. Global Ecology and Biogeography. 2016, 25: 117–126.

Kasha Patel, 2018. NASA Earth Observatory (https://earthobservatory.nasa.gov/images/92090/the-floating-islands-of-india)

Knapp S, Winter M, Klotz S. Increasing species richness but decreasing phylogenetic richness and divergence over a 320-year period of urbanization. Journal of Applied Ecology. 2017, 54(4):1152-1160.

NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

Oro D, Genovart M, Tavecchia G, Fowler MS, Martínez-Abraín A. Ecological and evolutionary implications of food subsidies from humans. Ecology letters. 2013, 1;16(12):1501-1514.

Patton, J.L. and Emmons, L.H. 2015. Family Dasyproctidae Bonaparte, 1838. In: Patton, J.L., Pardiñas, U.F.G. and D'elia, G. (eds), Mammals of South America Volume 2: Rodents, pp. 733-762. University of Chicago Press, Chicago.

Pirta RS. Comparative psychology: Understanding behaviour of non-human primates. Psychological studies- University of Calicut. 2002, 47(1/3):25-37.

Sally R. Walker; The Indian Natural History Project (1801-1808) and the Menagerie at Barrackpore (1803-1878): Lost, stolen or strayed: the fate of missing natural history collections; Naturalis Museum, Leiden, The Netherlands. 10–11 May 2001.

Seto KC, Güneralp B, Hutyra LR. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences. 2012, 109(40):16083-16088.

Sinha A. Not in their genes: phenotypic flexibility, behavioural traditions and cultural evolution in wild bonnet macaques. Journal of biosciences. 2005, 1;30(1):51-64.

Smythe, N. 1978. The natural history of the Central American agouti (*Dasyprocta punctata*). Smithsonian Contributions to Zoology 257:1-52.

Smythe N. 1989. Seed survival in the palm *Astrocaryum standleyanum*: evidence for dependence upon its seed dispersers. Biotropica 21:50-56

UNEP [United Nations Environment Programme]. 1992. Convention on biological diversity. Nairobi (Kenya): UNEP

Vandar Wall SB. 1990. Food hoarding in animals. University of Chicago Press, Chicago.

3

Understanding the stereotypic behaviour of Bengal Tigers *(Panthera tigris tigris)* in captivity in various human-modified enclosures in West Bengal

Apita Majumdar[1], Manabi Paul[2], Subhankar Sen Gupta[2*]

[1]University of Calcutta, Department of Environmental Science, Kolkata, West Bengal, India.

[2]Zoological Garden, Alipore, Kolkata, West Bengal, India.

*Corresponding Author details: Shri Subhankar Sen Gupta, IFS, Chief Conservator of Forest & Director, Zoological Garden, Alipore

Email: director@kolkatazoo.in, Contact: +91 943314790

ABSTRACT

The tiger *(Panthera tigris)* is globally threatened. As a large obligate predator, it plays a significant role in representing the habitat condition. Unfortunately, the global wild tiger population is less than the population of tiger in captivity. Human-modified captive environments are known to alter the natural behavioural pattern of an animal. The captive field behaviours are influenced and dominated by various factors like enclosure design, enrichment availability, visitors' interactions, etc. This present article highlights the effect of captive enclosures on the behavioural patterns of 12 individual tigers of varied age groups. This study was conducted in two different types of habitats, one in a semi-natural open area of Bengal safari, and another one in the human-altered, captive enclosures of the Alipore Zoological Garden where human interferences are considerably higher. The results of this study indicate that a captive environment may interfere with natural behavioural responses and thus can alter different physiological parameters of an animal. This study revealed that the tigers kept in closed enclosures spent more time exhibiting stereotypic behaviours as compared to those having access to extended open areas.

KEYWORDS

Tiger, stereotyped behaviour, captivity, time activity budget, pacing.

INTRODUCTION

Tigers play a pivotal role in indicating the habitat condition in a given ecosystem. The global wild tiger population is almost 3500 , however, the number of tigers in the wild is less as compared to those in-captivity. To ensure the well-being of the tiger population, the importance of ex-situ conservation efforts have gained importance. It has been observed that captivity alters the natural behavior of an animal behavior and this is primarily due to the artificial closed environemnt that drastically differ from their natural habitat. Moreover, the animals in captivity are exposed to human-modified environmental conditions that sometimes poses severe stress and resultant behavioural alterations (Carlstead, 1996). These alterations can affect physiological parameters, lead to repetitive abnormal behaviours and affect the growth and reproduction (Garner, 2005; Mason, 2010). Additionally animals in captivity do not get the chance to express the wide range of behaviours that are required to sustain their natural behavioural repertoire primarily due to the limitation of space (McPhee, 2002). To cope up with such altered conditions, the animals may exhibit the the redundancy of certain behavioural patterns broadly classified as stereotyped behaviour (Manson, 1991). To maintain the behavioural development and the well-being of an animal in captivity, studying behavioural pattern together with exploring the time activity budget can be one of the useful methods of assessment. Mohapatra et al., 2014 reported that the, usual behaviours (daily activity pattern, postures, movement, resting patterns, sleep, aggression etc.) can be less in number or absent, whereas frequencies of stereotypic behaviours can be notably higher in captivity. The article provides the time activity budget and occurrence of stereotype behaviour of 12 different tigers held at two captive facilities in West Bengal.

MATERIALS AND METHODS

Study Area: TThe study was carried out in two different locations of West Bengal viz; the North Bengal Wild Animal Park, commonly known as Bengal Safari situated in Siliguri and Zoological Garden, Alipore (Fig.1). All total 12 tigers were studied with seven from Bengal safari, Siliguri, and five from Alipore zoo. In Bengal Safari tigers of three different age groups were observed, two adults, two sub adults, and three tiger cubs whereas all tigers of Alipore zoo were adult.

Fig. 1: Satellite images taken from Google Earth represent the landscape of two study areas: Bengal Safari and the Zoological Garden, Alipore, Kolkata.

Data Collection: All the tigers of Bengal Safari were observed between 2nd to 16th November, 2021, for a total of 7200 minutes. During this time period all the tigers were observed from the shelter and the CCTV room. On the other hand, in the Alipore Zoo, tigers were observed between 3rd to 17th December 2021, for a total of 4500 minutes. Behaviours were predetermined through an ad-libitum study for first one week of the observational periods. A behavioural ethogram having a total of 33 individual behaviour was made from the ad-libitum study (Table 1). The behavioural ethogram was made by using the references from a handful of scientific studies on common felid behaviours (Wasser, 1978; Lindburg, 1988; Baldwin, 1991; Seidensticker and McDougal, 1993; Lyons et al., 1997). The behaviours were divided into three distinct categories- resting, exploring and stereotyping (Table 1). The exploring behaviours was further classified as grooming, mating (sexual behaviours), playing and other activities. The stereotypic behaviour included observation on animal pacing as reported by (Mason, 1993). Walking was considered as pacing when tiger repeat walking pattern in a shape of "8" (eight) (more than two rotations).

We observed the tigers by using focal sampling method (Aultman ,1972), keeping an interval of 15 minutes between two consecutive observation sessions on daily basis. Observed behaviours with their respective time were documented in a data sheet. Observations where animals were out of sight were not included in the analysis. These frequencies were converted to the proportion of time spent in that behaviour (percentage of time spent). Percentage of time spent in different behavioural activities was compared with respect to their age, sex, and enclosure size. To avoid sampling biasness, the selection of the individual tiger, observation period as well as the order of the observation was done by random sampling.

In Bengal safari the tigers used to spend their daily time in two different types of environments, one is in the caged or captive

areas of jungle safari. The adult tigers (Bivan, Sheela and Kika) were released alternatively in the jungle safari area during the day time, from 10 am to 4.30 p.m. The tiger safari is a large 20 Ha area which is mainly covered by Saal, Segun, Mehogoni, Jarul, Bamboo Bushes along with shrubs. From 4.30 pm they were kept in their night shelter. All the tigers of the Bengal Safari were captive born.

In case of Alipore Zoo, all the five tigers which were observed from the outside of their cages. Among them, Sundarban new and Payel live in the closed enclosure of comparable dimensions, whereas Snehashis lives in the Glass protected area (200 ft x 140 ft), the White Tiger Raja lives in an open enclosure (120 ft X 100 ft), and the Sundarban Raja lives in the Open-Air Enclosure (160 ft X 120 ft). Among the Tigers, Sundarban New (M), and Sundarban Raja (M) were wild, rest are captive born. Initially we recorded the behaviours without identifying the tigers with their name, but a separate code was used for each tiger (such as T1, T2, etc.) to avoid biasness in data collection.

Statistical analysis: We used StatistiXL software (version 2.0) for conducting the statistical tests. We did the contingency chi-square tests for comparing the observed behaviours found in all these tigers from two distinctly different protected areas.

RESULTS

We found that the time allocation for various active and inactive behaviours was comparable for all adult tigers of Bengal safari and Alipore zoo (Contingency chi sq. test: ?2 = 0.021, p = 0.9). Hence, we combined all the seven adults together and compared their time activity budget with that one of the sub-adults, and cubs (Fig. 2). Here, interestingly we found that unlike adults and sub-adults, tiger cubs are more active, spent almost 70% of the total time in various activities, whereas adults and sub-adults spent only 40% and 46% time for active behaviours. We looked at the time allocation for various active behaviours only, for all three life stages . Fig. 3 shows that while cubs spent most of their active time in playful acts, sub-adults spent time in grooming. Adults are found to spent notable amount of time in sexual behaviours like mating. We found the sub-adult stage as the onset of stereotyped behaviours which became the dominant one in the adult captive tigers (Contingency chi sq. test: $X^2 = 103.23$, $p < 0.001$).

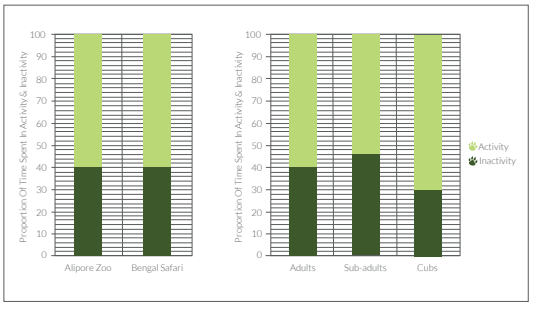


Fig.2, Left: Stacked bar diagrams representing the proportion of time spent by the adult tigers in various active and inactive behaviors. Right: The bar diagram represents the time allocation for the active and inactive behaviours observed for three age classes in tigers; adults, sub-adults, and cubs.

Table 1: Behavioural Ethogram for captive tigers describing the behaviours of interest.

BEHAVIOURAL CATEGORY	BEHAVIOUR	CODE	DESCRIPTION
RESTING	Sitting	Sis	Sitting usually, forelimbs straight, hind limbs curved
		Sih	Sitting, fore limb straight, hind limb curved, head down on the fore limb
		Siq	Squat like sitting
	Sleeping	SLs	the body laid down on one side, limbs stretched
		SLc	the body laid down on one side, limbs curled, head down
		SLh	Laid down holding the wall or cage with paws
	Watching object	WO	
	Watching surroudnings	WS	
	Lying	LY	Lying in sidewise or straight, eyes open
	Stretching	STR	
	Resting awake	RA	Sitting or lying but eyes open, ears stretched
EXPLORE	Aggravated	AG	Threat display or warning motions directed toward other tiger or animal keeper
	Alert	AL	Standing or lying, open eyes focused on object, cospecies, or human
	Drinking	DR	Drinking water from the pool or given a bowl
	Eating	Etf	Eating the given food
		Etg	Eating the grass
	Grooming	GU	Licking own body parts with tongue
	Grooming	GS	Licking body parts of the siblings/ partners with tongue
	Playing	PU	Playing with enrichments
		PS	Playing with the siblings; Non-aggressive interaction with other tigers and not grooming
	Reacting to partner	RP	calling highly, trying to reach the partner or impressing it
	Responding to keeper	RK	come near the cage boundary, scratch the body on the boundary, especially the neck part, and creates a sound

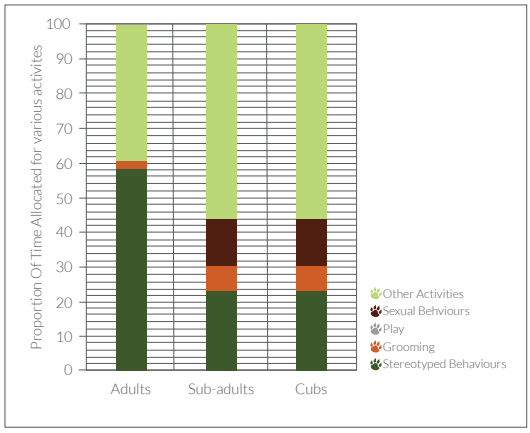


Fig. 4: The stacked bar diagram highlighted the time activity budget separately for the adults of Bengal safari and Alipore zoo.

Stereotyped behaviours: Since we have adults in both Alipore Zoo, and Bengal Safari, we compared them for their time allocation for different activities, throughout the day. Adult tigers in Bengal Safari seem to be more active, spent times in playful acts, and various sexual activities. However, the captive condition of Alipore Zoological Garden, together with heavy human interferences, adult tigers are observed to show higher amount of stereotyped behaviours (Contingency chi sq. test: $_x2 = 35.9$, $p < 0.001$) (Fig. 4). Pacing was observed as the most common stereotyped behavious in tigers of the both study locations.

Bengal Safari vs Alipore Zoo: We found that the adult tigers of Bengal Safari spent comparable amount of times in stereotyped behaviours (13%) which is the lowest among all observed adult tigers. Among the tigers of the Zoological Garden, Alipore, T3 and T1 were distinctly different and spent 50-60% of their total time in stereotyped behaviours. T4 and T5 were almost similar to the tigers of Bengal Safari (Fig. 5). The pie diagram (Fig. 6) reveals that T1, the captive born Payel, allocated the available active times largely for resting and pacing (46% each), while the wild caught T3 (Sundarban new) spent very less time in resting (only 29%). T3 spent almost 60% of the total available time in pacing, which is a highly stereotyped behaviour.

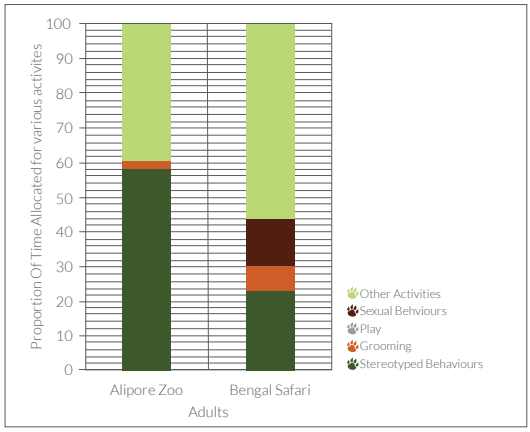


Fig. 4: The stacked bar diagram highlighted the time activity budget separately for the adults of Bengal safari and Alipore zoo.

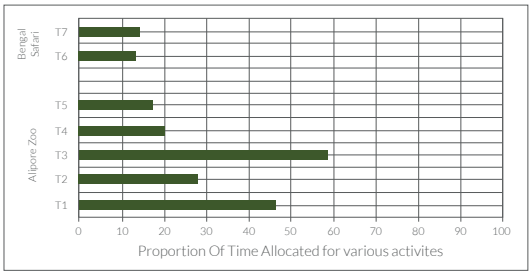


Fig. 5: The horizontal bar diagram represents the comparative visualization for the total time spent on the stereotyped behaviours, separately for all seven adult tigers.

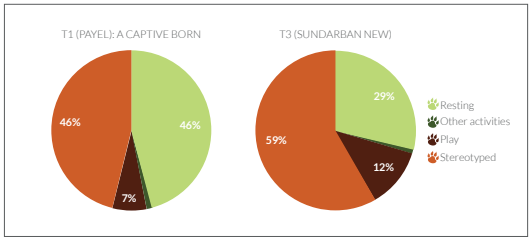


Fig. 6: The pie chart shows the variation in time allocation for the resting and pacing behaviours, separately for T1 (Payel), who is a captive-born tiger, in contrast to T3 (Sundaban new), who is wild caught and later kept in the captive enclosure of Alipore Zoo.

All adults at a glance: The time activity budget of all these seven tigers revealed that the tigers of Alipore Zoo who remained in a full-captive enclosure, mostly from their birth, are more stereotyped in contrast to the tigers of Bengal safari (Fig. 7). The tigers (T2, T3, and T5) who were caught from the wild environment of Sundarban, are similar to the tigers of Bengal Safari.

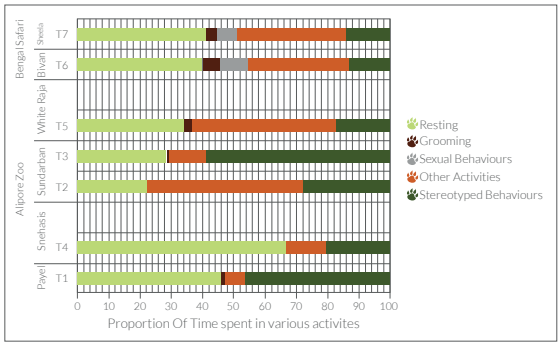


Fig. 7: The horizontally stacked bar represents the varied time allocation for inactive behaviours (resting), and different active behaviours such as grooming, mating, pacing, etc. for all seven adult tigers.

DISCUSSION

Behavioural activity pattern study plays an important role in understanding the development and wellbeing of any animal. The frequencies of stereotypic pacing in the captive tigers are shown in Figure 3. This study indicates that, in comparison with the Tigers of Bengal Safari, the tigers of Alipore Zoo invested larger proportion of their daily activity pattern in pacing. From the graph we can state that, as the tiger of Bengal Safari gets both semi in situ and semi ex situ environment as they spent their time in both jungle safari area and in closedenclosure, they are in less stressed situationthan the tigers of Alipore zoo. From the Figure 3 it can be stated that, despite having the sameenclosure size the tiger Sundarban New (T3) spent more time in pacing than the tiger Payel (T1). As Payel is a captive born tiger and Sundarban New is a wild tiger which came to Alipore after being rescued from Sundarban, thus Sundarban New is not still habituated with the closed enclosure and showing more stress than others. Besides that it can also easily be understood that both the tigers Sundarban Raja (T2) and Sundarban New (T3) are wild tigers that came from Sundarban, but as Sundarban Raja lives in Open air Enclosure, it gets more space to explore, larger variety of enrichments as well as sufficient vegetation cover; thus, Raja is in less stressed condition than Sundarban New. The time activity budget in any behavioural repertoire is a good reflection of resources (Toung, 2003). In captivity, an animal's time budget differs from its conspecifics in the wild in various ways. This study shows a comparative graph showing the time activity budget of the different tigers. This present study also represents that the tiger cubs show very minimum amount of stereotypic

behaviour, only if they are in stressed condition (like get a chance to see or hear their mother). Tiger cubs (T1, T2,T3) were more playful than others; like to play with each other, or with the wooden logs. They were more active in morning and afternoon time between 8.30 to 10 a.m. and 3 to 4 p.m. They were also observed to groom each other. These results are anticipated to support a number of developmental initiatives aimed at reducing stereotyping. (Mason, 1993; Clubb and Mason 2001; Young, 2003).

CONCLUSION

This study found that captive tigers show a high prevalence of stereotypic pacing.

Nevertheless, a negative interpretation of the captivity is insufficient enough to explain these results. In case of Alipore Zoo, it is situated in the heart of the city of Kolkata. Due to rapid urbanisation and higher demographic pressure, it is impossible to increase the enclosure size for the betterment of the animals. Thus, relocation of the animals to other places, after a certain age become important. But, as the environment in captivity is less flexible than in the wild, some natural wild behaviours become absent in these tigers . From the observation in the Bengal Safari, it can be stated easily that Captive tigers of Bengal Safari live on a diet of fresh beef, mutton and chicken meat. Hence, even though the larger open Safari area (20 ha) is provided with remarkable number of living prey (jungle fowl, spotted deer, mongoose etc.), these Tigers do not even hunt any of them following optimal foraging theory .

REFERENCES

A. (2019, February 27). Orphan Tigress of Kanha Translocated to her New Home in Nauradehi. Kanha National Park Blog | Latest Wildlife News From Kanha. https://www.kanha-national-park.com/blog/kanha-orphan-tigress-translocated-nauradehi/

Alipore Zoological Garden, Kolkata Zoo. (n.d.). https://kolkatazoo.in/alipore/

Altmann, J. 1973. Observational study of behaviour: sampling methods. Behaviour 49:227-263.

Baldwin, R.F. 1991. Behavior of Carnivores in Outdoor Exhibits at the National Zoo. Master's Thesis, George Mason University

Bradley, M., C. Lambert, V. Power, H. Mills, G. Gaikhorst, and C. Lawrence. 1999. Reproduction and captive breeding as a tool for mammal conservation: the role of modern zoos. Australian Mammalogy 21:47-54.

Carlstead, K., 1996. Effects of captivity on the behavior of wild animals. In: Kleiman, D., Allen, M., Thompson, K., Lumpkin, S. (Eds.), Wild Mammals in Captivity. University of Chicago Press, Chicago, pp. 317e333.

Clubb, R., Mason, G.J., 2001. Are some carnivore species predisposed to develop stereotypy because of their foraging strategy in the wild? In: Hare, V.J., Worley, K.E., Myers, K. (Eds.), Proceedings of the Fourth International Conference on Environmental Enrichment. The Shape of Enrichment, San Diego, USA, pp. 139e141.

Garner, J. P. (2005, January 1). Stereotypies and Other Abnormal Repetitive Behaviors: Potential Impact on Validity, Reliability, and Replicability of Scientific Outcomes. ILAR Journal, 46(2), 106–117. https://doi.org/10.1093/ilar.46.2.106

Lindburg, D.G. 1988. Improving the feeding of captive felines through application of field data. Zoo Biology 7:211-218.

Lyons, J., Young, R. J., & Deag, J. M. (1997). The effects of physical characteristics of the

environment and feeding regime on the behavior of captive felids. Zoo Biology: Published in affiliation with the American Zoo and Aquarium Association, 16(1), 71-83.
Mason, G.J., 1991. Stereotypies: a critical review. Anim. Behav. 41, 1015e1037
Mason, G.J., 1993. Forms of Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare CAB International, Wallingford, pp. 7e40.
McPhee, M.E., 2002. Intact carcasses as enrichment for large felids: effects on onand off-exhibit behaviors. Zoo Biol. 21, 37e47
MEDWAY), C. J. L. (1969, January). STUDYING WILD MAMMALS IN CAPTIVITY: Studying wild mammals in captivity: standard life histories with an appendix on zoo records. International Zoo Yearbook, 9(1), 316–328. https://doi.org/10.1111/j.1748-1090.1969.tb02700.x
Mohapatra, R. K., Panda, S., & Acharya, U. R. (2014). Study on activity pattern and incidence of stereotypic behavior in captive tigers. Journal of veterinary behavior, 9(4), 172-176.
Mohapatra, R.K., Mishra, A.K., Parida, S.P., Mishra, S., 2010. Behavioural responses to environmental enrichment in captive tigers *(Panthera tigris)* at Nandankanan Zoological Park, Orissa. e-planet. 8(2), 44e48
North Bengal Wild Animals Park. (n.d.). https://www.northbengalwildanimalspark.in/products.php
Poddar-Sarkar, M., & Brahmachary, R. L. (2014). 15 Pheromones of Tiger and Other Big Cats. Neurobiology of Chemical Communication, 407.
Seidensticker, J., & McDougal, C. (1993). Tiger predatory behaviour, ecology and conservation. In Symposium of the zoological society of London.
Singh, L.A.K., 1999. Born Black: The Melanistic Tigers in India. WWF-India, New Delhi.
Van Aardt, W., & Weber, R. E. (2010, October). Respiration and hemoglobin function in the giant African bullfrog *(Pyxicephalus adspersus Tschudi)* (Anura: Pyxicephalidae) during rest, exercise and dormancy. African Journal of Herpetology, 59(2), 173–190. https://-doi.org/10.1080/21564574.2010.521197
Young, R.J., 2003. Environmental Enrichment for Captive Animals. Blackwell Science, Oxford, UK.

ACKNOWLEDGEMENTS

The authors acknowledge the help of the director of North Bengal Wild Animal Park, Siliguri, and the director of Zoological Garden, Alipore, and their team, who provided support and permission for data collection.
The work was initiated as a dissertation project of the PGMS curriculum for which permission was given by both the Principal Chief Conservator of Forests& Head of Forest Force, West Bengal and the Member-Secretary, West Bengal Zoo Authority.

CONFLICT OF INTEREST

The authors declare no conflict of interest for this research article.

4

Captive breeding and rewilding of animals at Arignar Anna Zoological Park, Chennai

Chandramouli, S.R. [1], Sekar, M. [1], Kamaraj, G. [1] and Shankari, P.[1]

[1]Arignar Anna Zoological Park, Vandalur, Chennai – 600048.

Email: directoraazp1@gmail.com

ABSTRACT

The paper explores the impact of providing congenial environments for zoo animals, emphasising the reduction of physiological stress and the promotion of breeding, even within confined spaces. Drawing upon past successes in captive breeding across India, the study highlights the role of Arignar Anna Zoological Park as a hub for animal rewilding. Recent instances of rewilding are noted, and the zoo's contribution extends beyond targeted conservation breeding efforts to include the successful ex-situ breeding of species of lesser priority. Among the ten species released, two reptiles are listed under Schedule I of the Indian Wild Life (Protection) Act, 1972, while the Indian porcupine and other birds are classified under Schedule IV. Despite their lower priority designation, these efforts have proven instrumental in bolstering local species populations crucial to the domestic semi-urban ecosystem.

KEYWORDS

Rewilding, Captive breeding, Reptiles, Indian porcupine, Painted stork, Indian zoo

INTRODUCTION

Zoological Parks serve as vital centres for ex-situ wildlife conservation, wherein select species are brought from the wild, bred and maintained in captivity for various purposes such as education awareness, recreation and captive breeding. Among these, captive/conservation breeding is one of the critical functions by which rare and endangered species of animals are bred in captivity for various purposes, including display, exchange with other zoos and rewilding. Rewilding restocks captive-bred animals back into their native habitat through systematic release and monitoring. Several species of wild animals have been identified and prioritised for aided conservation breeding programmes by the Central Zoo Authority of India, New Delhi (CZA 2024a). Apart from such target species, other species of organisms of lower conservation priorities but of ample ecological significance are bred for release back into the wild, a process known as rewilding. Arignar Anna Zoological Park is located in the town of Vandalur (12.879490° N, 80.082509° E, ~ 40–170 m asl.), near the outskirts of the metropolitan city of Chennai. It enjoys a tropical climate and consists primarily of tropical dry evergreen and scrub jungles as the natural climax vegetation type. Arignar Anna Zoological Park has been serving as a haven for wild animals and aiding in their captive breeding, resulting in the rewilding of several species of animals since its inception in 1985 (Anonymous 2013). This article presents records of successful captive breeding of certain species of animals, resulting in their release back into the wild between 2022 and 2024. 2024a). Apart from such target species, other species of organisms of lower conservation priorities but of ample ecological significance are bred for release back into the wild, a process known as rewilding. Arignar Anna Zoological Park is located in the town of Vandalur (12.879490° N, 80.082509° E, ~ 40–170 m asl.), near the outskirts of the metropolitan city of Chennai. It enjoys a tropical climate and consists primarily of tropical dry evergreen and scrub jungles as the natural climax vegetation type. Arignar Anna Zoological Park has been serving as a haven for wild animals and aiding in their captive breeding, resulting in the rewilding of several species of animals since its inception in 1985

(Anonymous 2013). This article presents records of successful captive breeding of certain species of animals, resulting in their release back into the wild between 2022 and 2024.

METHODS

Animals were maintained in captivity in near natural enclosures with naturalistic settings and appropriate periodical enrichment to keep the animals in a physically as well as mentally healthy state that would facilitate and provide opportunities for their breeding throughout the year, in general, and during the respective breeding seasons for seasonal breeders. For breeding, animal stocks in captivity were always maintained with multiple viable individuals and were partitioned times into sections if necessary. Such cases included species like the Indian Gaur *(Bos gaurus)* and Bengal Tiger *(Panthera tigris)*. They were provided with nutritious feed throughout the year and enriched seasonally as per the requirements, such as giving frozen and water-rich foods during summer to combat the heat and keep the animals sufficiently hydrated. Most species are maintained in the display yard area in their respective enclosures. Certain species identified and prioritised for conservation breeding programmes are kept in a separate off-display enclosure that remains isolated and far from the visitors to mimic a forest environment. Records of the age class and sex of the animals in each enclosure were maintained, and the presence of viable males and females in each enclosure was ensured to promote captive breeding. Based on the population of each species bred in captivity and the carrying capacities of their respective enclosures as per the CZA guidelines (CZA, 2024b), decisions were made to exchange or release such surplus animals with due consent from the competent authority. Biologists surveyed protected areas across Tamil Nadu to identify appropriate sites for releasing various animals bred in captivity. These included parts of the Western and Eastern Ghats, coastal plains and scrub jungles in reserve forest areas. Upon successfully breeding a species in captivity that is both surplus and native to the region, a team of biologists and veterinarians identified animals deemed fit for release back in the wild. Following the approval of the competent authority, captive-bred animals are released back into the wild in the sites identified beforehand. Protocols for transporting the animals for release followed the guidelines provided by the IUCN (Menon et al. 2005).

RESULTS

Mammals: Six individuals of the Indian porcupine *(Hystrix indica)*, comprising three males and three females, were released in the Vallam Reserve Forest of Chengalpattu division (Fig. 1).

Fig. 1: Porcupines being released at Vallam RF.

Birds: Birds were released in two phases, in December 2022 and November 2023. Twenty-four unsexed individuals of Little egret *(Egretta garzetta)*, twelve individuals of White ibis *(Threskiornis aethiopica)*, eighty-two

individuals of Painted storks *(Mycteria leucocephala)* were released in Otteri Lake in Vandalur Reserve Forest. Two hundred and thirty-two individuals of Night herons *(Nycticorax nycticorax)* were released in the Pallikaranai marsh area of Chennai. In the second phase, a total of eighty-night herons, 40 painted storks, ten little egrets and ten Grey herons *(Ardea cinerea)* were released in the Pallikaranai marsh area of Chennai on 12 Nov 2023 (Fig.2). Eleven Black kites (*Milvus migrans)* were released in Nanmangalam Reserve Forest area of Tambaram.

Fig. 2: Painted storks being released in Pallikaranai Marsh.

Reptiles: Eighteen unsexed individuals of Rat snakes *(Ptyas mucosa)* were released in the Vandalur Reserve Forest Area (Fig. 3).

Fig. 3: Rat snakes being released in Vandalur RF.

DISCUSSION

Providing zoo animals with congenial environments reduces physiological stress and promotes breeding even in confined environments. Several zoo animals have bred successfully in captivity across India (Think Wildlife Foundation 2024). Animal rewilding happens regularly at the Arignar Anna Zoological Park; recent instances have also been documented (Manimozhi et al., 2022).

Table 1: Summary of captive-bred animals at Arignar Anna Zoological Park released in the wild

S. NO.	SPECIES	SCIENTIFIC NAME	NO.S	RELEASE SITE	DATE
1	**Indian porcupine**	*Hystrix indica*	**6**	Vallam RF, Chengalpattu	Dec 2022
2	**Little egret**	*Egretta garzetta*	**24**	Otteri Lake	Dec 2022
3	**White Ibis**	*Threskiornis aethiopica*	**12**	Otteri Lake	Dec 2022
4	**Painted stork**	*Mycterina leucocephala*	**82**	Otteri Lake	Dec 2022
5	**Night herons**	*Nycticorax nycticorax*	**312**	Pallikaranai Marsh	Nov 2023
6	**Painted stork**	*Mycterina leucocephala*	**40**	Pallikaranai Marsh	Nov 2023
7	**Grey heron**	*Ardera cineria*	**10**	Pallikaranai Marsh	Nov 2023
8	**Black kite**	*Milvus migrans*	**11**	Nanmangalam RF, Chengalpattu	Dec 2022
9	**Indian rock python**	*Python molurus*	**30**	Sathyamangalam Tiger Reserve	June 2022
10	**Rat snakes**	*Ptyas mucosa*	**18**	Vandalur Rf, Chengalpattu	Nov 2022

Apart from the targeted efforts directed towards the conservation breeding of designated species, the zoo has served as an effective ex-situ breeding centre for other species that are less prioritised. Of the ten species released, the two reptiles are listed under Schedule I of the Indian Wild Life (Protection) Act, 1972 (Anonymous 2022), while the Indian porcupine falls under Schedule IV and the other birds are classified under Schedule IV (Fig. 4). Nevertheless, it has aided in improving the local population of these animals that are of immense ecological significance in the domestic semi-urban ecosystem.

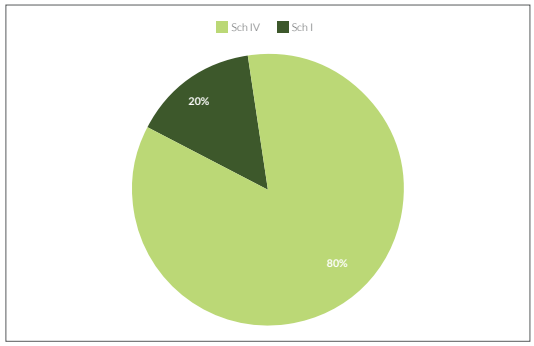


Fig. 4: Proportion of Schedule I and Schedule IV species bred in captivity and released

REFERENCES

Anonymous. (2013): Masterplan – Arignar Anna Zoological Park.Tamil Nadu Forest Department:170 pp.

Anonymous (2022): Amendments to the Indian Wildlife (Protection) Act. 1972.

Central Zoo Authority(2024a): Conservation Breeding Programme. https://cza.nic.in/uploads/documents/CBP/CBP%20for%20website.pdf accessed on 10 Feb 2024.

Central Zoo Authority(2024b): Guidelines on minimum dimension of enclosures for housing animals of different species in Zoos. https://cza.nic.in/uploads/documents/guidelines/english/G-10.pdf accessed on 10 Feb 2024.

Manimozhi, A., Sekar, M., Thyasekar, K., Sridhar, Allwin, B. and Kalaingan, P. (2022): Species in Focues: Indian star tortoises. Ex-situ Updates 4(2): 15-16.

Menon, V. Ashraf, N.V.K., Panda, P. and Mainkar. K. (2005): Back to the wild: Studies in wildlife rehabilitation. Wildlife Trust of India, New Delhi: 302 pp.

Think Wild Life Foundation. (2024): Captive Breeding Programs proving successful in India. https://thinkwildlifefoundation.com/captive-breeding-programs-proving-successful-in-india / accessed on 15 Feb 2024.

5

Management of Asiatic Lion suffering from Covid -19 In Etawah Safari Park Breeding Center

[1]Robin Singh Yadav, [2]Mohd Nasir, [1]Sarvesh Rai, 3R.K. Singh, [1]Suyash Sachan, [1]K.K. Singh and Aditya Kumar4

[1]Etawah Safari Park, Fisher Forest, Etawah, Uttar Pradesh 206001.

[2]Kanpur Zoological Park, Azad Nagar, Nawabganj, Kanpur, Uttar Pradesh 208002.

[3]Animal Husbandry Department, Vikas Bhawan Meerut, Uttar Pradesh 250002.

[4]PhD Scholar, Department of Veterinary Medicine, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar, Uttarakhand 263145.

Email: safaripark-up@nic.in

ABSTRACT

The paper details a case of COVID-19 infection among Asiatic lions housed at the Etawah Safari Park Breeding Center in Etawah. In May 2021, two Asiatic lionesses exhibited symptoms consistent with COVID-19, including hypersalivation, anorexia, rapid breathing, frequent vomiting, and elevated body temperature. Additionally, the lionesses displayed restlessness and abnormal physiological markers such as Blood Urea Nitrogen (BUN) levels. Treatment for these cases involved a month-long regimen of fluid therapy, renal medications, multivitamins, antacids, and supportive drugs. Continuous monitoring throughout the treatment period facilitated a successful and complete recovery.

INTRODUCTION

SARS–coronavirus -2 (SRAS-CoV-2) is the pathogenic agent that causes the disease COVID-19 and was first reported in December 2019. SARS-CoV-2 is thought to have emerged from animal sources and spilt over to the human population (Cui et al. 2019; Chen 2020). Although genetically closely related viruses have been isolated from Rhinolophus bats, the exact source of SARS-CoV2 and route of introduction into the human population has been established. In humans, the virus that causes COVID-19 binds to the ACE2 receptor (Ahmed et al., 2020). Experts looked at the other animals' ACE2 sequences and predicted that several types of animals are at risk for COVID-19 (Chatterjee et al., 2020). This may include wild animals and animals in captivity. Researchers have tested over 50 animal species in multiple zoos and aquariums. There have been reported cases of COVID-19 infection in animals like large felids, Otters, Minks, non–human primates, White-tailed deer, Spotted hyenas, hippopotamuses, Ferrets, Binturongs and Fishing cats. A better understanding of the transmission dynamics and pathogenesis in susceptible species will mitigate the risk to humans and wildlife. Here, we report the infection of SRAS-CoV-2 in Asiatic lions in Etawah Safari Park Breeding Center, Etawah. The health genomic surveillance identified the delta variant strain among the infected lions. At the time, infected felids developed mild, abnormal respiratory signs. SARS-CoV-2 RNA was detected in respiratory secretion and faeces from both the lionesses. This was the first reported infection of Delta mutant of SARS–CoV–2 in Asiatic lions of India.

ETAWAH SAFARI PARK AT A GLANCE

Etawah Safari Park is located in the historical fisher forest area, located at the Etawah-Gwalior Road, about 5 km from Etawah town in Uttar Pradesh. The Etawah Safari Park is spread over an area of 350 ha and has been developed as per guidelines of Central Zoo Authority (CZA), New Delhi. The park was setup for the conservation breeding of Asiatic lion. The lions at Etawah Safari Park came from Pradhyuman Zoological Park, Rajkot and Sakkarbaug Zoological Garden, Junagadh of Gujarat. The park was successful in breeding Asiatic lions and is one of the few institutions in the country that do so on a regular basis.

MATERIAL/METHODS & RESULTS

Covid-19 outbreak at the breeding center Of Asiatic Lions: At the Asiatic lion breeding center, Etawah Safari Park, in April 2021, two adult lionesses named Jenifer and Gauri displayed symptoms such as rapid breathing, bilateral

Figure1. One of the veterinarian, clad in PPE, to provide essential care to lions at during the COVID-19 pandemic at Etawah Safari Park Breeding Center

nosebleeds, and high temperatures of 106.6°F (Jenifer) and 104.2°F (Gauri). Both Gauri and Jenifer were transferred to Etawah Safari Park from Sakkarbaug Zoological Garden, Junagadh, on September 25, 2019, with the national stud book numbers 898 and 897 respectively. After observing initial symptoms, blood, serum, nasal, and oropharyngeal swabs were collected and sent to the local pathology lab and IVRI for CBC, LFT, KFT, and COVID-19 testing. All hematological parameters were within normal range except TLC. On May 7, 2021, IVRI reported that both lionesses tested positive for COVID-19. They were immediately moved from the breeding center to the safari hospital after the animals were observed being lethargic, dehydrated, and weak, with off-feed behaviour. Regular blood and serum tests showed abnormal increases in all parameters. Creatinine levels in Gauri and Jenifer were 18.0 mg/dL and 18.5 mg/dL respectively, indicating acute renal failure, along with high TLC. Both lionesses were closely monitored and treated accordingly. Precautionary measures were taken upon receiving the positive COVID-19 reports, including cleaning the lionesses' living spaces with disinfectant and sanitizing the surroundings of the breeding center. All caretakers and cleaners were isolated from their duties for 14 days. Nasal and oropharyngeal swabs were collected from all lions in the breeding center immediately, and samples were sent to IVRI for RT-PCR COVID-19 testing on May 5, 2021, with results received on May 7, 2021 (Table-1). The pathological findings indicated a secondary bacterial infection and renal dysfunction. Additionally, there was evidence of deep vein thrombosis, with elevated platelet and D-Dimer levels, as well as significantly increased SGPT and SGOT levels. Gauri's creatinine level measured 18.5 mg/dL, while Jenifer's was 35.5 mg/dL. Jenifer had a TLC of 55,000 cells/cubic meter, whereas Gauri's TLC was 34,000 cells/cubic meter. Furthermore, both lionesses exhibited markedly low albumin levels.

safari hospital to the breeding centre in

Table 1 pantoprazole at 0.7 mg/kg per day, piperacillin

SR NO.	NAME	SEX	CT VALUE	RESULTS
1	**Heer**	Female	*>35*	**Negative**
2	**Neeraj**	Cub	*>35*	**Negative**
3	**Kesari**	Female	*>35*	**Negative**
4	**Rupa**	Female	*>35*	**Negative**
5	**Sonia**	Female	*>35*	**Negative**
6	**Bharat**	Male	*>35*	**Negative**
7	**Manan**	Male	*>35*	**Negative**
8	**Gigo**	Male	*>35*	**Negative**
9	**Simba**	Male	*>35*	**Negative**
10	**Bahubali**	Male	*>35*	**Negative**
11	**Kabha**	Male	*>35*	**Negative**
12	**Jessica**	Female	*>35*	**Negative**
13	**Gauri**	Female	*30.7*	**Positive**
14	**Jennifer**	Female	*24.0*	**Positive**

TREATMENT

Based on symptoms and clinical examination, the treatment protocol included the administration of normal saline infusion at a rate of 50 ml/kg per day, Ringer's lactate infusion at 30 ml/kg per day, and albumin infusion at a slow rate of 10 to 20 ml/kg per day. Additionally, calcium gluconate injection at a dosage of 20 ml infused with 100 ml of normal saline intravenously per day, sodium bicarbonate injection at a dosage of 1 to 5 mEq/kg, and dextrose 5% infusion at a rate of 30 ml/kg per day were given. Furthermore, injections of the B complex (10 ml/day), vitamin C (6 ml/day), ondansetron at 0.5 mg/kg, sulbactam at 5 mg/kg repeated at 12-hour intervals, and clindamycin at 5.5 mg/kg twice daily were administered. Amino acid infusion was provided at a dosage of 0.087 mg/kg body weight per day, alonwith subcutaneous injections of heparin at 250 IU/kg body weight at five-day intervals and erythropoietin at 75 IU/kg body weight at five-day intervals. Over one month of treatment, both lionesses responded positively, with their blood and biochemical values returning to normal ranges. They resumed feeding, gradually increasing their intake from 200 grams to five kg of their regular diet. Gauri was transferred from the

Table – 2 : Biochemistry Values

PARAMETER	LIONESS GAURI		LIONESS JENNIFER	
	Pre- Treatment	Post- Treatment	Pre- Treatment	Post- Treatment
SGPT (IU/L)	144.3	44.2	140.4	50.1
SGOT (IU/L)	134.2	49.7	331	48.3
S. Alkaline Phosphates (IU/L)	50.2	0.83	82.37	12.99
Serum Bilurubin total (mg/dl)	0.40	0.17	2.02	0.35
Serum Bilurubin direct (mg/dl)	0.42	0.02	2.21	0.35
Serum Bilurubin indirect (mg/dl)	2.01	0.13	0.03	0.19
Blood urea (mg/dl)	303	54.17	230	53.34
Serum creatine (mg/dl)	18	3.14	18.5	3.0
Serum ca (m.mol/lit)	6.40	10.48	5.45	11.20
Serum albumin (gm%)	2.39	3.9	1.91	3.8
Serum globulin (gm%)	3.9	5.6	3.8	5.0

safari hospital to the breeding centre in September 2021, followed by Jenifer in October 2021. It was a joyous occasion for the Safari Park when Jenifer gave birth to a male cub on August 10, 2022. Both lionesses are now healthy and residing in the breeding centre.

Figure 2. Veterinary team attending lioness Jennifer

DISCUSSION

In both cases afflicted with COVID-19, clinical observations revealed chronic renal insufficiency alongside symptoms such as anorexia, vomiting, lethargy, elevated body temperature, and rapid breathing. Haematological examinations indicated a decrease in mean haemoglobin concentration and hematocrit values, with a notable increase in mean leukocyte and granulocyte counts in both lionesses. Additionally, the biochemical investigation showed a significant rise in thrombocyte count and d-dimer levels. Elevated levels of SGPT, SGOT, total bilirubin, blood urea, serum creatinine, and decreased albumin levels were also noted based on blood and serum reports from IVRI, confirming the

Table – 2: Hematological Values

PARAMETER	PRE-TREATMENT	POST -TREATMENT
Lioness Gauri		
Hb (g%)	6	14.6
TEC (Million/cu.mm)	7.97	4.80
PCV (%)	30	48
TLC (cu.mm)	38000	12000
Platelet (lac/cu.mm)	6.90	1.70
Differential leucocytic Count		
Neutrophils (%)	80	77
Lymphocytes (%)	32	18
Eosinophils (%)	2	5
Monocytes (%)	1	2
Lioness Jennifer		
Hb (g%)	9.9	14
TEC (Million/cu.mm)	8.9	5.56
PCV (%)		
TLC (cu.mm)	35000	12700
Platelet (lac/cu.mm)	4.45	1.98
Differential leucocytic Count		
Neutrophils (%)	80	77
Lymphocytes (%)	32	18
Eosinophils (%)	2	5
Monocytes (%)	1	2

presence of COVID-19 and associated immunosuppression with chronic renal failure. The primary objective was to manage both lionesses' heightened haematological and biochemical parameters. Despite antibiotic resistance, treatment strategies were adjusted accordingly to combat the infection. Both lionesses experienced severe dehydration and required daily fluid therapy, to which they responded well. Both lionesses are in good health and reside in the breeding centre of the safari park.

ACKNOWLEDGEMENT

We extend our heartfelt gratitude to the Central Zoo Authority, New Delhi, for their invaluable assistance. Our sincere thanks also go to the Mathura Veterinary College for their unwavering support in the treatment and management processes. Additionally, we express our gratitude to IVRI (Indian Veterinary Research Institute) for their valuable contributions. We also sincerely thank the veterinary doctors at Kanpur Zoological Park, Kanpur, and Nawab Wajid Ali Shah Zoological Park, Lucknow, for their dedicated efforts and expertise.

REFERENCES

Ahmed, S.F., Quadeer, A.A. and McKay, M.R. (2020): Preliminary identification of potential vaccine targets for the COVID-19 Coronavirus (SARS-CoV-2) based on SARS-CoV immunological studies. Viruses. 12(3):254.

Chatterjee, P., Nagi, N., Agarwal, A., Das, B., Banerjee, S., Sarkar, S., Gupta, N. and Gangakhedkar, R.R. (2020): The 2019 novel coronavirus disease (COVID-19) pandemic: A review of the current evidence. Indian J. Med. Res. 151(2-3): 147-159.

Chen, J. (2020): Pathogenicity and transmissibility of 2019-nCoV: A quick overview and comparison with other emerging viruses. Microbes Infect. 22(2):69-71.

Cui, J., Li, F., Shi, Z.L. (2019): Origin and evolution of pathogenic coronaviruses. Nat. Rev. Microbiol. 17(3):181-192.

6

Rescue, wound management and release of a female Bengal tiger *(Panthera tigris)*

Rakesh Kumar Verma[1], P.K. Chandan[3], Jasmeet Singh[2], Sonam Mishra[1]

Nandanvan Zoo & Safari, Nava Raipur, Chhattisgarh

1. Veterinary officer, Nandanvan Zoo & Safari, Nava Raipur

2. Assistant professor, Department of Wildlife Health and Management, College of Veterinary Science and Animal Husbandry, Anjora, Durg

3. Veterinary officer, Kanan Pendari Zoological Garden, Bilaspur

Email: dfojunglesafari@yahoo.com

ABSTRACT

A 5-year-old Bengal tigress *(Panthera tigris tigris)* rescued from Surajpur division, Kalamanjan Odgi (Forest Development Corporation), Chhattisgarh, was brought to the rescue centre of Nandanvan Zoo & Safari, Nava Raipur. Upon thorough examination, major wounds were observed: a 2-inch-long and 1-inch deep laceration in the left eyelid, a 5-inch-long and 1-inch-deep wound in the left maxillary region, a deep wound observed in the skull, a 2.5-inch-long laceration below the suitable ear base, a 2-inch-long laceration present in the left lateral neck region, and multiple small injuries present in the head and neck region.

Surgical interventions for wound management was planned and the animal was immobilized using a combination of Xylazine and Ketamine. The wound showed complete healing by 28th day. The tigress was released into the wild following the directives and Standard Operating Procedures (SOPs) of the National Tiger Conservation Authority (NTCA).

KEYWORDS

Royal Bengal tiger, rescue, surgery

INTRODUCTION

An unfortunate incident unfolded when three villagers from Kalamanjan Odgi village, located in the Surajpur division, ventured into the adjacent forest and encountered a tigress in the early hours of the day. Tragically, a confrontation ensued between the villagers and the tigress, resulting in the loss of two lives and severe injuries to the third villager. During the altercation, the tigress also sustained significant injuries to her head and neck from blows inflicted by the villagers' axes. Subsequently immobilised, the tigress sought refuge in nearby bushes. Upon receiving information of the incident, a rescue team was dispatched to the site the same day. The challenging terrain rendered conventional vehicle access impossible, necessitating the utilisation of a JCB machine to approach and tranquilise the injured animal. Employing a combination of Xylazine and Ketamine for sedation, the rescue team successfully subdued the tigress, conducting a thorough examination upon sedation by a team of veterinarians at a nearby forest rest house. Considering the severity of the tigress's injuries and her overall health, the decision was taken to transfer the tigress to the rescue facility at Nandanvan Zoo & Safari, located in Nava Raipur. Under the careful supervision of veterinarians, the tigress was transported overnight, arriving at the facility early morning on March 29, 2023. Surgery was promptly scheduled for the following day, and following a successful procedure and subsequent continuous monitoring and treatment, all wounds were healed. The tigress was then successfully reintroduced into the wild, marking a hopeful conclusion to the challenging ordeal.

MATERIALS AND METHOD

The tigress was released into the cubicle of the rescue centre in the early hours of March 30, 2023, with all preparations made for surgery. Xylazine and ketamine were chosen as the anaesthetic agents. The dosage was divided into two parts: an initial dose of 150 mg of xylazine and 250 mg of ketamine, followed by 70 mg of xylazine at the onset of induction (Steeil et al. 2012). A top-up of 250 mg of ketamine was administered to maintain anaesthesia during the surgery, which lasted for approximately 1 hour and the surgery was

performed under aseptic conditions. A deep wound, penetrating skull (Fig. 1) with bony pieces was debrided, and the wound was sutured using vicryl no. 1 and subcutaneous suture using vicryl no. 2-0. The left eyelid laceration extending towards the facial region was sutured using absorbable suture, vicryl no. 2-0 incorporating subcuticular tissue (Fig. 2).

Fig. 1. Deep wound on skull

Fig. 2. Laceration below left eyelid and horizontal wound on left maxillary region

Big horizontal wound over the left maxillary region (Fig. 2) was sutured using vicryl no. 0, after curetting necrotic tissue and flushing with Normal saline. The wound over the left lateral neck region was sutured with non-absorbable sterile polyamide no. 0 in the interrupted pattern. The big wound (Fig. 3) below the right ear base was freshened and sutured with non-absorbable silk no. 0 in the interrupted pattern. During surgery, fluid therapy was maintained with an intravenous infusion of 500 ml of Normal Saline (NS), Dextrose Normal Saline (DNS), and Ringer's Lactate (RL) each. An antibiotic injection of Convenia (Cefovecin Sodium), 8 mg/kg body weight, was administered subcutaneously to prevent secondary bacterial infection. Tramadol Hydrochloride - 400mg was administered intramuscularly to alleviate severe pain. After suturing all wounds, an antiseptic dressing was applied using ointment Lorexane. Yohimbine 3 ml was administered intravenously for revival. The day after surgery, oral medication was continued, including analgesics and high amino acid protein Petnext-p powder to improve appetite. Polybion-Lc syrup was administered for further appetite enhancement.

Fig. 3. Aseptic suturing of wounds

RESULT AND DISCUSSION

The enclosure housing the animal was securely closed, with a window fitted with a CCTV camera for continuous monitoring. Medication was preferably administered orally, concealing it within meat or sprinkling it over. The animal was provided with minced meat and small pieces of chicken to accommodate the injury to her upper jaw, which hindered her ability to consume more significant chicken portions. Ten days post-surgery, a satisfactory outcome was

Fig. 4. Sutured wounds

observed upon examination of the wounds (Fig. 4). This included nearly 70 per cent healing of the major wound on the temporal and maxillofacial region, facilitated by alternate-day dressing with hot water fomentation (Fig. 5). Additionally, high amino acid protein powder was introduced into the diet to expedite wound healing.

A follow-up examination was conducted a week later, revealing satisfactory healing of all wounds except for the temporal area, where, although good granulation was evident, the wound edges remained separated. Oral antibiotics like Amoxirum forte 1.5 gm bolus were administered for three days, along with Serratiopeptidase 40 mg, to promote improved wound healing. On April 26, 2023, the tigress

Fig. 5. Healing of major wounds.

Fig. 6. Day before release shows complete healing of wounds.

was reexamined, revealing the temporal region wound near-complete healing (Fig. 6). Additionally, she was commenced on ad-lib feeding.

After 28 days of treatment and observation, the tiger was fit for release into the wild. After getting permission from NTCA and CZA and with the help of WII, a VHF satellite collar was used to track and monitor the tigress. Under the supervision of CWLW, the tigress was released (Fig. 7) into the Achanakmar Tiger Reserve of Chhattisgarh.

Fig.7. Release of tigress in Achanakmar tiger reserve

CONCLUSION

As the tigress sustained severe injuries from the axe blow, postoperative care presented significant challenges. However, her prime age, robust physical condition, healthy appetite, and the appropriate selection of medications have contributed to accelerated wound healing.

Additionally, a new feeding strategy has been implemented, with feed provided randomly throughout the day and night to avoid conditioning the animal to specific feeding times. These measures have played a crucial role in expediting the tigress's recovery process.

ACKNOWLEDGEMENT

The authors would like to express sincere gratitude to Shri Sudhir Agrawal, PCCF cum CWLW, Shri Kaushlendra Kumar Singh, APCCF (WL), and Smt. M. Mercy Bella, Director cum Conservator of Forest at Nandanvan Zoo and Safari, Nava Raipur, for granting permission to perform the surgery and providing all necessary facilities, despite the high risk to the patient's life. The authors also extend heartfelt thanks to the staff of the Wildlife Veterinary Hospital for their wholehearted support throughout the operation.

REFERENCES

Steeil, J., Schumacher, J., Seibert, R. and Tobias, K. (2012): Cefovecin (Convenia) for the treatment of septic peritonitis in a female lion *(Panthera leo)*. J. Zoo. Wildl. Med. 43: 678-81.

7

A case report on *Trichophyton* spp. infection in Red-Tailed Monkey *(Cercopithecus ascanius)* at Harinalaya Zoo

Ishita Chongder[1], Tara Sankar Pan[2], Mihir Kumar Biswas[3], Wasikur Rahaman[4], Ram Prasad Badana [5], Ankita Bhaduri[6] and Vivek Kumar Ojha[7]

[1]Zoo Biologist, West Bengal Zoo Authority

[2]Veterinary Consultant, Harinalaya, New Town, Kolkata

[3]Veterinary Officer, Harinalaya, New Town, Kolkata

[4]Veterinary Assistant, Harinalaya, New Town, Kolkata

[5]Ex-Officio Director Harinalaya & DCF URF Kolkata

[6]Ex-Officio Assistant Director, Harinalaya, New Town, Kolkata

[7]Ex-Officio Unit-In-Charge, Harinalaya, New Town, Kolkata

Corresponding Author:

Ishita Chongder, Zoo Biologist, West Bengal Zoo Authority,

E-mail: ishita.titir@gmail.co

ABSTRACT

A female Red-tailed monkey *(Cercopithecus ascanius)* exhibited symptoms of alopecia, dermatitis, and itchiness, and laboratory testing confirmed a *Trichophyton* sp. infection. Treatment involved administering various medications, including topical application of herbal extracts. This case study highlights the utilization of Ivermectin, Fluconazole, and herbal extracts over time, resulting in the restoration of the animal's natural skin condition.

KEYWORDS

Fungal infection, Hair Loss, Ivermectin, Fluconazole, Herbal extract

INTRODUCTION

Red-Tailed Monkey *Cercopithecus ascanius* (Audebert 1799) is Old world primate commonly native to Central Africa. As this species is uncommonly housed in zoos, there are limited case studies on them in captivity. A Female Red-tailed Monkey co-housed at Harinalaya Zoo with four more conspecific, was seen to have skin infection that increased from a small patch to progressive skin wound followed by hair loss. This report illustrates the contagion of *Trichophyton* sp. in the Red-tailed monkey and its cure due to successful medical intervention over a period of six months. *Trichophyton* sp. can be characterized as a dermatophyte filamentous fungus, which often causes Dermatophytosis (Phair et al. 2011), where superficial layer of skin is mainly affected due to their accumulation (Groll et al. 2009).

MATERIALS AND METHODS

Study area: The study was done at Harinalaya (Mini Zoo), New Town, Kolkata.

Study individual and study period: The present study was done on an affected female Red-tailed Monkey. The period of study was from July 2023 to January 2024.

Month 1: The individual was seen to have a small patch without hair on the right side of the body (Image 1). Gradually hair loss was seen at the base of the tail and arms over two weeks. Itching one another symptom, that was increasing gradually. The individual was given Vitamin AD3E orally for a period of twenty-five days. As there was no such improvement observed, so further treatment was done.

Image 1: Red-tailed monkey with Alopecia

Month 2 - Month 4: As the individual was having Alopecia (Novak and Meyer 2009), dry skin patches in different body parts so skin scrapping, and hair sample was taken from the individual for Intradermal parasite tests and Microplasma identification. For detection of the causative agent, sample of skin scraping

was collected and send to the laboratory, PCR test was performed, and the samples tested positive for dermatophytes infection *(Trichophyton sp.)*. As fungal infection was detected, the affected individual was given Fluconazole, A syrup extracted from herbs including Neem *(Azadirachta indica)*, Babool *(Accasia nilotica)*, Manjistha *(Rubia cordifolia)*, Brahmi *(Bacopa monnieri)*, Basa *(Adhatoda vasica)*, Bhringraj *(Eclipta alba)*, Giloy *(Tinospora cordifolia)*, Chiraita *(Swertia sp.)*, Haldi *(Curcuma longa)*, Nagarmotha *(Cyperus rotundus)*, Tulsi *(Ocimum sanctum)*, Vidang *(Embilia ribes)*, Dalchini *(Cinnamomum zeylanicum)*, Daruhaldi *(Berberis aristata)*, Mulethi *(Glycyrrhiza glabra)*, Indraju *(Hollarhena antidysentrica)* etc. and the medicines were continued for three months. Ivermectin injection was also administrated at the back of the neck in subcutaneous route once in a week for three weeks.

Image 2: Small Patches at skin without hair

Month 5 - Month 6: After the said medicines continued, the gradual improvement of skin and growth of hairs were seen. The treatment continued with another mixture, including oil extracted from herbs, Deodar *(Cedrus deodara)* and Haldi *(Curcuma longa)* with Methyl Paraben Sodium and Propyl Paraben Sodium. A liquid containing essential fatty acids, vitamins A, D3 and E, wheatgerm and lecithin was applied to improve the skin coat. Besides, another syrup comprising hydroxyzine hydrochloride and Sodium benzoate was applied. After five months, a blood sample was drawn from the affected individual, and skin scraping was again collected on a clean slide for a mycological examination. The test was found negative.

Image 3: Administering medication to the Red-tailed monkey

Image 4: Lessening of excessive hair loss

RESULT

The result depicts the effectiveness of the medicines applied to the affected Red-tailed monkey based on the laboratory test reports and the gradual improvement seen over time (Table 1).

Over about six months of observation, the affected individual gained a normal skin condition (Image 6).

Image 5: Gradual improvement in skin condition and hair growth in the effected monkey

Image 6: Fully recovered Red-tailed monkey after treatment.

DISCUSSION

Different fungal infections need effective treatment strategies as it can often persist with high morbidity and mortality (Mukherjee et al. 2005). This case study represents the effectiveness of the drug Ivermectin, which is a broad-spectrum endectocide drug, that is active against both endoparasites and ectoparasites (Mathachan et al. 2021) and Fluconazole, that has an antifungal property which prevent the growth of protective covering of fungus around themselves, the herbal extractions also had a played an important role for improving the immunity in curing the infections.

CONCLUSION

The current case study is based on the observation over a period of six months on different interventions. This study gives some conclusion of the effectiveness of drugs and the care in captivity. Exotic species such as Red-tailed monkey are rarely housed in Indian zoos. So, the captive care and proper medication have some indication for approaching the skin health management in this case study.

ACKNOWLEDGEMENT

We would like to acknowledge Mr. Saurabh Chaudhuri, IFS, Addl. Principal Chief Conservator of Forest and Member Secretary, West Bengal Zoo Authority, West Bengal for giving us the permission to study this case. We would like to thank the Joint Director, A.R.D and Dr. Pralay Mandal AD, ARD, IAH&VB (R&T), Kolkata for helping us for diagnosis and analyzing the samples. And we would like to thank the supervisor, animal keepers and animal attendants of Harinalaya Zoo for their assistance with this case.

Table 1

SYMPTOMS	TYPES OF SAMPLES COLLECTED	TESTS PERFORMED	FINDINGS	TREATMENT	RESULT	SUPPORTING IMAGES
Small patches of skin without hair, Itchiness	-	-	-	Vitamin AD_3E	No such improvement was seen	Image 1
Gradual Alopecia, wounds and dry skin, severe hair loss, Increased itchiness	Blood sample and skin scraping	Bacteriological (PCR Technique) and Mycological examination	No pathogenic bacteria were detected after 48 hours of aerobic and anaerobic incubation in a blood sample. Skin scrapping was positive for Tricophyton sp. fungus	1. Fluconazole 2. Syrup with herbal extract 3. Herbal oil extract 4. Syrup containing essential fatty acids, vitamins A, D3 and E, wheatgerm and lecithin. 5. Syrup comprising of hydroxyzine hydrochloride and Sodium benzoate. 6. Ivermectin injection	Lessening of excessive hair loss Gradual improvement in skin condition, hair growth	Image 2 Image 3 Image 4 Image 5

REFERENCES

Groll, A. H., Roilides, E. and Walsh, T. J. (2009): Fungal infections in pediatric patients. Clinical mycology, 2nd ed. Elsevier, Philadelphia, PA: 481-499.

Mathachan, S. R., Sardana, K. and Khurana, A. (2021): Current use of ivermectin in dermatology, tropical medicine, and COVID-19: An update on pharmacology, uses, proven and varied proposed mechanistic action. Indian Dermatol. Online J. 12(4): 500.

Mukherjee, P. K., Sheehan, D. J., Hitchcock, C. A. and Ghannoum, M. A. (2005): Combination treatment of invasive fungal infections. Clin. Microbiol. Rev. 18(1): 163-194.

Novak, M. A. and Meyer, J. S. (2009): Alopecia: possible causes and treatments, particularly in captive nonhuman primates. Comp. Med. 59(1): 18-26.

Phair, K., Larsen, R. S. and Wack, R. (2011): Dermatophytosis *(Trichophyton mentagrophytes)* in a Coquerel's Sifaka *(Propithecus coquereli)*. J. Zoo. Wildl. Med. 42(4): 759-762.

8

Enhancing Animal Welfare Through Positive Reinforcement-based Training

Swarali Buchke*[1], Snehasish Mondal[1], Soham Mukerjee[1,2].

[1]Sardar Patel Zoological Park, Ektanagar, Gujarat, IN.

[2]Life Science Education Trust, Bangalore, Karnataka, IN.

*Corresponding Author: Swarali Buchke

Email: SPZP.zoo@gmail.com

ABSTRACT

This article investigates the implementation and impact of positive reinforcement-based training in modern zoological settings, emphasising the benefits of improved animal welfare and enhanced visitor experiences. The study demonstrates the effectiveness of such training in facilitating routine husbandry tasks, reducing stress, and promoting natural behaviours by analysing case studies from various species, including giraffes, mega-herbivores, primates, and psittacines.

KEYWORDS

Animal training, animal welfare, zoo husbandry, positive reinforcement, operant conditioning.

INTRODUCTION

The practice of animal training is deeply interwoven with the history of human-animal relationships, reflecting an evolution from fundamental survival interactions to sophisticated, ethical engagements aimed at animal welfare and conservation. One of the earliest and most significant examples of animal training can be traced back to ancient India, where the strategic use and training of elephants for warfare and ceremonial purposes were documented in texts like the Arthashastra by Kautilya in the 4th century BCE (Trautmann, 2015). This tradition not only underscores the importance of elephants in Indian society but also highlights an early recognition of the need for specialised animal training techniques that consider animal psychology and behaviour.

Parallel to this, ancient Egyptian murals dating back to circa 4000 BCE depict the taming and training of animals such as dogs and cheetahs for hunting and companionship, indicating the global antiquity of human-animal training practices (Teeter, 2011).

Furthermore, evidence from ancient civilisations like the Indus Valley and Mesopotamia suggests the presence of domesticated animals in agricultural and societal functions, pointing towards the inception of training for work and ceremonial purposes (Clutton-Brock, 2012).

The utilisation of animals in warfare and entertainment further evolved these practices. Notably, the deployment of war elephants by Carthaginian and Indian armies around the 4th century BCE and the Roman Empire's use of animals in circus games for public spectacle during the same period exemplify the militaristic and entertainment training of animals (Kistler, 2007; Toynbee, 1973).

A pivotal shift occurred with the introduction of scientific methodologies to animal training by American behavioural scientist Dr. B.F. Skinner during World War II. Skinner's operant conditioning method departed from traditional training practices towards a more structured and humane approach, laying the groundwork for modern animal training techniques (Schultz-Figuero, 2019). However, its full integration into zoo animal welfare practices has been slow, with training often regarded as an optional rather than an essential component of animal care (Fernandez, 2020).

At the Sardar Patel Zoological Park (SPZP), we challenge this perspective by prioritising training sessions tailored to the individual capabilities of each animal. These sessions serve as a form of enrichment that facilitates medical interventions, enhances keeper safety, manages animal stress, stimulates intellectual engagement, and prepares for emergencies, thus embodying modern techniques like operant conditioning based on positive reinforcement.

This article explores the significance of recall, desensitisation to touch, command training, and conditioning precisely desired behaviours through the shaping method, all within the framework of Operant Conditioning. By focusing on these practices, we highlight the critical role of ethical training in advancing animal welfare and conservation goals within the zoo setting.

CASE STUDIES: ANIMAL TRAINING ACTIVITIES AT SPZP

1. Shaping behaviour and promoting cooperation in giraffe: Physical restraint of animals for routine care tasks is increasingly recognised as a problem in modern zoo management, frequently resulting in unnecessary stress, potential chaos, and an increased risk of injury for both animals and keepers. This is especially true for larger animals, where physical and psychological consequences of restraint can be severe. At SPZP, we have adopted positive reinforcement-based training techniques as a cornerstone of our animal training programme, as evidenced by our work with "Jennie", a Giraffe *(Giraffa camelopardalis)* housed in a mixed-species enclosure with Blue wildebeest *(Connochaetes taurinus)*, Gemsbok (*Oryx gazella)*, and Plains zebra *(Equus quagga)*.

Training Jennie presented unique challenges, not least because of the variety of species in the enclosure and the need for individualised attention. To lay the groundwork for communication, we familiarised Jennie with her name. Early training sessions focused on simple behaviours like head turns, and Jennie's responses to her name were selectively reinforced with treats as positive rewards. This method, known as shaping, involves gradually refining a behaviour towards a desired outcome through selective reinforcement (Dadone, 2016). When Jennie consistently approached upon hearing her name, accepting rewards and demonstrating a clear understanding of the association, successful name recognition was achieved.

Building on this foundation, we introduced more complex behaviours, such as accepting supplements hidden in treats and teaching Jennie to follow trainers from one location to another. These behaviours were not only quickly adopted by Jennie, who preferred fresh carrots as rewards, but also provided several practical and educational benefits. For example, Jennie's ability to approach the visitor alley with guidance has improved educational opportunities for zoo visitors, allowing for more intimate encounters and learning experiences without physical restraint.

Furthermore, the training has practical applications Furthermore, the training has practical applications in animal management, such as facilitating isolation for medical care or preventing conflicts within the enclosure. Looking ahead, we hope to expand Jennie's training to include hoof trimming and cleaning while using positive reinforcement to guide her into a chute designed for safe handling.

2. Voluntary restraint and desensitisation in Indian rhinoceros: Improving the care of mega-herbivores, such as rhinoceroses, in zoos necessitates innovative management strategies that ensure the safety of the animals and their keepers and the upkeep of the enclosures. SPZP's enclosures are divided into three main sections: Paddock Area, Isolation Area/Kraal, and Keeper Alley. Given the complex elements of the enclosures, such as artificial water bodies, sliding doors, and barriers, this design makes routine

Figure 1: Trust building and training of giraffe. (Pic Credit: Mitesh Patel)

maintenance tasks more accessible, which is critical for the inhabitants' well-being and the facility's stability. The difficulty of performing maintenance tasks in these enclosures raises severe concerns about safely and effectively managing animals with physical strength far exceeding that of humans.

Traditional physical restraint methods are impractical when dealing with such formidable animals and can jeopardise the animals' welfare and zoo personnel's safety. As a result, positive reinforcement-based training principles become indispensable. A critical component of this approach is name association and developing a solid recall system, which serves as the foundation for progressing these animals' training to more complex levels. For example, "Mangal", our male Indian rhinoceros *(Rhinoceros unicornis)*, has been trained to open his mouth with a gestural cue. This response allows for examining dental hygiene, the manual administration of supplements, and oral medication, indicating the first steps towards comprehensive health management via training.

The training regimen goes beyond easy instructions to include desensitisation to touch, which is essential for performing thorough health checks and treating injuries without causing undue stress to the animals. This aspect of training is necessary for mega-herbivores, as it allows keepers to closely examine and treat areas that would be difficult to access or inspect in less cooperative individuals. Adding instructions that allow for the animals' repositioning further simplifies this process, ensuring that specific body parts can be examined and treated as needed. Looking ahead, the training programme for our rhinoceroses will include desensitisation to injectables, which is an essential step in administering vaccinations and drawing blood while the animal is conscious.

Positive reinforcement-based zoo training marks a shift towards more ethical and scientifically informed management practices. Studies have shown that such training can improve animal welfare, reduce stress during medical procedures. Positive reinforcement-based zoo training marks a shift towards more ethical and scientifically informed management practices. Studies have shown that such training can improve animal welfare, reduce stress during medical procedures, and improve overall health management in captive animals (Laule and Whittaker, 2007; Fernandez et al., 2009).

Figure 2: Voluntary restraint in Indian rhinoceros using verbal and gestural cues. (Pic Credit: Mitesh Patel)

3. Voluntary acceptance of supplements and medicines in primates: ositive reinforcement-based training is practical in zoo animals, especially for primates with complex social structures and cognitive abilities (Schapiro, 2010). Our training programme for primates, which includes Ring-tailed lemur *(Lemur catta)*, Squirrel monkey *(Saimiri sciureus)*, Red-handed tamarin *(Saguinus midas)*, Common marmoset *(Callithrix jacchus)*, and apes such as the Bornean orangutan *(Pongo pygmaeus)*, is based on rewarding positive behaviours with treats. This method not only builds trust between animals and their caregivers, but it also streamlines critical care procedures like oral drug administration. By associating the receipt of favourite treats, such as fruit juice and Nestum cereal, with compliance during minor physical encounters, we have seen a significant increase in voluntary cooperation.

The transition from treat-based rewards to including essential supplements in these rewards has been smooth, thanks to the trust and routines established through regular training sessions. These training efforts aim to make medical procedures, such as physical examinations, blood draws, and vaccinations, less stressful for the animals by desensitising them to touch and associating medical equipment with positive experiences.

Figure 4: Voluntary acceptance of supplement mixed with fruit juice by Bornean orangutan. (Pic Credit: Vaibhav Kansara)

Figure 5: Voluntary acceptance of supplements mixed with Nestum cereal by Red-handed tamarin. (Pic Credit: Krunal Trivedi)

Future goals for our primate training programme include expanding the repertoire of behaviours that can be requested and rewarded, improving the primates' welfare, and streamlining their care. Research supports the effectiveness of training in enhancing captive primates' psychological well-being, resulting in more cooperative behaviour during routine and novel husbandry tasks (Lambeth et al., 2006; Bloomsmith et al., 1994).

4. Station training in parrots: Psittacine birds, or parrots, have advanced cognitive abilities due to their well-developed forebrains, distinguishing them from other avian species (Emery, 2006; Olkowicza et al., 2016). These abilities aid in complex problem-solving and allow these birds to engage in nuanced social interactions, emphasising the importance of providing intellectually stimulating environments for captive care.

At SPZP, we have used the innate cognitive abilities of our exotic psittacines, such as macaws, cockatoos, parrots, amazons, lorikeets, conures, etc., to improve their welfare and management practices. We began introductory training sessions that capitalised on the birds' ability to understand and respond to verbal cues like "Step-up" and "Step-down" while encouraging vocabulary development. This approach made it easier to manage their physical health by allowing for precise body weight measurements (stationing on weighing scales) and tailored supplement and medication administration (voluntary acceptance). Still, it also aided their psychological well-being by providing a stimulating environment. To ensure a standardised assessment of body weights across our aviary's various psittacine species, we trained selected individuals who represented their respective species. This strategy allowed us to generalise body weight data for all species, which is critical for effectively managing their health and well-being. To safeguard the integrity of this training and the trust established between the birds and their trainers, we used a system in which birds were trained to respond only to cues from their designated trainers. This measure prevented any potential abuse of the animals' trust and strengthened the bond between individual birds and their keepers.

Figure 5: Station training of blue and gold macaw on weighing machine to keep regular track of body weight. (Pic. Credit: Krunal Trivedi)

CONCLUSION

The implementation of positive reinforcement-based training in modern zoos represents a significant step towards improving animal welfare, increasing keeper safety, and enriching educational experiences for visitors. This approach demonstrates the effectiveness of ethical training methodologies in promoting natural behaviours, reducing stress, and facilitating routine care, thereby establishing new standards in animal management. These initiatives reflect the zoological community's broader commitment to ethical, transparent, and science-based

practices, emphasising modern zoos' critical role in advancing animal welfare and conservation education.

ACKNOWLEDGEMENT

We extend our heartfelt thanks to Akanksha Mukherjee for her support and guidance on the fundamentals of animal training and its significance. We also appreciate Krunal Trivedi, whose efforts in training various animals and providing essential feedback on the manuscript have been invaluable.

Furthermore, we are grateful to Vaibhav Kansara for his contribution to documenting these critical events. Finally, we want to thank Mitesh Patel and our Keepers Daxesh Tadvi, Anil Tadvi, Umesh Tadvi, Daxa Tadvi, Sunil Tadvi and Chetan Tadvi, whose commitment to regularising training practices has been pivotal to our success.

REFERENCES

Bloomsmith, M.A., Stone, A.M. and Laule, G.E. (1994): Positive reinforcement training to enhance the voluntary movement of group-housed Sooty mangabeys (*Cercocebus atys*). Am. J. Primatol. 32(4): 275-284.

Clutton-Brock, J. (2012): Animals as Domesticates: A World View through History. East Lansing: Michigan State University Press. p. 189.

Dadone, L. I. (2016): Positive Reinforcement Training for a Giraffe for Voluntary Hoof Care. J. Zoo. Aquar. Res. 4(3): 147-152.

Emery, N. J. (2006): Cognitive ornithology: The evolution of avian intelligence. Philos. Trans. R. Soc. B. 361(1465): 23-43.

Fernandez, E. J. (2020): The Role of Positive Reinforcement Training in Zoo Animal Welfare: A Review. Anim. Welfare. 29(1): 11-22.

Fernandez, E. J., Tamborski, M. A., Pickens, S. R. and Timberlake, W. (2009): Animal-visitor interactions in the modern zoo: Conflicts and interventions. Appl. Anim. Behav. Sci. 120(1-2): 1-8.

Kistler, J. (2007). War Elephants. Westport, CT: Praeger Publishers.Westport. p. 352.

Laule, G. and Whittaker, M. (2007). Positive reinforcement training as an enrichment strategy. In Second Nature: Environmental Enrichment for Captive Animals. Smithsonian Institution Press. Washington, D.C. pp. 302-313.

Lambeth, S. P., Hau, J., Perlman, J. E., Martino, M. & Schapiro, S. J. (2006): "Positive reinforcement training affects hematologic and serum chemistry values in captive Chimpanzees (*Pan troglodytes*). Am. J. Primatol. 68(3): 245-256.

Olkowicza, S., Kocourek, M., Lučan, R. K., Porteš, M., Fitch, W. T., Herculano-Houzel, S. and Němec, P. (2016): Birds have primate-like numbers of neurons in the forebrain. Proc. Natl. Acad. Sci. U S A. 113(26): 7255-7260.

Schapiro, S.J. (2010): The role of Positive Reinforcement Training in enhancing the care of primates in zoos. J. Appl. Anim. Welf. Sci.13(1): 57-69.

Schultz-Figuero, L. (2019): The Evolution of Animal Training: From War to Conservation. Anim. Behav. Cogn. 6(3): 188-201.

Teeter, E. (2011). Animals in Ancient Egypt. In The Oxford Handbook of the Archaeology of Ritual and Religion. Oxford University Press. p.1108.

Toynbee, J. M. C. (1973). Animals in Roman Life and Art. London: Thames and Hudson. pp. 431.

Trautmann, T. R. (2015). Elephants and Kings: An Environmental History. University of Chicago Press. Chicago. P 372.

9

Successful breeding and pack establishment of Indian grey wolf *(Canis lupus pallipes)* after two decades at Indira Gandhi Zoological Park, Visakhapatnam.

Dr. Nandani Salaria1 and M. Purushotham[2]

[1]Curator, Indira Gandhi Zoological Park, Visakhapatnam,
Andhra Pradesh 530040
[2]Biologist, Indira Gandhi Zoological Park, Visakhapatnam,
Andhra Pradesh 530040

E-mail:igzpvizag@gmail.com

ABSTRACT

This study investigates the breeding behaviour and pack dynamics of the critically endangered Indian grey wolf *(Canis lupus pallipes)* within the confines of the Indira Gandhi Zoological Park in Andhra Pradesh, India. Designated as a Schedule 1 species under the Wildlife Protection Act of 1972, the Indian grey wolf is facing severe endangerment. A pair of wolves, aged between 3 to 4 years, was selected for observation to elucidate their daily behavioural patterns and reproductive tendencies. Behavioural observations were meticulously recorded from 2021 to 2022, encompassing a range of activities. Distinct behavioural patterns emerged, categorized into active and inactive behaviours, each exhibiting unique characteristics depending on whether the wolf was solitary or part of a captive wolf pack. The time-slice method was employed for data collection, with observations documented at intervals of five to ten minutes, totalling fifteen times per day during the morning hours. Following the breeding period, an examination of the establishment and behavioural dynamics of the wolf pack was conducted to gain further insights into their social structure and interactions.

KEYWORDS

Conservation breeding, captive management, maternal care, Indian grey wolf, Indira Gandhi Zoological Park.

INTRODUCTION

Nestled within the picturesque Eastern Ghats of Andhra Pradesh, Indira Gandhi Zoological Park (IGZP) is a distinguished testament to modern zoological conservation in India. Established in honour of former Prime Minister Indira Gandhi, this sprawling sanctuary was officially unveiled on May 19, 1977. Encompassing a vast expanse of 625 acres (253 hectares), IGZP is renowned for its meticulous upkeep and dedication to preserving indigenous flora and fauna.

Notably, IGZP is one of the few zoos in India where the successful breeding of the Indian grey wolf *(Canis lupus pallipes)* has been achieved, marking a significant milestone in wildlife conservation efforts. The park is a vital habitat for diverse plant and animal species, fostering a thriving ecosystem that highlights the region's rich biodiversity. Wolves, known for their highly social nature and complex social structures, form tight-knit family units known as packs (Mech 1970, 1977). Within these packs, adult members exhibit distinct roles and responsibilities, with parental guidance and division of labour shaping their interactions (Mech, 1977). The dominant alpha male and female play pivotal roles in leading the pack, overseeing territory marking and ensuring the welfare of their offspring (Mech 1970). The dominance hierarchy in wolves is thus a reflection of the age, sex, and reproductive structure of the group. Single wolves exist near packs and may even share kills on certain occasions (Jhala, 1991).

To support and facilitate the breeding of wolves within IGZP, the park's management has implemented rigorous preventive measures, ensuring optimal conditions for the reproductive success of these iconic predators. Through careful planning and dedicated conservation efforts, IGZP remains committed to safeguarding the future of the Indian grey wolf and promoting the preservation of India's natural heritage.

MATERIAL AND METHODS

Study area: The Indian grey wolf enclosure forms an integral part of the Indira Gandhi Zoological Park, situated within the Seethakonda Reserved Forest of Visakhapatnam, Andhra Pradesh. The landscape of the zoo park encompasses undulating terrain, characterised by two prominent hillocks positioned in the northeast and southwest directions, gently sloping towards a central valley. Adjacent to the valley lies a deep gorge, culminating in a small plain area near the Bay of Bengal to the east. The topographical features surrounding and within the zoo park can be broadly classified into Coastline Valley, and Hills.

Located within a tropical monsoon climate zone, the park experiences two distinct rainy seasons: the Southwest Monsoon from June to September and the Northeast Monsoon from October to November. This climatic region boasts a humid environment, with an average annual rainfall ranging from 900 to 1600 mm. Approximately 70% of the rainfall occurs during the Southwest Monsoon, with the remaining 30% during the Northeast Monsoon. Temperature variations are notable, with a decrease observed with the onset of the Southwest Monsoon, reaching a minimum in mid-January (~12°C), followed by a gradual increase to a mean maximum of 30°C by the end of May. During the hottest months, temperatures soar to around 40°C.

The proximity of the zoological park to the coast moderates temperature gradients, resulting in relatively mild seasonal changes. November, December, and January constitute the winter months, characterized by comparatively cooler temperatures. Humidity levels remain consistently high throughout much of the year, with mean daily relative humidity averaging around 75% at 0800 hrs and 70% at 1700 hrs. Summer months often witness heavy winds and gales, with cyclonic storms occasionally making landfall in the region between June and November. These storms, originating from depressions in the Bay of Bengal, can escalate into cyclones, bringing wind velocities ranging from 60 to 90 km/h.

RESULTS & DISCUSSIONS

History of Indian grey wolf in IGZP, Visakhapatnam: The Indian grey wolf has been a part of Indira Gandhi Zoological Park (IGZP) exhibits since the 1980s. However, no comprehensive observations regarding the species' natural history were documented during this period. Moreover, breeding of the species within the zoo was infrequent due to the limited dimensions of the enclosures at that time. Before the instances discussed in the current study, the most recent recorded breeding event at the zoo occurred in December 2001. During this time, four pups were born into a wolf pack comprising three males and one female. Subsequently, these offspring were transferred to Nehru Zoological Park, Hyderabad. Following this event, the last wolves from this particular pack at IGZP passed away in 2009.

After a decade-long hiatus, IGZP welcomed a new pair of Indian grey wolves on March 28, 2019, as part of an animal exchange program with Sri Chamarajendra Zoological Park, Mysore, Karnataka. The male, named Yuvaraj, and the female, Avanthika, were approximately 3 years and 2.6 years old, respectively, at the time of their arrival. Upon their arrival, the wolves underwent a mandatory three-month quarantine period to ensure their health and

safety. Following the completion of the quarantine period, they were released into their designated enclosure within the park.

Indian grey wolf enclosure in IGZP: The Indian grey wolf enclosure within the premises of Indira Gandhi Zoological Park, Visakhapatnam (Fig. 1), comprises the main animal enclosure along with auxiliary areas (Fig. 2a-c). The night kraal area spans approximately 6.80x5.10=34.68 square meters, while the dry moat exhibit area, also known as the Day kraal, covers approximately 0.218304 hectares. Constructed with concrete flooring, side walls, and roofs, the cells within the main animal house offer separate compartments designated as A, B, C, D, and E. These cells are interconnected via wire mesh transfer doors, with each cell measuring 2 x 1.8 x 2.5 meters in length, width, and height, respectively. Additionally, each cell is equipped with wire mesh transfer doors to facilitate easy movement of animals between adjacent compartments, along with a keeper access door. Moreover, there is an open moat exhibit access area, and each cell is furnished with a water trough for the animals' hydration needs. External access doors are provided for cleaning and feeding purposes. To enhance the environment, the enclosure is adorned with grassy landscaping and planted with indigenous tree species such as *Pongamia pinnata*, *Murraya koenigii*, *Pseudosasa japonica*, *and Azadirachta indica*. Furthermore, the outdoor enclosure features a sizable box structure constructed from wooden sheets, with PVC pipes arranged at its centre to serve as feeding enrichment. Food materials are placed inside the pipe holes, which the animals actively engage with, particularly during the morning hours.

Fig. 1 The Alpha pair of Indian grey wolves at IGZP

Fig. 2a: Night house of Indian grey wolf enclosure at IGZP

Fig. 2b: Individual night cells of wolf enclosure

Fig. 2c: Open moated paddock area.

NATURAL HISTORY AND BREEDING BIOLOGY OF INDIAN GREY WOLF IN IGZP

Breeding among Indian wolves typically occurs during the winter season, with mating rituals typically unfolding between October and November, typically involving the dominant (alpha) pair within the pack (Jhala 1991, 1993). Following a courtship phase that can last from several days to several months, wolves proceed to copulate during a brief estrus period lasting 5 to 7 days (Mech 1974). During copulation, the mating pair forms a lock known as a copulatory tie, typically enduring for approximately 20 to 30 minutes (Sheldon 1992). Subsequently, gestation spans a duration of 62 to 63 days, during which the breeding female, often the alpha, begins preparing a den 15 days to a month before giving birth, occasionally receiving assistance from the alpha male (Mech 1970). As the time for birthing approaches, the mother confines herself near the den approximately 5 to 7 days before delivery, typically birthing 2 to 6 pups inside the den. Newborn pups are initially blind, gradually developing blurred vision around the age of 15 days, with most milk teeth erupting by 3 weeks of age. Weaning generally commences at approximately 5 weeks of age (Mech 1970). The female remains in close proximity to the pups for at least 2 months, while the male and other pack members engage in hunting and provide sustenance for both the female and the offspring. In the wild, wolves typically attain sexual maturity by 18 months of age and may start dispersing from their natal pack around this time.

Upon their arrival at IGZP in 2019, the wolf pair, Yuvaraj and Avanthika, was active, healthy, and sexually mature. However, despite daily observations of their behaviour over the next two years, no breeding behaviour was observed. It was not until December 6, 2021, at 4:30 PM, that the first instance of mating was observed in their day kraal, lasting approximately 15 minutes. During mating, the male firmly mounted the female from behind, resulting in a copulatory tie. The two animals remained physically inseparable during this time, with the male ejaculating multiple times. A second mating event was observed on December 9, 2021, at 10:45 AM. Following these mating behaviours, the pair exhibited increased activity and exploration within their enclosure. An artificial den was constructed in the day kraal area near the night kraal entrance, prompting the female to display denning behaviour starting on January 19, 2022. Visual changes in the female's body, such as teat development and abdominal enlargement, confirmed her pregnancy, accompanied by an increase in feed intake (Fig 3. a). Two weeks before giving birth, the female spent most of her time in the den, with food offered near the den or the main entrance of the night kraal. On February 6, 2022, the birth of six pups was confirmed through visual observations by the keeper. The pups were born blind and deaf. Confirmation of the litter size was obtained six days after birth.

PARENTAL CARE OF INDIAN GREY WOLF IN IGZP

The female Indian grey wolf gave birth to six pups on February 6, 2022. Initially, we only identified three pups inside the den area, but after two weeks, we discovered another three pups. During the first week, the mother remained inside the den, solely focused on caring for the young ones. She only emerged from the den for feeding purposes. We provided chicken and beef in the centre

Fig. 3a: Alpha female with enlarged abdomen during advanced pregnancy

Fig. 3b: Artificial den in the enclosure

Fig. 3c: Wolf pups at 2 months of age

cubicle, which had an open moat exhibit access door for free movement from the night kraal to the dry moat exhibit area (night kraal). For the first two weeks, the pups stayed exclusively inside the den. Once they opened their eyes, they began to venture from the den to an above-ground "rendezvous site," exploring their surroundings (Fig. 3b.). As the pups grew more independent during this time, the mother focused solely on caring for them. Eventually, they started to explore the area immediately outside the den before gradually venturing a few meters away from it at around 5 weeks of age. They began eating regurgitated food after 2 weeks, by which time their milk teeth had emerged, and they were fully weaned by 8–10 weeks (Fig 3c.). During the first week of development, the dam typically stayed with her litter alone, but eventually, the father also contributed to the rearing of the pups in some way. During the current study, the sire provided regurgitated food to the pups until they were about 5 months old. At about 6 weeks of age, the pups were observed actively feeding on chicken and beef made into small pieces and mixed with feed supplements. Hence, it is recommended to provide additional feed supplements to pups once they start consuming solid food.

As the enclosure was vast with open spaces and areas with good vegetation, the wolves moved in groups (Fig. 4). Enclosures with a space of about 0.2 hectares and larger are ideal for a big pack of 15 or more wolves. This provides them with ample space for hiding and moving about in packs. The pups were observed picking up life skills during play with their parents and among themselves. Various play behaviours such as mock hunting, ambush, chase, escape, and mounting were observed. Deworming and vaccination of the pups were

carried out at regular intervals during their early stages of development.

OTHER OBSERVATIONS

During the initial stage, the grey wolf pups remained close to their mother, exploring their surroundings and interacting with other pups within their litter. In cases of perceived threats or disturbances, they would naturally seek refuge near their mother for protection. Upon release from the night kraal to the day kraal, the mother would often carry the pups to the den area during the initial three months. The observations of pack behaviour during this time are detailed below:

1. Alertness: Initially exhibited by adult members of the pack, followed by the pups, especially when approached by an observer.
2. Play: Engaging in interactive play with parents and other members of the pack.
3. Biting: Apart from displaying aggressive behaviour, biting at various objects such as sticks and bamboo culms.
4. Resting: Lying on the ground with their heads resting on their forelimbs, while the rest of their bodies are laid sideways.
5. Vocalization: Including growls, grunts, or howls used to gather pups or direct them to follow an adult.
6. Grabbing: Using their mouths to lift or catch objects.
7. Exploring: Walking around and exploring their habitat.
8. Aggression: Displayed by pups through biting, chasing, or charging into other individuals.
9. Grooming: Licking or biting themselves or other pack members.
10. Glaring: Staring directly at the observer's face, noticing movements as they approach.

VETERINARY CARE

Animal health management is a crucial aspect of zoo operations, overseen by the Zoo Veterinary team. The animal and veterinary

Fig. 4. Indian grey wolf in IGZP, VSP (Photo M. Purushotham, Biologist)

sections collaborate closely to ensure the well-being of the animals. The veterinary team provided the following care for the wolves:

a) Feed Supplements: Administered multivitamin tablets, Polybion syrup, glucose, and calcium supplements for daily consumption.

b) Deworming: Conducted mass deworming every three months using solutions like Fenbendazole, Ivermectin, Albendazole, Praziquantel, or Dectomax, with a dosage tailored to the animal's body weight. Periodic faecal sample screenings were conducted monthly.

c) Vaccination: Administered annual mass vaccinations to prevent rabies, canine distemper, adenovirus type 2, hepatitis, parainfluenza, parvovirus, leptospirosis, and others.

d) Antibiotics: Provided Lixen powder mixed with food when necessary.

The successful breeding of Indian wolves at the Indira Gandhi Zoological Park, Visakhapatnam stands as a testament to the culmination of decades of research and understanding in the field of captive animal management and reproductive biology. Drawing insights from seminal works such as Brown (1936) and Schonbemer (1965) on the reproductive biology of wolves, the zoo's efforts were informed by a deep understanding of the species' needs and behaviours. Additionally, Zimen's (1982) sociogram of wolf pack dynamics provided valuable insights into maintaining a conducive social environment within captive settings. Through meticulous application of this knowledge, coupled with dedicated care and management practices, the park successfully achieved the breeding of Indian wolves, contributing to the conservation efforts of this majestic species.

CONCLUSION

The successful breeding of the Indian grey wolf at Visakhapatnam's Zoological Park was facilitated by the collaborative efforts of zoo management and favourable climatic conditions within a conducive environmental zone. This endangered species holds significant conservation value throughout India, and the role of Indira Gandhi Zoological Park in the captive breeding of endangered species cannot be understated, especially given their successful breeding endeavours.

The conservation breeding program for the Indian grey wolf *(Canis lupus)* at IGZP can be deemed successful, considering that the adult pair achieved breeding after a two-year period since their introduction into captivity at the park. The wolf pair demonstrated proper site selection and establishment both pre and post denning, resulting in successful breeding within the enclosure. Crucial parental care during the post-denning phase contributed significantly to the establishment and rearing of the pups. Feeding enrichment activities and regular supervision undoubtedly played a vital role in facilitating the breeding process for the wolf pair. Notably, the pack displayed no stereotypic behaviours or any adverse events, indicating a healthy and well-adjusted environment within the enclosure. The spacious enclosure provided ample opportunities for the pack to engage in natural behaviours such as movement, selective resting, playing, and finding hiding spots. The easy accessibility to the day kraal, even during off-display hours, positively influenced the active status of the wolf pack. As the breeding season approaches, opening up the artificial dens could further facilitate breeding by encouraging the adult wolf pair, potentially indicating a trend towards active breeding of the Indian grey wolf at IGZP.

REFERENCES

Brown, C.E. (1936): Rearing wild animals in captivity, and gestation periods. J. Mammal. 17:10-13.

Jhala, Y. V. (1991): Habitat and population dynamics of wolves and Blackbuck in Velavadar National Park, Gujarat, India. Ph.D. dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 236 pp.

Jhala, Y. V. (1993): Predation on Blackbuck by wolves in Velavadar National Park, Gujarat, India. Conserv. Biol. 7(4): 874-881.

Mech, L. D. (1970): The Wolf: the ecology and behavior of an endangered species. Natural History Press. Garden City, New York. 384 pp.

Mech, L. D. (1977): Productivity, mortality and population trend of wolves in northeastern Minnesota. J. Mammal. 58(4): 559-574.

Schonbemer, D. (1965): Observations of the reproductive biology of the wolf. Zeitschrift fur Saugetierkunde 30: 171-178.

Zimen, E. (1982): A wolf pack sociogram. Pages 2B2-322. In F. Harfmgton and P. Paquet, (eds.) Wolves of the world: Perspectives of Behavior, Ecology, and Conservation, Noyes Publications. Park Ridge, New Jersey, U.S.A. 474 pp.

10

From Enclosures to Habitats: The Evolution of Reptile Housing in Modern Zoos

Soham Mukherjee*[1,2]

[1]Sardar Patel Zoological Park, Ekta Nagar, Gujarat, IN.

[2]Life Science Education Trust, Bangalore, Karnataka, IN

*Corresponding author: Soham Mukherjee

Email: SPZP.zoo@gmail.com

ABSTRACT

This article discusses the transition in housing reptiles in zoos; from minimalist designs to modern, bioactive enclosures that mimic natural habitats and meet the complex needs of the reptiles'. It emphasises the recognition of reptiles as sentient beings who require enriched environments for optimal health. The paper puts forth ideas for the creation of naturalistic enclosures and emphasises the importance of such environments in conservation education and biodiversity. A Sardar Patel Zoological Park case study demonstrates the successful application of these principles, showcasing a reptile house that combines animal needs with educational and conservation goals. Furthermore, the article discusses enclosure design and size, advocating for species-specific solutions that promote natural behaviours and increase visitor engagement through educational materials.

KEYWORDS

Reptile husbandry, bioactive enclosures, reptile welfare, herpetological husbandry

INTRODUCTION

Context and Importance: Reptile housing within zoological settings has historically been a challenging endeavour, often characterized by minimalist designs that fail to replicate the complex environmental conditions these animals encounter in their natural habitats (Warwick et al., 1995). Traditional enclosures frequently lacked the necessary spatial complexity, environmental gradients, and enrichment opportunities, leading to issues related to physical health, psychological well-being, and expression of natural behaviour among captive reptiles (Mendyk, 2018). Recognizing these shortcomings, there has been a paradigm shift towards creating more naturalistic and bioactive enclosures. Such environments not only better fulfil the physiological and behavioural needs of reptiles but also contribute to their overall health and welfare by incorporating live plants, natural substrates, and dynamic microhabitats that encourage natural behaviours (Baines et al., 2016).

The evolution of reptile housing aligns with an increasing emphasis on animal welfare science and the recognition of reptiles as sentient beings capable of experiencing a range of emotions and sensations (Burghardt, 2013). The move towards bioactive enclosures represents a significant advancement in herpetological husbandry, blending ecology with care to create self-sustaining ecosystems that promote microbial and invertebrate diversity, which, in turn, supports the health and well-being of the reptilian inhabitants (Bateman and Fleming, 2011).

Purpose of the article: The primary objective of this article is to delineate a comprehensive approach to the development of modern reptile houses that not only prioritize the physiological and ethological requirements of reptiles but also serve as educational platforms that engage and inform visitors. In line with the trends for the recent advances in herpetological husbandry, environmental enrichment, and enclosure design, this article aims to provide zookeepers, herpetologists, and exhibit designers with practical ideas for constructing environments that mirror the natural ecosystems of reptiles, thereby enhancing their quality of life in captivity. Furthermore, by fostering a deeper

Fig 1: Enclosure of Bengal monitor (Varanus bengalensis) showcasing a range of thermal environments, with shaded areas and sunlit basking spots for effective thermoregulation, simulating the reptile's natural habitat.

understanding and appreciation of reptiles among the public, modern reptile houses can play a pivotal role in conservation education and the promotion of biodiversity (Zimmermann et al., 2007).

CASE STUDY - SARDAR PATEL ZOOLOGICAL PARK (SPZP)

The Reptile House at SPZP implements modern herpetological husbandry practices. A holistic approach has been taken for the enclosure design, addressing not only the physiological and behavioural needs of its reptiles but also prioritising visitor engagement and education. Through this case study, the article will showcase at how SPZP successfully applied these design principles to create a cutting-edge reptile house that serves as a model for zoological parks worldwide.

Designing a modern reptile house requires an intricate balance between the reptiles' biological needs and the facility's educational aspirations.

DESIGN PRINCIPLES FOR A MODERN REPTILE HOUSE

1. Understanding Reptile Requirements:

- Thermoregulation: Reptiles, being ectothermic, rely on external heat sources to regulate their body temperature. Designing enclosures that offer a range of thermal environments, from cooler shaded areas to sunlit basking spots, is crucial. This can be achieved by creating microhabitats within the enclosure that mimic the reptile's natural habitat (Fig 1), ensuring they can thermoregulate effectively (Lillywhite, 2014).
- UVB Needs: Exposure to UVB light is

essential for reptiles to synthesise vitamin D3 and critical for calcium metabolism. Incorporating natural sunlight wherever possible, alongside artificial UVB lighting systems (Fig 2), ensures reptiles receive the necessary UVB radiation for their health (Ferguson et al., 2010).

Fig 2: A Green iguana (Iguana iguana) under artificial UVB lighting within a habitat that supports vital D3 synthesis, complementing natural sunlight to meet the species' health requirements.

• Humidity and hydration: Many reptiles require specific humidity levels to aid skin shedding and respiratory functions. Designing enclosures with water features or misting systems can help provide drinking water and water for soaking and also maintain appropriate humidity levels, reflecting the natural humidity of their habitats (Barten, 1993). Additionally, dense plantations can aid in maintaining higher humidity levels (Fig 3).

• Space for movement and rest: Reptiles exhibit various behaviours, from active foraging to rest periods. Enclosures must provide ample space for these activities, including vertical structures for climbing species (Fig 4) and secluded areas for retreat (Warwick et al. 2013).

Fig 3: A well-hydrated habitat with water features and lush plantations creating a humid environment essential for tropical species.

Fig 4: A strategically designed enclosure for Indian rat snake (Ptyas mucosa) featuring structures for climbing, facilitating natural exploring behaviour and utilising vertical spaces within the enclosure.

2. Incorporating Natural Elements:

• Natural Sunlight and artificial heat bulbs: A blend of natural and artificial light and heat sources (UVB and heat) ensures that the reptiles receive heat and a spectrum of light close to their natural environments (Fig 5). Skylights or mesh sections in the enclosure roof can allow natural sunlight penetration, complemented by artificial lighting to provide UVB and heat when natural sunlight is insufficient (Baines et al., 2016; Mukherjee et al., 2022).

Fig 5: Enclosure of Red tegu (Tupinambis rufescens) illustrating the use of both natural sunlight and artificial UVB heat bulbs to simulate the reptile's native lighting conditions for optimal health.

• Species-specific landscaping: Planting vegetation replicating the reptile's natural environment provides hiding and climbing structures (Fig 6) and contributes to the enclosure's humidity and air quality (Tollestrup, 1985).

Fig 6: The various reptile enclosures featuring species-specific habitat plantations, offering natural hiding and climbing opportunities, while enhancing enclosure humidity and air quality.

• Water Bodies: Incorporating water bodies, whether for drinking, soaking, or swimming, caters to the diverse hydration needs of different reptile species (Fig 7) and adds to the enclosure's aesthetic and educational value (Mendyk and Augustine, 2020).

Fig 7: Appropriately sized water body in enclosure for Red-eared sliders (Trachemys scripta elegans) and Yellow-bellied sliders (Trachemys scripta scripta), highlighting the provision for hydration, soaking, and the enhancement of the enclosure's aesthetic and educational appeal.

3. Artificial Environmental Control:

• Temperature and humidity gradients: Overall monitoring (with thermometers and thermohygrometers) and controlling of the environmental parameters (using timer based sprinklers, artificial heat sources) can simulate natural and seasonal variations (Fig 8) in temperature and humidity, essential for mimicking the reptile's natural environment and promoting physiological health (Divers and Mader, 2005).

Fig 8: A controlled habitat displaying temperature and humidity gradients with a waterfall feature on the left flowing further into a cascading fall ending in a deep pool at the right, designed to emulate the natural and seasonal variations of a tropical environment.

•Bioactive Enclosures: Bioactive substrates, incorporating live plants and a clean-up crew of microfauna, create a self-sustaining ecosystem that not only breaks down waste but also enhances the enclosure's naturalistic appeal (Brames, 2007) (Fig 9).

Fig 9: A bioactive reptile enclosure featuring a self-sustaining ecosystem with live plants and microfauna, contributing to waste breakdown. The enclosure's design prioritises naturalistic aesthetics, with the only exception being the periodic cleaning of the water body to maintain optimal conditions.

These design principles can be effectively applied to create environments promoting reptile health and well-being while providing immersive and educational experiences for visitors.

Fig 10: School children and visitors engaged in an educational observation of a reptile exhibit, where naturalistic enclosure design enhances animal welfare and serves as a platform for conservation education.

ENCLOSURE SIZES AND TYPES

In herpetology and zoological management, the design and size of reptile enclosures are critical in ensuring the health, well-being, and natural behaviour display of captive reptiles. The Central Zoo Authority of India mandates a minimum enclosure size of 40 square metres for small-sized reptiles and 80 square metres for larger species, excluding crocodilians.It is essential to incorporate evidence-based approaches in the captive husbandry of reptiles to promote their overall well-being and to reflect their natural lifestyles as closely as possible within the constraints of a managed environment.

A one-size-fits-all approach may not always meet the unique needs of different reptile species. This is echoed by Mendyk (2018), who advocates for challenging the traditional folklore husbandry and moving towards more evidence-based practices that consider the thermal and spatial requirements of reptiles, such as monitor lizards, which require specific temperature gradients for optimal health.

Expert groups, herpetological associations, and zoo associations recommend enclosure sizes and designs that are tailored to the needs of each species, balancing the visibility of the animals with the need for naturalistic habitats. Enclosures should be designed to ensure that visitors can readily observe the reptiles, without the space being so expansive that it hinders the viewing experience. Additionally, as highlighted by Moszuti et al. (2017), responses to novelty and environmental enrichment are vital indicators of reptile welfare and should be integrated into the enclosure design, thus fostering a habitat that provides both physical and mental stimulation (Mendyk and Augustine 2020).

The European Association of Zoos and Aquaria

(EAZA) offers enclosure recommendations, which consider the animal's life history, social structure, and activity level. These guidelines also recognize that sometimes too small enclosures can restrict natural behaviours, while too large spaces may make it challenging for certain species to thermoregulate effectively or find their food (EAZA 2018).

OPTIMUM ENCLOSURE DESIGN

To effectively balance available space with species-specific requirements, enclosure design must adopt a holistic approach that incorporates each species' natural history and behaviour. Loughman (2020) highlights the crucial role of natural history information in evidence-based herpetoculture, asserting that replicating suitable conditions in captivity necessitates a comprehensive understanding of a species' life in the wild. Oonincx and van Leeuwen (2017) also mentions that physical and behavioural requirements should be taken into consideration alongside nutritional and environmental needs in reptile housing.

For snakes and lizards, optimally utilising three-dimensional space is essential as it can substantially increase habitat complexity, thus offering a multitude of behavioural opportunities and improving welfare outcomes. Incorporating elements such as climbing structures, branches, and various substrate levels not only enriches the enclosure but also enhances the visitor experience, providing diverse viewpoints and insights into the animals' arboreal or semi-arboreal lifestyles (Barten, 1993; Brames, 2007).

The concept of bioactive enclosures, including live plants, microfauna, and natural substrates, fosters a self-sustaining ecosystem that closely simulates natural habitats, offering reptiles a dynamic and enriching environment (Brames, 2007; Ferguson et al., 2010). These principles are supported by the research of Michaels et al. (2021), who underscore the benefits of complex habitats that stimulate both the physical and mental faculties of reptiles.

Ultimately, the design of reptile enclosures that promote natural behaviours serves not only the well-being of the animals but also provides a rich educational resource for visitors. Engaging and immersive exhibits are instrumental in deepening the understanding and appreciation of reptiles, challenging common misconceptions, and underscoring the significance of conservation efforts (Caro, 2007, Berger-Tal and Saltz, 2014). Through such interactive and educational environments, zoos play a pivotal role in promoting conservation and enhancing public awareness about reptile species.

CONCLUSION

The use of naturalistic and bioactive enclosures represents a transformative approach to reptile husbandry in modern zoos. This shift away from minimalist enclosures and towards habitats that resemble natural ecosystems demonstrates a better understanding of reptiles' complex needs and recognises them as sentient beings. Such innovative practices not only benefit captive reptiles, but also improve conservation education and public engagement. The principles outlined here advocate for a future in which zoos play an important role in biodiversity conservation while seamlessly integrating animal welfare and educational goals.

REFERENCES

Baines, F. M., Chitty, J. and Gill, I. (2016): The use of UVB lighting in reptile husbandry. J. Exot. Pet Med. 25(4): 300-316.

Baines, F. M., Chattell, J., Dale, J., Garrick, D., Gill, I., Goetz, M., Skelton, T. and Swatman, M. (2016): How much UVB does my reptile need? The UV-Tool, a guide to the selection of UV lighting for reptiles and amphibians in captivity. J. Zoo. Aquar. Res. 4(1): 42-63.

Bateman, P. W. and Fleming, P. A. (2011): Frequency of tail loss reflects variation in predation levels, predator efficiency, and the behaviour of three populations of brown anoles. Biol. J. Linn. Soc.103(3): 648-656.

Berger-Tal, O. and Saltz, D. (2014): Using the movement patterns of reintroduced animals to improve reintroduction success. Curr. Zool. 60(4): 515-526.

Brames, H. (2007): Aspects of bioactive enclosure setups for reptiles. Reptilia 55: 48-52.

Burghardt, G. M. (2013): Environmental enrichment and cognitive complexity in reptiles and amphibians: Concepts, review, and implications for captive populations. Appl. Anim. Behav. Sci. 147(3-4): 286-298.

Caro, T. (2007): Behaviour and Conservation: A Bridge Too Far? Trends Ecol. Evol. 22(8): 394-400.

Divers, S. J. and Mader, D. R. (Eds.). (2005): Reptile Medicine and Surgery. Elsevier Health Sciences.

EAZA. (2022). EAZA Best Practice Guidelines.

Ferguson, G. W., Brinker, A. M., Gehrmann, W. H., Bucklin, S. E., Baines, F. M., and Mackin, S. J. (2010): Voluntary exposure of some western-hemisphere snake and lizard species to ultraviolet-B radiation in the field: How much ultraviolet-B should a lizard or snake receive in captivity? Zoo Biol. 29(3): 317-334.

Lillywhite, H. B. (2014): Thermoregulation in reptiles. Curr. Biol. 24(5): R193-R194.

Loughman, Z. J. (2020): Utilization of natural history information in evidence-based herpetoculture: A proposed protocol and case study with *Hydrodynastes gigas* (False water cobra). Animals, 10, 2021: 1-20.

Mendyk, R. W. (2018): Towards betterment: Husbandry improvements and breeding success of Cuban crocodiles *(Crocodylus rhombifer)* at the Bronx Zoo. Herpetol. Rev. 49(1): 41-51.

Mendyk, R. W. and Augustine, L. (2020): Water feature design in reptile and amphibian exhibits: Considerations for animal welfare and conservation. Zoo Biol 39(1): 1-12.

Michaels, C. J., Servini, C., Ferguson, A., Guthrie, A., Jayson, S., Newton-Youens, T., Strike, T. and Tapley, B. (2021): The effects of two calcium supplementation regimes on growth and health traits of juvenile Mountain chicken frogs *(Leptodactylus fallax)*. Herpetol. J. 31: 18-26.

Moszuti, S. A., Wilkinson, A. and Burman, O. H. (2017): Response to novelty as an indicator of reptile welfare. J. Appl. Anim. Welf. Sci. 193: 98–103.

Mukherjee, S., Mukherjee, A., Patel, U. and Dev, R. (2022). Captive Management and Husbandry of Green Iguana *(Iguana iguana)*. Intas Polivet 22(2): 122-129.

Tollestrup, K. (1985). The role of plantations in the ecology of reptiles. Ecol. Rep. 12: 391-398.

Warwick, C., Frye, F. L. and Murphy, J. B. (1995): Health and Welfare of Captive Reptiles. Chapman and Hall. London: 299 pp.

Zimmermann, A., Hatchwell, M., Dickie, L. A. and West, C. (2007). Zoos in the 21st Century: Catalysts for Conservation? Cambridge University Press. Cambridge: 373 pp

11

Medical Management of Slender Loris With Tonic-Clonic Seizures –A Case Report

Col. Dr. Navaz sheriff[1], Dr. Madhav H V[2], Dr. Darshan Banur B[3], Dr. Carmel Prins[4]

[1]Chief Veterinarian and General manager, PfA Wildlife Hospital, Bangalore

[2]Senior Veterinarian, PfA Wildlife Hospital, Bangalore

[3]Associate Veterinarian, PfA Wildlife Hospital, Bangalore

[4]Veterinary intern, PfA Wildlife Hospital, Bangalore

Email: gm@peopleforanimalsbangalore.org

ABSTRACT

A Slender loris *(Loris lydekkerianus)* weighing 230 g was presented after being found recumbent on the ground. Upon observation and physical examination, it was noted that the animal experienced tonic-clonic seizures every 30 minutes, with each episode lasting for 4-5 seconds. The animal was treated with an injection of Diazepam and oral homoeopathic medication, and it was fed a homemade feeding formula along with a glucose solution. After treatment, the animal was monitored for 36 hours, during which there were no recurrences of seizures. Subsequently, it was released back into the wildl

INTRODUCTION

The Grey slender loris (*Loris lydekkerianus)*, is a small, nocturnal prosimian endemic to the southern peninsular region of India and Sri Lanka (Nekaris and Jayewardene, 2003). There are two subspecies of Grey slender loris in India, namely the Mysore slender loris (*Loris lydekkerianus lydekkerainus)* and the Malabar slender loris *(Loris lydekkerianus malabaricus)*, found in the Eastern and Western Ghats respectively (Kumara et al., 2016). In the wild, Slender lorises primarily forage on various insects, especially ants and termites (Nekaris and Rasmussen, 2003; Kumara et al., 2005).

As per the IUCN Red List Assessment (2020), the Grey slender loris, previously under the category of least concern, is now categorised as Near Threatened, and this reduction in the loris population is mainly attributed to habitat loss and/or hunting practices. In India, these animals are illegally kept captive and used for the preparation of traditional medicines and black magic practices, which further adds to the decline in their population (Gnanaolivu et al., 2022).

This case report describes the treatment and release of a Grey slender loris, which was presented with a history of seizures.

Fig 1: Slender loris rescued immobile

MATERIALS AND METHODS

A Grey slender loris was presented to PFA Wildlife Rescue and Conservation Centre, Bengaluru with a history of seizures. The animal was found lying on the ground and immobile (Fig. 1). It was taken to the Deputy Conservator of Forests (DCF)-urban and later transferred to the PFA for treatment. A complete physical examination revealed no gross abnormalities. The animal weighed 230 g and presented with tonic-clonic seizures (Fig. 2) every 30 minutes. Each episode lasted for 4-5 seconds, and two such episodes were recorded.

The animal was treated with Inj. Diazepam (LORI®) at 0.5 mg/kg BW intramuscularly to control the seizures and Suspension Meloxicam (MeloneX®) at 0.2 mg/kg orally once daily for two days. Homeopathic drops of Hypericum at 2 drops daily was also given (Fig.

3). Hand feeding was done with glucose solution, handmade feeding formula, and super worms.

Fig 2. Slender loris is having seizures

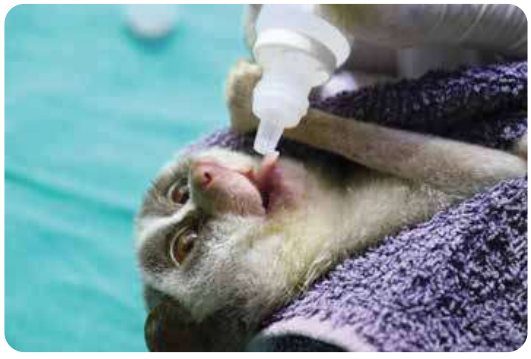


Fig 3: Slender loris treated with homeopathic medicine: Hypericum

The animal was kept under observation for 36 hours after treatment, during which it showed no recurrence of seizures (Fig. 4). The animal was deemed fit and released back into the same habitat.

Fig 4: Slender loris recovered after treatment

RESULTS AND DISCUSSION

Seizures in animals are clinically manifested as altered or loss of consciousness, changed behaviour, tonic-clonic movements, and incontinence with sudden onset and cessation (Berendt et al., 2015; Blatt et al., 2017). Although there are no known reports of seizures in wild Grey slender lorises, reports of epileptic seizures and their treatment have been recorded in other wild/captive animals (Iwata, 1998; Blatt et al., 2017; Simeone et al., 2022) Baroni and Poli (2015) describe the use of benzodiazepenes such as diazepam and midazolam as the first pharmacological action to control epileptic seizures in animals. In the present case, diazepam was administered for its anticonvulsant action and showed positive results in the Grey slender loris. There is a lack of veterinary literature describing the dose of diazepam in prosimians, and therefore, dosing was based on that used in domestic animals.

This is the first report on successfully treating a Grey slender loris with seizures and its release into the wild. The case describes the use of diazepam for anti-convulsant activities and further promotes research on the use and dose of the drug in other wild species.

ACKNOWLEDGEMENTS

The authors thank all the staff at PfA Wildlife Hospital for their expertise in handling animals, Rahul J and Vasanth R. for rehabilitation and Anand B. for rescuing the animal.

REFERENCES

Baroni, M., & Poli, F. (2015): Status Epilepticus: a clinical approach. Veterinaria (Cremona) 29(1): 37-45.

Berendt, M., Farquhar, R. G., Mandigers, P. J., Pakozdy, A., Bhatti, S. F., De Risio, L. and Volk, H. A. (2015): International veterinary epilepsy task force consensus report on epilepsy definition, classification and terminology in companion animals. BMC Vet. Res. 11(1): 1-11.

Blatt, E. R., Seeley, K. E., Lovett, M. C., and Junge, R. E. (2017): Management of a Reeve's muntjac (*Muntiacus reevesi*) with seizures using levetiracetam. J. Zoo. Wildl. Med. 48(4): 1197-1199.

Dittus, W., Singh, M., Gamage, S. N., Kumara, H. N., Kumar, A. and Nekaris, K. A. I. (2020): *Loris lydekkerianus* (amended version of 2020 assessment). The IUCN Red List of Threatened Species 2022: e.T44722A217741551. https://dx.doi.org/10.2305/IUCN.UK.2022HPERLINK"https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T44722A217741551.en" 1.RLTS.T44722A217741551.en. Accessed on 23 September 2023.

Gnanaolivu, S. D., Campera, M., Nekaris, K. A. I., Nijman, V., Satish, R., Babu, S., and Singh, M. (2022): Medicine, black magic and supernatural beings: Cultural rituals as a significant threat to Slender lorises in India. People Nat. 4(4): 1007-1019.

Iwata, E. (1998): Epilepsy Suspected Seizure and Control in California sea lion (*Zαlophus cα liforniαnus*). Jpn. J. Zoo. Wildlife. Med. 3(1): 59-63.

Kumara, H. N., Kumar, S. and Singh, M. (2005): A novel foraging technique observed in slender Loris *(Loris lydekkerianus malabaricus*) feeding on red ants in the Western Ghats, India. Folia Primatol.76(2): 116-118.

Kumara, H. N., Sasi, R., Chandran, S. and Radhakrishna, S. (2016): Distribution of the Grey slender loris (*Loris lyddekerianus* Cabrera, 1908) in Tamil Nadu, Southern India. Folia Primatol. 87(5): 291-302.

Nekaris, K. A. I. and Jayewardene, J. (2003): Pilot study and conservation status of the slender loris (*Loris tardigradus* and *L. lydekkerianus*) in Sri Lanka. Primate Conserv. 19: 83-90.

Nekaris, K. A. I., and Rasmussen, D. T. (2003): Diet and feeding behavior of Mysore slender lorises. Int. J. Primatol. 24: 33-46.

Simeone, C. A., Andrews, J. P., Johnson, S. P., Casalia, M., Kochanski, R., Chang, E. F. and Baraban, S. C. (2022): Xenotransplantation of porcine progenitor cells in an epileptic California sea lion (*Zalophus californianus*): illustrative case. J. Neurosurg. Case lessons.: 3(12).

12

Management of Shell Repair in Indian Pond Terrapin

Col. Dr.Navaz sheriff[1], Dr.Madhav H V2, Dr. Jayanth K V3, Dr. Dhanush Yellappa4

[1]Chief Veterinarian and General manager, PfA Wildlife Hospital, Bangalore

[2]Senior Veterinarian, PfA Wildlife Hospital, Bangalore

[3]Associate Veterinarian, PfA Wildlife Hospital, Bangalore

[4] Associate Veterinarian, PfA Wildlife Hospital, Bangalore

Email: gm@peopleforanimalsbangalore.org

ABSTRACT

An Indian pond terrapin *(Melanochelys trijuga)* was rescued with a history of being run over by a vehicle. Upon examination, it was noticed that it had a shell (carapace) fracture. The terrapin weighed 500 g. Shell repair was performed under general anaesthesia using Ketamine and butorphanol and maintained under Isoflurane. Metal dress hooks were used to bring the shell into opposition, and these hooks were anchored to the shell with epoxy putty. Stainless steel wires were placed in the cloth hook and tightened to get the cloth hooks together for the shell closure, thus facilitating the healing process.

INTRODUCTION

The Indian black turtle, *(Melanochelys trijuga)* (Family Geoemydidae), is a medium-sized (carapace length of 38.3 cm), mainly still-water species from northern, northeastern, and peninsular India, Sri Lanka, Myanmar, Nepal, Bangladesh, Thailand, and possibly Pakistan. Six subspecies are currently recognised. Omnivorous in dietary habits, the species takes aquatic plants in addition to invertebrates and carrion. Although in no immediate danger in India, the species is exploited in unknown numbers for food, and population declines have been reported in Sri Lanka (Das, 1995). The carapace is elongated, relatively more elevated in adults than juveniles, and tricarinate with a feebly serrated marginal posterior. The nuchal scute is small and distinctly triangular (Das, 1995). The plastron is about as long as the carapace and is truncated anteriorly (Das, 1995). The head is moderate in size, with a short snout shorter than the eye's diameter (Das, 1995).

Shell trauma are a common presentation in wild turtles and should be provided with immediate analgesia and supportive care, debridement and cleaning of the wound followed by fracture fixation where required. There are many methods of fracture fixation, and the decision for which method to use is based on the characteristics of the fracture, the veterinarian's familiarity with the technique, and the time and money available for the case. Epoxies and adhesives are suitable for some fractures. Methods that bridge the fracture include cable ties, metal bridges, clothing hooks, and the top closure method. Orthopaedic fracture fixation methods include metal sutures, screws with wire, and metal plates (Roffey and Miles, 2018). This case was presented with a carapace fracture and fixed using a metal cloth hook and wires.

MATERIALS AND METHODS

An Indian black turtle was presented to the PFA Wildlife Rescue and Conservation Centre, Bangalore, with a history of being run over by a vehicle. On examination, it was noticed that it had a fracture in the carapace (Fig.1).

Fig.1: An Indian Black Turtle rescued with a fracture in Carapace.

The animal was immediately treated with Tramadol at 5 mg/kg s/c (Carpenter, 2012). For pain management, the animal was stabilised with subcutaneous fluids and tramadol for

three days before the surgery.

On the day of the surgical procedure, Tramadol was administered initially, followed by Ketamine at 10 mg/kg (Carpenter, 2012) and Butorphanol at 1 mg/kg (Carpenter, 2012). Following induction, maintenance anaesthesia was achieved using Isoflurane with oxygen at a rate of 2 l/min.

Fig.2. Cloth hooks are placed on the shell using epoxy putty.

Cloth hooks were affixed to the shell using epoxy putty and left to dry overnight. Stainless steel wires were then utilised to secure the hooks. Pre-cut pieces of wire were wrapped around one hook and passed to the other, bringing the fractured shell into alignment and closure. The wire was threaded in between the two screws in an eight-pattern (refer to Fig. 3), and this process was repeated, ensuring that the knot was positioned in the centre of both hooks (refer to Fig. 4).

After the operation, Enrofloxacin was administered intramuscularly at a dosage of 5 mg/kg, along with intramuscular injections of tramadol at 5 mg/kg and meloxicam at 0.1 mg/kg. The wound was flushed with a 2% solution of chlorhexidine, followed by regular saline irrigation (Mader and Divers, 2014).

Fig.3: Stainless steel wires are wrapped around the hook in a figure of 8 pattern.

Fig.4: The Knot is made with stainless wire to keep the fragments in position.

RESULT AND DISCUSSION

Treating and surgically repairing shell fractures in chelonians pose significant challenges and require considerable time and effort. The rehabilitation process can span one to two years as the shell undergoes gradual healing and restoration. This extensive period is necessary to ensure the chelonian's complete recovery and successful reintegration into its natural habitat upon release.

ACKNOWLEDGMENTS

The authors express their gratitude to all the personnel at PFA Wildlife Hospital for their expertise in animal care and to Rahul J and Vasanth R for their efforts in rehabilitation.

REFERENCES

Carpenter, J.W. (2012): Exotic Animal Formulary. 4th edition. Elsevier Health Sciences, p.744.

Das, I. (1995): Turtles and Tortoises of India. Bombay, Oxford University Press, New Delhi. p.176.

Mader, D. and Divers, S. (2014): Current Therapy in Reptile Medicine and Surgery. P.462.

Roffey, J. and Miles S. (2018): Turtle shell repair. In: Doneley B, Monks D, Johnson R, Carmel B, editors. Reptile medicine and surgery in clinical practice. Hoboken: John Wiley & Sons. pp. 397-408.

13

Enrichment and Reproductive Success of Fishing Cat *(Prionailurus viverrinus)* under Captivity - A Scientific Approach

Ishita Chongder[1], Dipak Kumar Mandal[2], Moitri Mondal[3] and Saurabh Chaudhuri[4]

[1]Zoo Biologist, West Bengal Zoo Authority

[2]Divisional Forest Officer, Howrah Division and Ex-Officio Director Garchumuk Zoological Park

[3]Forest Range Officer, Garchumuk Zoological Park

[4]Addl. Principal Chief Conservator of Forest & Member Secretary, West Bengal Zoo Authority

Corresponding Author: Ishita Chongder, Zoo Biologist, West Bengal Zoo Authority

E-mail ID: ishita.titir@gmail.com

ABSTRACT

The present study describes the breeding success of four pairs of fishing cats under captivity at Garchumuk Zoological Park. This paper depicts the gradual procedure of familiarising male and female fishing cats with each other, from their acclimatisation in the night shelter to behavioural compatibility with each other to release in the paddock area, successful breeding, giving birth, and cub survival. In captivity, most animals show stereotypical behaviours due to a lack of habitat enrichment. This ultimately leads to different stressful events followed by mate incompatibility, unsuccessful breeding and a high mortality rate. howThis article showcases the efforts of the zoo in conserving this vulnerable species through providing semi-natural habitat, proper diet, medication, and other captive care, with the ultimate result of breeding success, is the main focus of this study.

KEYWORDS

Habitat enrichment, captive breeding, copulation, breeding success, cub survival

INTRODUCTION

The Fishing cat, *Prionailurus viverrinus* Bennett, 1833 (Carnivora: Felidae), is a small semiaquatic felid that belongs to the Schedule I of the Indian Wildlife (Protection) Act, 1972, and is categorised as 'Vulnerable' by the IUCN in 2015. The leading causes of the declining number of Fishing cats in the wild are habitat degradation and fragmentation, road accidents (Mishra et al. 2021), retaliatory killing, hunting, or poaching (Chowdhury et al. 2015) and poisoning. In the last 15 years, about 44% of wetlands have experienced a decline owing to human activities, leading to a fragmented distribution of the Fishing cat population (IUCN 2015). Captive breeding of Fishing cats has become the foremost priority (Shepherdson et al. 1993), as the population of Fishing cats in the wild is threatened. Conservation breeding and reintroduction into their natural habitat (Bowkett et al. 2009) are the last alternatives to save this animal from further population depletion.

In West Bengal, the Fishing cat is locally common in certain areas, including Howrah, Hooghly (Kolipaka et al. 2019), Sundarbans, Jhargram (Mukherjee et al. 2012) and East Medinipur (Chakraborty et al. 2020) etc. But as the entire population is under severe threat, since 2012, the Fishing cat has been declared the state animal of West Bengal to emphasise their conservation (Chongder et al. 2022).

The main aim of conservation is to maintain genetic diversity and healthy populations of all wild taxa and preserve ecological processes, biological interactions, and environmental functions (IUCN 2015).

The agenda of in-situ species conservation can be challenging due to excessive habitat alteration and fragmentation, climate change, decline in population dynamics of prey base, conflict with humans and invasion of different pathogens (Nowell and Jackson 1996). For such instances, ex-situ breeding programmes can be a practical approach. The zoos have played a crucial role in captive and conservation breeding and releasing captive-bred animals into their natural habitats. The foremost challenges in ex-situ breeding are the low founder number, mate incompatibility and disease prevalence (Fazio et al. 2019). Concerning the mating of wild species in a confined environment and maintaining a self-sustaining population, the main coerces are poor conception rate in

selected mating partners, high infant mortality rate and poor survival rate (Barnes et al. 2002; Clubb and Mason 2002; Clubb and Mason 2004). So, a sustainable captive population can be bent by maintaining 90% founder heterozygosity (Ballou and Foose 1996).

Environmental enrichments play a crucial role in determining captive animals' different behavioural and physiological responses, which is also beneficial for creating a framework for animal welfare (Mellen and Shepherdson 1997). In confined environments, most animals show typical stereotypical behaviours (Philbin 1998), and significantly less active cats remain inactive most of the time. In captivity, breeding fishing cats can be unsuccessful due to low founder numbers, behavioural incompatibility among the pairs (Kinzer and Groome 2011), and captivity-induced stress (Fazio et al. 2020). A sterile captive environment can have deleterious impacts on species-specific behaviour, which may cause stress and psychosomatic disorders in animals (Broom, 2011). We often fail to provide them with enough enclosure enrichment, which can increase infant mortality. So, effective strategies such as suitable housing, habitat enrichment, proper diet and nutrition, treatment, and medications are essential for improving the behaviour of captive fishing cats, and therefore, stress-free management practices based on animal welfare are vital for the success of conservation breeding programs (Swaisgood, 2010).

The present study focuses on the habitat enrichment and successful reproduction of fishing cats under captivity at Garchumuk Zoological Park. The selection of healthy individual care in captivity, ethnological monitoring, diet, health care, hygiene, and habitat enrichment (Chongder et al. 2022) can be the critical factors for the successful breeding and survival of fishing cat kittens, which is the main emphasis of this study.

MATERIALS & METHODS

Study area: The current study was conducted in Garchumuk Zoological Park, situated at 22.34560 N latitude and 88.08580 E longitude with an average elevation of 12 m asl. It is established over 9.115 hectares within the Uluberia Sub-Division of Howrah District in West Bengal at the confluence of Damodar Irrigation Canal (Kata Damodar) and River Hooghly. Howrah district is located on the southwestern flank of the Bengal Basin. The land's topography is almost flat, alluvial plain with red sandy loam and deep soil, which is very fertile. Due to clay soil, water stagnation is a significant problem, but water availability is advantageous for agricultural practices.

Housing and Enrichment: Individual Fishing cats were housed in a night shelter with a total area of 52 sqm, featuring eight feeding cells measuring 2.5 m × 1.5 m × 2.5 m each. The design of the cubicles in the night shelter allowed for ample space, ensuring sufficient sunlight entry and ventilation.

The paddock, covering an area of 496 sqm, was constructed to mimic a wetland habitat within the enclosure. Various wetland reeds and grasses such as *Typha selephantina*, *Saccharum spontaneum*, and *Colocasia esculenta* were planted in the paddock area. Additionally, shade trees were incorporated, including *Vachellia nilotica*, *Mangifera indica*, *Citrus maxima*, and *Leucaena leucocephala*. A large natural pond measuring 41×33×5 ft was created, stocked with fish species such as Shol *(Channa striata)*, Lata *(Channa punctatus)*, Bata

(Labeo bata), Rohu *(Labeo rohita)*, and Catla *(Catla catla)* to allow captive individuals to hunt and exhibit natural behaviours. Various materials, such as platforms made from logs and hollow logs, were also provided.

To prevent diseases and infections, the night shelter, squeeze cages, exhibit area, and enclosure were disinfected using Khorsolin. Turmeric powder was used to clean the walls and floors of the shelter. A 1% Potassium permanganate solution was utilised for dips, rinses, and equipment disinfection. Potassium permanganate solution was also used as a foot bath to prevent contamination. Additionally, during the onset of monsoon, calcium carbonate was sprayed as a disinfectant in muddy or swampy areas (Chongder et al. 2022).

Feeding and medication: Each individual was given 250g of chicken and 500g of live fish in the afternoon, except on Mondays (fasting day). Additionally, they could hunt live fish being reared in the pond within the enclosure.

Upon detection of pregnancy, vitamin B12 with iron and calcium supplements were administered to them. Omega-3 fatty acids were also provided.

Selection of healthy individuals and Behavioural monitoring: Garchumuk Zoological Park has housed a number of Fishing cat individuals from its early days. At the initiation of the conservation breeding programme, the individuals were kept in a quarantine centre for a period of 30-45 days (38.3±1.9). To prevent endoparasite infestation, deworming was conducted using Albendazole, Fenbendazole, Praziquantel, and Pyrantel Pamoate as advised by the veterinarian.

After establishing the individuals' genetic relatedness healthy founders were selected for the breeding programme (Chongder et al. 2022). In the first year, the study was conducted on two pairs, followed by two pairs the next year. For mate compatibility and acclimatization, the male and female individuals were initially released into the night shelter with the gates closed between them. After observing their behavioural interactions, the gate between the night shelters was opened, allowing free access for each individual to the other's night shelter for 24 hours. Each pair was kept in the night shelter for one month, and a range of behaviours were recorded using the ad-libitum behaviour sampling method (Lehner 1992). Focal sampling method was employed to observe each pair in the morning, noon, and afternoon for one hour each during the entire study period. Initially, the individuals were observed over a period to ensure their compatibility. After one month, the compatible individuals were released into the paddock area, and their behavioural changes were monitored accordingly. Various behavioural patterns related to courtship and copulation were recorded and categorized, including aggressive behaviour, approaching each other, sitting in close proximity, scent marking, vocalization, attempting to mate, and successful copulation. CCTV data were also monitored to understand their ethology (Bowkett et al. 2006).

Breeding Success: Survival of any species depends on its reproductive capability. In captivity, along with different biological factors, nutritional factors and interspecific interactions (Mellen 1991), environmental enrichment is one of the greatest stimuli of successful breeding (Mellen 1991; Mellen and Shepherdson 1997). Breeding success, litter

Fig. 1: Behaviour of fishing cat pair during courtship

size and seasonal variation of the litter size was monitored. Activity budget of the behavior was calculated considering all occurrences of behavioural events (Goswami et al. 2021) and average time engaged in each behaviour was considered accordingly.

The data was analysed using Excel and SPSS version 10 (Kinnear and Gray 1999).

RESULTS

Though January to June (Kinzer, 2011) has been identified as the peak breeding season, they can breed all year round in captivity. The present study shows the breeding success of three pairs of captive fishing cats in Garchumuk Zoological Park among the four pairs selected in two consecutive years. The months of their courtship and mating varied from May to September, and they gave birth between July and November. In the first year of the study, two pairs were seen to mate successfully after they were released in the naturally enriched paddock.

Pair 1: The first pair showed diverse behaviours in the night shelter, including aggressiveness, approaching, proximity, different vocalisations, and scent marking. Though they showed different courtship behaviour, copulation was not seen in the night shelter. After being released in the paddock, they were seen to copulate successfully after 15 days. The gestation period was nearly 71 days. The female successfully gave birth to two female individuals (Fig.1., Image 1).

Pair 2: The most common behaviour in this pair was proximity, approaching each other, and different vocalisations. The female gave birth to two male and two female individuals (Image 2) almost after 65 days of successful copulation. The pair were seen to copulate two times in the paddock area (Fig. 2.).

Pair 3: This pair was seen to copulate in the night shelter. This pair gave birth to three kittens (Image 3), two male and one female, of which a male kitten died almost after 45 days of survival.

Pair 4: After introducing the male and female in the night shelter, more playful behaviour was observed. Aggressive behaviour was rarely seen. Most of the behaviour shown by them was proximity and approaching towards each other and different vocalizations. Scent marking was seen several times. The mother gave birth to one individual but the male killed the kitten immediately after birth (Fig. 4.).

The graphical representation of the activity budget (Fig. 5.) denotes the number of times each behaviour was recorded and average time engaged in behaviour for the study period. The night shelter floor was covered with straw each time after the females successfully gave birth to the kittens. As the night shelter gates had open access for 24 hours, surprisingly it was seen that after giving birth, the mothers took the kittens into the night shelter for hiding. It was noticed that, almost 7-8 days before giving birth, the females of the first pair and the third reduced their feed intake. While in the female in the second pair showed, no such changes. The female of the fourth pair stopped feed intake completely two days before giving birth.

Fig. 2: Kittens of the Pair 2 fishing cats.

DISCUSSION

Garchumuk Zoological Park has effectively created a wetland-like habitat in the paddock area, which has been beneficial for mate compatibility, successful breeding, and cub survival in successive years. The present study shows that, though courtship behaviour is seen in the confined areas of the night shelter, but successful mating depends on an appropriate habitat. Along with that, proper captive management including suitable housing, diet and nutrition, medication, veterinary care, and management have contributed to high survival

and low mortality of the cubs (n=10, survival rate 80%, mortality rate 20%).

CONCLUSION

The West Bengal Zoo Authority has prioritized the conservation breeding programme of the Fishing cats with the ultimate goal of reintroducing the captive-bred individuals into their natural habitat. In spite of several challenges scientific zoo management, habitat enrichment, and understanding the ethology of each selected individual of the species have played a pivotal role in the reproductive success of the captive individuals.

ACKNOWLEDGEMENT

We would like to acknowledge Mr. Sanjay Kumar Shukla, IFS, Member Secretary, Central Zoo Authority for supporting us in conducting the studies at the respective zoo. We are grateful to Dr. Indrani Das, Associate Professor of Botany, Seth Anandram Jaipuria College, Kolkata and Dr. Sulata Maity, Scientific Officer, West Bengal Zoo Authority for their support. We would like to acknowledge Dr. Bikash Santra, Veterinary Officer for his immense support. We are indebted to the Animal Keepers and Animal Attendants of Garchumuk Zoological Park for taking care towards the animals.

REFERENCE

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. In Kleiman D. G., Thompson K. V. and Baer, C. K. (eds.). Wild Mammals in Captivity: Principles and Techniques for Zoo Management. 2nd Edition. University of Chicago Press. Chicago, IL. pp. 219-252.

Barnes, R., Greene, K., Holland, J. and Lamm, M. (2002). Management and husbandry of duikers at the Los Angeles Zoo. Zoo Biol. 21(2): 107-121.

Bowkett, A. E. (2006): How do you monitor rare and elusive mammals? Counting duikers in Kenya, Tanzania and Zimbabwe. In Animals, Zoos and Conservation. Zgrabczyñska, E., Ćwiertnia P. and

Ziomek, J. (eds.). Zoological Garden in Poznan, Poland. pp. 21-28.

Bowkett, A. E. (2009): Recent captive-breeding proposals and the return of the ark concept to global species conservation. Conserv. Biol. 23(3): 773-776.

Broom, D. M. (2011): A history of animal welfare science. Acta Biotheor. 59: 121-137.

Carlstead, K., and Shepherdson, D. (1994): Effects of environmental enrichment on reproduction. Zoo Biol. 13(5): 447-458.

Chakraborty, S., Barik, S., Saha, R., Dey, A., Deuti, K., Venkatraman, C. and Saha, G. K. (2020): Camera-trap records of Fishing Cat *(Prionailurus viverrinus)* from East Medinipur (West Bengal, India), and notes on threats to this population. Écoscience 27(3) 149-156.

Chongder, I., Maity, S., Mitra, N. and Chaudhuri, S. (2022): Species in Focus: Fishing Cat, West Bengal Zoo Authority, Kolkata. Ex-situ updates 4 (2, 3):11-14.

Chowdhury, S. U., Chowdhury, A. R., Ahmed, S. A. K. I. B. and Muzaffar, S. B. (2015): Human-fishing cat conflicts and conservation needs of fishing cats in Bangladesh. Cat News 62: 4-7.

Clubb, R. and Mason, G. (2002): Review of the Welfare of Zoo Elephants in Europe. RSPCA; Horsham, UK. pp. 303.

Clubb, R. and Mason, G. (2004): Pacing polar bears and stoical sheep: testing ecological and

evolutionary hypotheses about animal welfare. Anim. Welfare 13: 33-40

Fazio, J. M. (2016): Assessment of adrenal activity and reproductive cycles during captive management in the Fishing cat *(Prionailurus viverrinus)* (Doctoral dissertation, George Mason University).

Fazio, J. M., Freeman, E. W., Bauer, E., Rockwood, L. and Parsons, E. C. (2019): Evaluation of management in North American zoos to enhance breeding success of the Fishing cat *(Prionailurus viverrinus)* ex situ population. Zoo Biol. 38(2): 189-199.

Fazio, J. M., Freeman, E. W., Bauer, E., Rockwood, L., Brown, J. L., Hope, K. and Parsons, E. C. M. (2020): Longitudinal fecal hormone monitoring of adrenocortical function in zoo housed Fishing cats *(Prionailurus viverrinus)* during institutional transfers and breeding introductions. Plos one 15(3): e0230239.

Goswami, S., Patel, S. K., Kadivar, R., Tyagi, P. C., Malik, P. K. and Mondol, S. (2021): Effects of a combined enrichment intervention on the behavioural and physiological welfare of captive Asiatic lions *(Panthera leo persica)*. Appl. Anim. Behav. Sci. 236: 105222.

IUCN, (2015). The IUCN Red List of Threatened Species. Retrieved April 28, 2015, from www.iucnredlist.org

Kinnear, P. R. and Gray, C. D. (1999): SPSS for Windows made simple. Taylor & Francis.

Kinzer, J., and Groome, C. (2011): Population analysis and breeding and transfer plan: Fishing cat. *(Prionailurus viverrinus)*: 1-21.

Kolipaka, S. S., Srivastava, D. P., Prasad, S., and Rust, N. A. (2019): Fishing cat conservation in human-dominated landscapes in West Bengal, India. CatNews 69: 21-24.

Lehner, P. N. (1992): Sampling methods in behavior research. Poult. Sci. 71(4): 643-649.

Mellen, J. D. (1991): Factors influencing reproductive success in small captive exotic felids (*Felis* spp.): a multiple regression analysis. Zoo Biol. 10(2): 95-110.

Mellen, J. D. and Shepherdson, D. J. (1997): Environmental enrichment for felids: an integrated approach. Int. Zoo Yearb. 35(1): 191-197.

Mishra, R., Gautam, B., Kaspal, P. and Shah, S. K. (2021): Population status and threats to fishing cat, *Prionailurus viverrinus* (Bennett, 1833) in Koshi Tappu wildlife reserve, Eastern Nepal. Nepalese J. Zool. 5(1): 13-21.

Mukherjee, S., Sanderson, J., Duckworth, W., Melisch, R., Khan, J., Wilting, A. and Howard, J. G. (2016): *Prionailurus viverrinus*. The IUCN Red List of Threatened Species 2010: e. T18150A7673993.

Nowell, K. and Jackson, P. (Eds.). (1996). Wild cats: status survey and conservation action plan (Vol. 382). Gland, Switzerland: IUCN.

Philbin, N. (1998): Towards an understanding of stereotypic behaviour of laboratory macaques. Ani. Technol. 49: 19-33.

Reading, R. P., Miller, B. and Shepherdson, D. (2013): The value of enrichment to reintroduction success. Zoo Biol. 32(3): 332-341.

Shepherdson, D. J., Carlstead, K., Mellen, J. D. and Seidensticker, J. (1993): The influence of food presentation on the behavior of small cats in confined environments. Zoo Biol. 12(2), 203-216.

Shomita Mukherjee, S. M., Tiasa Adhya, T. A., Prachi Thatte, P. T. and Uma Ramakrishnan, U. R. (2012): Survey of the Fishing cat *Prionailurus viverrinus* Bennett, 1833 (Carnivora: Felidae) and some aspects impacting its conservation in India. J. Threat. Taxa. 4(14): 3355-3361.

Swaisgood, R. R. (2010): The conservation-welfare nexus in reintroduction programmes: a role for sensory ecology. Anim. Welfare 19(2): 12

14

Photograph-based morphological identification as a non-invasive tool for differentiating individual Red Pandas Ailurus fulgens (Cuvier F, 1825)

Saurabh Gurunga*, Asim Giri[a], Pranita Gupta[b], Joy Dey[c] & Basavaraj S. Holeyachi[d]

[a*, a,b,c,d] Padmaja Naidu Himalayan Zoological Park, Darjeeling, West Bengal, India.

Email: a*pnhzp@yahoo.com, agiriasim2013@gmail.com, bpranita.gupta.subba@gmail.com, cjoydarjeeling@yahoo.co.in, dbasavifs@gmail.com

ABSTRACT

A non-invasive method for identifying individual Red pandas *(Ailurus fulgens)* is vital in the conservation of this endangered species. The photography technique is one of the most effective and accessible tools for identifying animals. This study made efforts to accurately document the various distinguishing features of the morphology of individuals at Padmaja Naidu Himalayan Zoological Park (PNHZP), Darjeeling. The animal's body was divided into head, body/ torso, and tail to develop a clear understanding of the various morphological features. In this study, four distinct facial patterns were observed across the individuals, among other features. Comparisons have been made with previous literature regarding the morphology of the species. Some of the results obtained in our study such as certain geometric shapes of the muzzle tips have not been reported in earlier studies. Our study has also reported the presence of the bald facial pattern only among females. Morphological profiles for individual red pandas were prepared to maintain a database for the animal's morphology and to accurately identify animals in captivity.

KEYWORDS

Profiling, animal husbandry, captive management

INTRODUCTION

Individual identification of animals is often achieved by the insertion of tags (PIT Tags) in the animal's body. This process, however, is invasive as it involves the capturing and handling of the individuals which may lead to injuries. Some of the reported problems include increased corticosteroid levels after capture, the possibility of infection through the tag-wound (Bowen & Witzell 1996), and alteration of nesting behaviour (Broderick & Godley 1999). The loss rate of tags over time is also a variable that needs to be considered. The non-intrusive nature of photo-identification is of utmost advantage in endangered animals such as the Red panda. The use of natural marks in an animal is being increasingly used as an effective tool in the identification of individual animals.

Photographic identification and the creation of respective databases can assist in better research and understanding of the species. The photographic method is one of the most promising methods to identify individual animals, track their patterns, and estimate the population density as well. It is widely used now as it is cost-effective and non-invasive compared to the traditional tagging method (Karlsson et al. 2005). This method has been applied in several studies of wild animals like Snow leopards (Jackson et al. 2005), Common leopards (Harihar et al. 2009) and Tigers (Thapa et al. 2013).

Photographic identification of animals has been used in studying the site fidelity of the species as in the case of Fin whales (Agler et al. 1993). This was used to estimate the amount of time spent by the individual at a particular site. Thus, this method can serve as a major non-invasive tool in the tracking of animals throughout the year and can also be used to predict the migration pattern of a particular animal. It has been proven to be an effective method for studying the life history and the behavioural aspects of animals as well.

The photographic identification of individual Red panda *(Ailurus fulgens)* is difficult compared to other animals due to their small size, shiny fur, and diffuse colouration pattern. Direct methods of population studies are difficult due

to their deceptive and shy nature in the wild. It possesses postcranial reddish or orange-brown dorsal pelage and glossy black ventral pelage; legs are black and the soles of the feet are covered with dense white hair (Roberts & Gittleman 1984). The Red Panda is differentiated from other lesser carnivores by its facial features, especially its reddish tear mark that extends from the inferior region of orbit to the corner of the mouth (Fig. 1). Other facial features such as teardrop, muzzle, nose bridge, eyebrows, and cheek patches are highly variable in individual red panda which makes it the most important part of the body for photographic identification (Shrestha et al. 2015). Reddish-brown fur on the upper part and blackish on the lower part helps camouflage them from predators. Its long bushy tail helps to balance while climbing down the trees. The tail's alternating rings also provide excellent camouflage. With the help of tail rings and facial patterns, red pandas can be identified individually (Shrestha et al. 2015). However, the red panda has no sexual dimorphism in colour or size (Roberts & Gittleman 1984.

Our study focuses on developing morphological profiles for unique red pandas in captivity. This could help in animal husbandry as a non-invasive tool provides a quick and non-harmful method for zookeepers and other stakeholders of captive management of red pandas for primary identification of the individuals.

MATERIALS AND METHODS

A total of 22 Red panda individuals were photographed for their morphological identification. All these individuals were present at three different sites of Padmaja Naidu Himalayan Zoological Park (PNHZP), Darjeeling: PNHZP display, Old Conservation Breeding Centre (CBC), and Topkeydara CBC. These photos were then categorised according to the respective individuals and analysed for individual identification. Shrestha et al. (2015) have mentioned a few differences in the features of juveniles and adults. This means that the profiles of the Red panda taken during their juvenile stage may not prove to be confirmed once they reach the adult stage. Thus, juveniles were not photographed for this study..

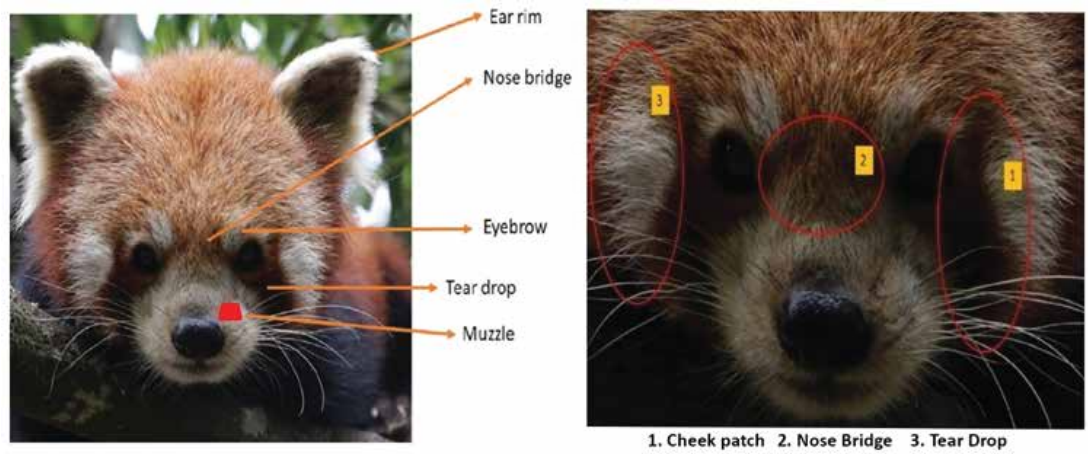


Fig. 1 : Representation of various distinguishing facial features

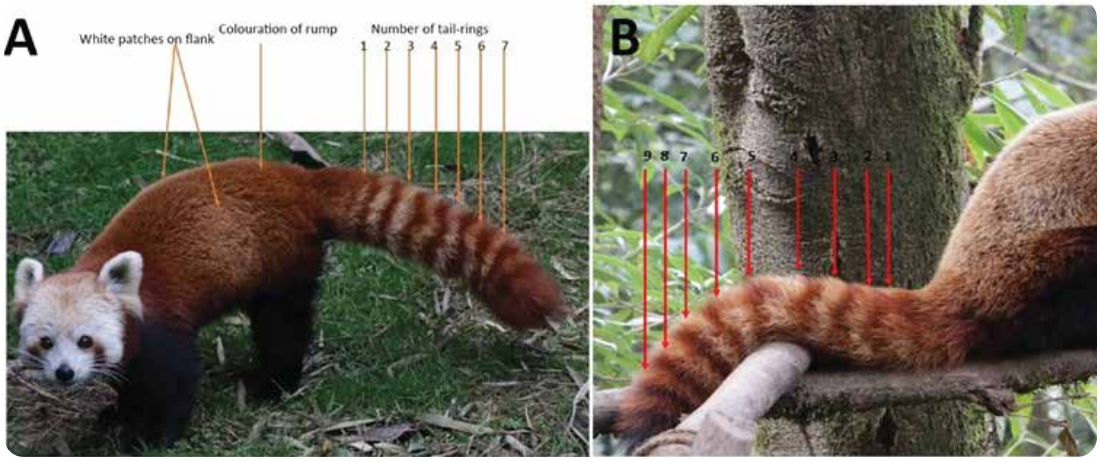


Fig. 2. Representation of various distinguishing body and tail (ring number) features. Panda A shows 7 tail rings in contrast to 9 in Panda B.

PROTOCOL FOR MORPHOLOGICAL IDENTIFICATION

Two primary observers used a Canon D700 camera mounted with an 18-135mm lens to take photographs of the individual Red Pandas. Photographs were taken by categorising the body into three sections: Head, Body/Torso, and Tail (Shrestha et al. 2015). Precautions were taken to carefully organise the photographs for each individual separately. It was followed by uploading the pictures to a computer and identifying different parts of each section for every individual. The different body parts were categorised into ten features and differentiated based on shape, colour, structure, and number. These features included seven features of the head, two of the body, and one of the tail (Table 1). To avoid discrepancies due to lighting or other weather conditions, special care was taken to note the identifying features on-site before photographic confirmation.

The geometrical shape of the muzzle tip, breadth and shape of the cheek mark, direction of the nose bridge, teardrop breadth, distinctness of the eyebrow, and thickness of the ear rim were all used to differentiate between individuals. Each individual was assigned to one of the four facial patterns based on their cheek marks and other distinct features based on their side profiles. The presence and positioning of white patches on the body of the individuals were also considered for differentiation purposes. This, in addition, led to the use of rump colouration as a differentiating factor for identification as well. The number of ochre rings on the tail of the individuals was counted to check for variations across the sample set. Profiles were prepared for each individual using the different morphological features.

The percentages of the animals containing the different facial patterns and the percentages with the other tail rings were also calculated and presented in a pie chart.

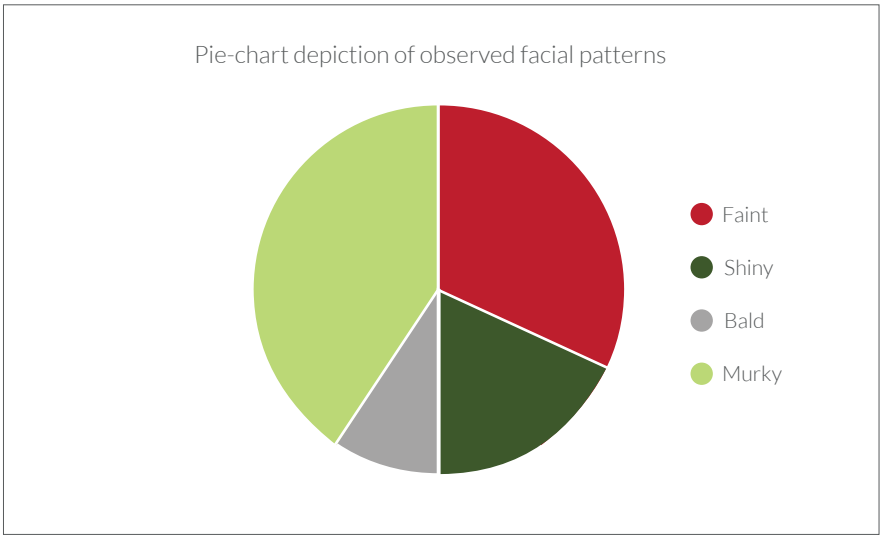


Fig. 3. Variation of facial patterns among the studied red pandas

Table 1 : Morphological features for Red Panda identification

SR. NO.	FEATURES	OBSERVED INSIGHTS
1.	**Head**	
a.	Facial pattern	Faint, Shiny, Murky or Bald (as shown in T.2)
b.	Muzzle shape tip	Oval, Triangular, Pentagonal, Rectangular, Trapezoid, Quadrilateral, Semi-spherical
c.	Cheek mark	Thin, Thick, Triangular or Indistinct
d.	The shape of the nose bridge	Straight, downwards, or upwards
e.	Teardrop	Broad, narrow or curved
f.	Eyebrow	Coloured or Indistinct
g.	Ear rim	Only “thick” was observed
2.	**Body**	
a.	White patch	Positioning on body
b.	Rump colouration	Relative to flank
3.	**Tail**	
a.	No. of ochre rings	n= 6, 7, 8, 9, 10

RESULTS

Photographic identification was done for the 22 Red pandas present at PNHZP. Different morphological features of the head, body/ torso, and tail were identified and differentiated among the various individuals (Shrestha et al. 2015). Two composite tables containing the complete morphological profiles of all the male individuals (Table 4) and that of the female individuals (Table 5) was prepared.

Four kinds of facial patterns were observed across the 22 individuals (Faint; Shiny; Murky; and Bald) (Fig. 3 & Table 2). The bald pattern, however, was not observed in males while the Murky facial pattern was most prevalent in male individuals (five). At the same time, the faint facial pattern was most prevalent in females (five). The nose bridge was identified and differentiated based on the direction in which it was pointed, and the muzzle tip based on its geometric shape (Table 3). The nose bridge was pointed downwards in most individuals (14), while it was straight for five individuals and pointed upwards for three. The different shapes of muzzle tips seen in the individuals included oval (five), triangular (three), rectangular (one), quadrilateral (one), trapezoid (three), pentagonal (six) and semi-spherical (one). Additionally, we found that two individuals possessed muzzle tip that did not conform to a specific geometric shape and therefore classified as irregular. Cheek marks, teardrop, and ear rims were distinguished based on their thickness (Table 3). Seven individuals contained thin cheek marks while ten had thick. In addition, a triangular cheek mark was also observed in three individuals. The cheek mark was indistinct in the two female individuals who had bald facial pattern. Teardrop was broad in nineteen individuals while it was narrow in one. The teardrops of the remaining two individuals were curved. All the individuals seemed to have thick ear rims. Distinct white eyebrows were observed in sixteen individuals, while the eyebrows were faint in four of them. The eyebrows of two individuals were not visible and hence classified as indistinct (Table 3). Two individuals had white patches on their backs, while six of them had it on their flanks. Seven Red Pandas possessed white patches (Fig. 2) on both their back as well as their flanks, while it was absent in the rest (seven). Due to the absence or presence of these white patches on their bodies, the rump colour was observed to be red in fourteen individuals, while the colour was a mixture of red and white (depicted as mixed in Table 4 and Table 5) in eight individuals (mixed in Fig. 2).

The number of tail rings could not be distinguished in one animal, while across the other twenty-one animals, it ranged from six to ten (seven in Fig. 2). Of these, 38% (eight) of the animals had nine, 33% (seven) had eight, 14% (three) had seven, 10% (two) had six and only five per cent (one) had ten Tail rings (Fig.4).

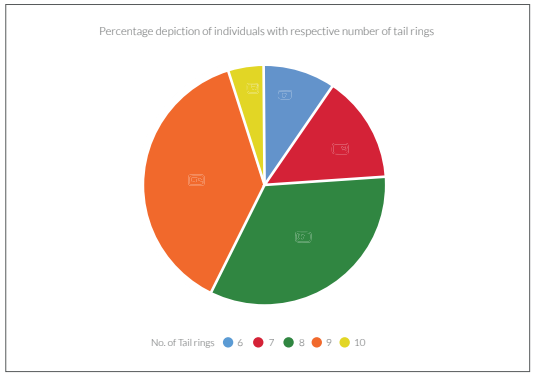


Table 2 : Observed facial patterns of Red panda

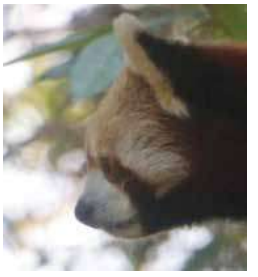
PATTERN	DISTINGUISHING CHARACTER	PHOTOGRAPHIC REPRESENTATION
Faint	Thin cheek marks and other features are visible.	
Shiny	Broad and shiny cheek marks are visible.	
Murky	Triangular cheek marks visible.	
Bald	Indistinct cheek mark; white colouration of face extending from the tip of the muzzle and extending toward the forehead and the tear-drop area.	

Table 3 : Photographic representation of morphological differentiation of head features

FEATURE	OBSERVED INSIGHTS			
Muzzle	 Oval	 Pentagonal	 Quadrilateral	 Triangular
Cheek	 Thick	 Thin	 Triangular	 Indistinct
Nose	 Upwards	 Downwards	 Straight	
Tear	 Broad	 Narrow	 Curved	
Eyebrow	 Distinct white	 Indistinct	 Faint white	

Table 4. Morphological profiles of male Red panda Individuals

SR. NO.	NAME OF INDIVIDUALS	MORPHOLOGICAL FEATURES								
		FACIAL PATTERN	MUZZLE TIP	CHEEK MARK	NOSE BRIDGE	TEARDROP	EYEBROW	WHITE PATCH	COLOURA-TION	TAIL RINGS
1.	Balam (M)	Faint	Irregular	Thin	Upwards	Broad	Distinct white	Back and fanks	Mixed	9
2.	Kimbu (M)	Faint	Rectangular	Thin	Downwards	Broad	Distinct white	Flanks	Red	10
3.	Noel (M)	Murky	Irregular	Thick	Upwards	Narrow	Faint white	Absent	Red	9
4.	Pabu (M)	Murky	Triangular	Triangular	Downwards	Broad	Distinct white	Absent	Red	9
5.	Prasanjit (M)	Murky	Pentagonal	Thick	Downwards	Broad	Distinct white	Flanks	Red	8
6.	Ram (M)	Shiny	Trapezoid	Thick	Straight	Broad	Distinct white	Absent	Red	0
7.	Satvik (M)	Murky	Pentagonal	Thick	Straight	Broad	Distinct white	Back and flanks	Mixed	6
8.	Shifu (M)	Murky	Pentagonal	Triangular	Straight	Broad	Distinct white	Back and flanks	Mixed	9

Table 5 : Morphological profiles of female Red panda Individuals

SR. NO.	NAME OF INDIVIDUALS	MORPHOLOGICAL FEATURES								
		FACIAL PATTERN	MUZZLE TIP	CHEEK MARK	NOSE BRIDGE	TEARDROP	EYEBROW	WHITE PATCH	COLOURA-TION	TAIL RINGS
1.	Angela (F)	Faint	Oval	Thin	Downwards	Broad	Distinct White	Absent	Red	9
2.	Janaki (F)	Murky	Triangular	Thick	Downwards	Broad	Distinct White	Absent	Red	9
3.	Karma (F)	Shiny	Triangular	Thick & Shiny	Straight	Curved	Faint White	Back and flanks	Mixed	8
4.	Teesta (F)	Murky	Pentagonal	Thick	Downwards	Broad	Distinct White	Absent	Red	8
5.	Kitchi (F)	Murky	Pentagonal	Thick	Downwards	Broad	Distinct White	Back	Mixed	8
6.	Nikki (F)	Shiny	Oval	Thick	Downwards	Broad	Distinct White	Back and flanks	Mixed	7
7.	Neera (F)	Shiny	Oval	Thick & Shiny	Downwards	Broad	Distinct White	Absent	Red	6
8.	Numa (F)	Bald	Pentagonal	Indistinct	Upwards	Curved	Indistinct	Flanks	Red	7
9.	Prasanna (F)	Faint	Quadrilateral	Thin	Downwards	Broad	Distinct White	Absent	Red	7
10.	Rigsel (F)	Faint	Oval	Thin	Straight	Broad	Faint White	Flanks	Red	8
11.	Shova (F)	Faint	Trapezoid	Thin	Downwards	Broad	Distinct White	Flanks	Red	9
12.	Smile (F)	Bald	Oval	Indistinct	Downwards	Broad	Indistinct	Back and flanks	Mixed	8
13.	Sunita (F)	Murky	Semi-sphercal	Triangular	Downwards	Broad	Distinct White	Back and flanks	Mixed	8
14.	Yeshe (F)	Faint	Irregular	Thin	Downwards	Broad	Faint White	Flanks	Red	9

DISCUSSIONS

Shrestha et al (2015) described the presence of four major facial patterns of red pandas in their study. Our study verifies the presence of all four facial patterns and most of the other morphological features in the individuals housed at the mentioned sites. In addition to the features and profiles earlier detected, we have also come across other variations in some morphological features of the animal. Shapes of muzzle tips not reported by Shrestha et al. (2015), such as oval, rectangular, pentagonal, and semi-spherical, is reported in our study. Ear rims across all the individuals were observed to be only thick and hence, this feature could not be used as a distinguishing factor for differentiation. The number of tail rings also varies from that reported by Shrestha et al. (2015), we observed only six to ten rings in contrast to their report of 12-18 rings. We also observed that the Bald facial pattern was present only among females, which could mean that this is a gender-specific feature. However, since other females possessed other facial patterns as well, we cannot assign all females to be of bald facial patterns. A wider sample set analysis needs to be done to verify the same.

Features such as ear cores and the shape of the crown were not identified during this study as there was not enough photographic evidence to differentiate the same from one individual to another. It needs to be considered that the colour of the animal's fur may change across seasons and thus, it may not be the most accurate distinguishing feature for their differentiation. However, there is no study to prove the change in the number of tail rings or the facial patterns of the animal. These may thus serve as more adequate measures of morphological differentiation for the Red panda.

Previous observations that the tail rings of the Himalayan Red panda are less distinct than the Chinese Red panda (Hu et al. 2020) may not hold in our study as most of the Red pandas have shown distinct tail rings (Fig. 2A).

These visible differences in the various morphological features across individuals will help us identify individual animals at the facility. This can further be used to create profiles of other individuals of the same species in the future, thus leading to the formation of a large database of morphological profiles of Red panda (Reisser et al. 2008). Strategic partnerships among various countries where Red panda species are found are vital to achieving such a goal.

This was the first attempt at preparing morphological profiles of individual Red pandas at PNHZP, Darjeeling. Creating a profile of Red Panda individuals based on their morphology can be very useful in identifying the animal in captivity as well as in the wild. Morphology-based identification can help zookeepers manage the animals with ease and increased specificity. Animal health is of utmost concern in captive populations of Red pandas and a non-invasive identification tool can help in precise management of the same.

Morphological identification can also serve as a major tool in population studies in the wild. Since the number of Red panda individuals is very low in the wild, this can serve as a very useful conservation tool to monitor the population of the species in the wild as well. Captures from camera traps in the wild can be used to distinguish the individuals of the population and give us an idea of the population even if genetic studies cannot be conducted. However, since the Red panda is a very shy and elusive animal, photographing them in the wild could prove to be a major

challenge. Camera trap studies could prove to be very useful, but precautions should be taken to ensure high-quality and clear images of the individual to be profiled. A further study could be done to efficiently use this protocol with the help of camera trap techniques, combined with handheld photography of live encounters to aid in population studies.

CONCLUSION

Photograph-based morphological identification of animals has been very effective in that it is non-invasive as well as inexpensive. In addition, the ease of collection of photographs of individuals in captivity allows for the generation of a huge database of the morphology of the species. Our study firmly suggests the use of this non-invasive tool for individual Red panda identification, as it can aid in better management of the species in captivity.

We are hopeful that this morphological identification can help in species-related future studies and work at PNHZP and elsewhere.

ACKNOWLEDGEMENTS

The authors would like to thank Shri Saurabh Chaudury IFS, Member Secretary, West Bengal Zoo Authority (WBZA) for funding the project. We would also like to extend our gratitude to the Principal Chief Conservator of Forest (PCCF) and the Chief Wildlife Warden (CWLW), West Bengal. We are also grateful towards all the staff of Padmaja Naidu Himalayan Zoological Park.

REFERENCES

Agler BA, Schooley RL, Frohock SE, Katona SK, & Seipt IE. (1993). Reproduction of Photographically Identified Fin whales, *(Balaenoptera physalus)*, from the Gulf of Maine. Journal of Mammalogy, 74(3): 577–587. https://doi.org/10.2307/1382276.

Ardovini A, Cinque L, & Sangineto E. (2008). Identifying elephant photos by multi-curve matching. Pattern Recognition, 41(6): 1867–1877. https://doi.org/10.1016/j.patcog.2007.11.010.

Bowen BW, & Witzell WN. (1996). Proceedings of the International Symposium on Sea Turtle conservation Genetics.

Broderick AC, & Godley BJ. (1999). Effect of tagging marine turtles on nesting behaviour and reproductive success. Animal Behaviour, 58(3): 587–591.

Choudhury A. (2001). An overview of the status and conservation of the Red panda *(Ailurus fulgens)* in India, with reference to its global status. Oryx, 35(3): 250–259. https://doi.org/10.1046/j.1365-3008.2001.00181.x

Cuvier F. (1825). Histoire naturelle des mammifères: avec des figures originales, coloriées, dessinées d'aprèsdes animaux vivans 5(3).

Davis DD. (1964). The giant panda: a morphological study of evolutionary mechanisms. Chicago Natural History Museum. https://doi.org/10.5962/bhl.title.5133

Harihar A, Pandav B, & Goyal SP. (2009). Density of leopards *(Panthera pardus)* in the Chilla Range of Rajaji National Park, Uttarakhand, India. Mammalia, 73(1). https://doi.org/10.1515/MAMM.2009.007

Hu Y, Thapa A, Fan H, Ma T, Wu Q, Ma S, Zhang D, Wang B, Li M, Yan L, & Wei, F. (2020). Genomic evidence for two phylogenetic species and long-term population bottlenecks in red pandas. Science Advances, 6(9). https://doi.org/10.1126/sciadv.aax5751

Jackson, Rodney M, Jerry DR, Rinchen W, & Don OH. (2005). Surveying Snow leopard populations with emphasis on camera trapping: a handbook.. The Snow Leopard Conservancy, Sonoma, California, 73.

Karlsson O, Hiby L, Lundberg T, Jüssi M, Jüssi I, & Helander B. (2005). Photo-identification, Site Fidelity, and Movement of Female Gray seals *(Halichoerus grypus)* Between Haul-outs in the Baltic Sea. AMBIO: A Journal of the Human Environment, 34(8): 628–634. https://doi.org/10.1126/sciadv.aax5751

McGrew, & Paul O. (1938). Dental morphology of the Procyonidae with a description of Cynarctoides gen. nov. Field Museum of Natural History, Geological Series , 6: 323–339.

Miles SR, & John LG. (1984). *(Ailurus fulgens)*. In Mammalian Species. 222: 1–8.

Pocock RT. (1921). The External Characters and Classification of. the Procyonidæ. Proceedings of the Zoological Society of London, 91(2): 389–422. https://doi.org/10.1111/j.1096-3642.1921.tb03270.x

Reisser J, Proietti M, Kinas P, & Sazima I. (2008). Photographic identification of sea turtles: method description and validation, with an estimation of tag loss. Endangered Species Research, 5: 73–82. https://doi.org/10.3354/esr00113

Shrestha S, Shah KB, & Bista D. (2015). Cite This Article: Saroj Shrestha, Karan Bahadur Shah, Damber Bista, and Hem Sagar Baral. Applied Ecology and Environmental Sciences, https://doi.org/10.12691/aees-3-1-3 3(1): 11–15.

Thapa K, Kelly MJ, Karki JB, & Subedi N. (2013). First camera trap record of pack hunting dholes in Chitwan National Park, Nepal. Canid Biology and Conservation. Canid Biology and Conservation, 16(2): 4–7.

15

Conservation and Captive breeding of Endemic Nicobar Pigeon *(Caloenas nicobarica)* in Andaman and Nicobar Islands

Dr. Sam Varghese, Shri A.C Tilak, smti Suma Anand Kashyap
Department of Environment and Forests , UT Administration ,
Andaman and Nicobar , Van sadan , Port Blair
Email : drsam 2041@gmail .com

ABSTRACT

Nicobar pigeon *(Caloenas nicobarica)*, is an unique bird species in the pigeon family, endemic to Andaman and Nicobar Islands. Despite its name, this bird species, is not merely confined to the Nicobar group of islands, but also found in the southern group of Andaman Islands, and has been reported in South Andaman especially in areas of Maccapahad, Shoal bay, Chidiyatapu and also in Little Andaman. The Nicobar pigeon is accorded the highest level of protection and is included under Schedule I, Part III of the Wild Life (Protection) Act, 1972.

Genetic data indicates that NP is the last surviving relative of the Dodo bird (Raphus cucullatus) which has been believed to be extinct for over 300 years and is currently the last surviving member of the of Caloenas genus (Heupink et al., 2014;Shapiro et al., 2002). This makes the conservation of NP an extremely important and urgent matter to protect both the biodiversity and its genetic resources.

This article presents a comprehensive study on the breeding behavior and nesting behavior, nesting pattern of NP, In Chidiyatapu Biological park, highlighting their unique characteristics. Through field observations and analysis, this research sheds light on the, breeding behaviour, and nesting pattern and squab rearing behavior of Nicobar pigeon.

KEYWORDS

Nicobar pigeon, captive breeding, ex-situ, germplasm, aboriginal tribes, squab, near threatened, Biological Park, Chidiyatapu, Zoo

INTRODUCTION

The Nicobar pigeon *(Caloenas nicobarica nicobarica)* is an endangered species which is native to small Indo Australian islands. Linnaeus (1758) named the Nicobar pigeon (NP hereafter) as *Columba nicobarica*. He described it briefly as having a white tail, a black body and a shining green back and listed its habitat as the Nicobar Island. Salvadori (1893) cites the earliest use of the generic name *Caloenas* in 1840, and gave 16 other latin names by which the pigeon was also known.

NP is a ground dwelling bird in the pigeon and dove family (Columbidae), Columbiformes order (Gray, 1840). These are medium sized birds with overall compact appearances including short wings and tail that enable them to fly short distances. Their habitat ranges from the Andaman and Nicobar islands and Malayan archipelago to the islands of Southeast Asia. Although they have become increasingly difficult to find in the wild (Bird life international 2016), it is due to the deep blue green feather color and long hackle which makes them valuable targets for trapping for illegal trades as pets. Also due to the limited flight capability they are hunted for the meat and gizzard stones. NP is currently classified as a near threatened species, according to the International Union for Conservation of nature (IUCN) Red list. It is protected under schedule I , Part III of the Wild Life (Protection) Act , 1972 in India. Two subspecies are recognized, *C nicobarica nicobarica* (Linnaeus . 1758) –found in Andaman and Nicobar islands, Malaya Archipelago to New Guineas, Phillipines and Solomon islands and *C nicobarica pelewensis* (Finsch . 1875) found in Palau islands.

Genetic data indicates that NP is the last surviving relative of the Dodo bird *(Raphus cucullatus)* which has been believed to be extinct for over 300 years and is currently the last surviving member of the of *Caloenas* genus (Heupink et al., 2014;Shapiro et al., 2002). This

makes the conservation of NP an extremely important and urgent matter to protect both the biodiversity and its genetic resources.

Captive breeding of NP has been difficult due to their sexually monomorphic appearance. Male and female birds are virtually non-distinguishable morphologically and behaviorally. Moreover, females typically only lay one- two eggs per clutch, and fertilized eggs need approximately 21-28 days of incubation before hatching. Therefore, the reproduction rate of NP is much slower than the rate at which they are trapped and hunted. The relative rarity and breeding difficulty of NP makes it necessary to establish a non-invasive, accurate and reliable technique to identify male and female birds to facilitate breeding in captivity, such as in zoos and wildlife breeding facilities.

Though the NP is distributed in both the Andaman and Nicobar group of islands, as such no in-situ and ex-situ research has been done for the conservation breeding of this rare, endangered, near threatened species of A&N islands. In this context, the Biological Park Chidiyatapu, for the first time carried out breeding of this rare threatened species, to study its breeding behaviour, morphological observable differences, so as to collect data and to conserve this precious germplasm which is fast declining in the wild due to illegal hunting, trade and lack of conservation awareness among the Nicobari tribes.

MATERIAL AND METHODS

Study area: The Biological Park Chidiyatapu, study site is a forest of 40 hectare area, diverted from Bimblitan reserve forest of South Andaman and as per the Champion and Seth classification is rich in Andaman semi evergreen forest (2A/C1) , Andaman moist deciduous forests (3A/C1) and is surrounded by Littoral forest (4A/L1) and Tidal Swamp Forest (Mangroves) (4B/TS2). The temperature and humidity during the breeding season of Nicobar pigeon i.e. from month of January to June in Chidiyatapu is 28-32 Degrees Centigrade with 60 -75% % humidity on an average.

The study method used for breeding observation: The method to study the breeding behaviour of the NP was done by ad libitum sampling (Altaman 1974) and focal animal sampling (Altman 1974). The focal animal sampling was used to study the specific behaviour of the male and female NP during the breeding season and for observing the nesting and squab rearing behaviour. By adlibitum sampling, the general behavior of the birds, were recorded throughout the breeding and in non-breeding period. As the enclosure was accessible, on ground, there was no need to use binoculars to observe the behavior from very close range.

Founder population : Though an initial attempt for conservation of the germplasm of NP was done in the Mini zoo , Haddo, Port blair in the early 1980s, the founder population, collected from the wild, did not survive due to foot infections, and no breeding took place in the Mini zoo, Haddo, Port Blair. After the new biological park was established in 2009 at Chidiyatapu, he park took up captive breeding of NP. It got a pair of unsexed NP rescued from the Nature park interpretation centre, Haddo , Port Blair . The pair of adult but immature birds was received on 25 .07.2019, and after four years the female pigeon, laid an egg on 07/06/2023. The egg hatched, at 0930 hrs on

05/07 /23. Ground nesting was noticed with this pair instead of other observations where the pigeons, usually builds a nest at a height of 3m or at a height of 6 -10 m (Hume 1890). The other interesting observation, was that breeding season was restricted to the months of March with nesting behavior being observed in the month of April and egg laying in the month of May and June (observation in tropical island). The sexes were confirmed based on ethology. As there were only two individuals in the enclosure, the male and female could be observed by focal sampling method, and there was no confusion with respect to the sex of individual NP, once identified.

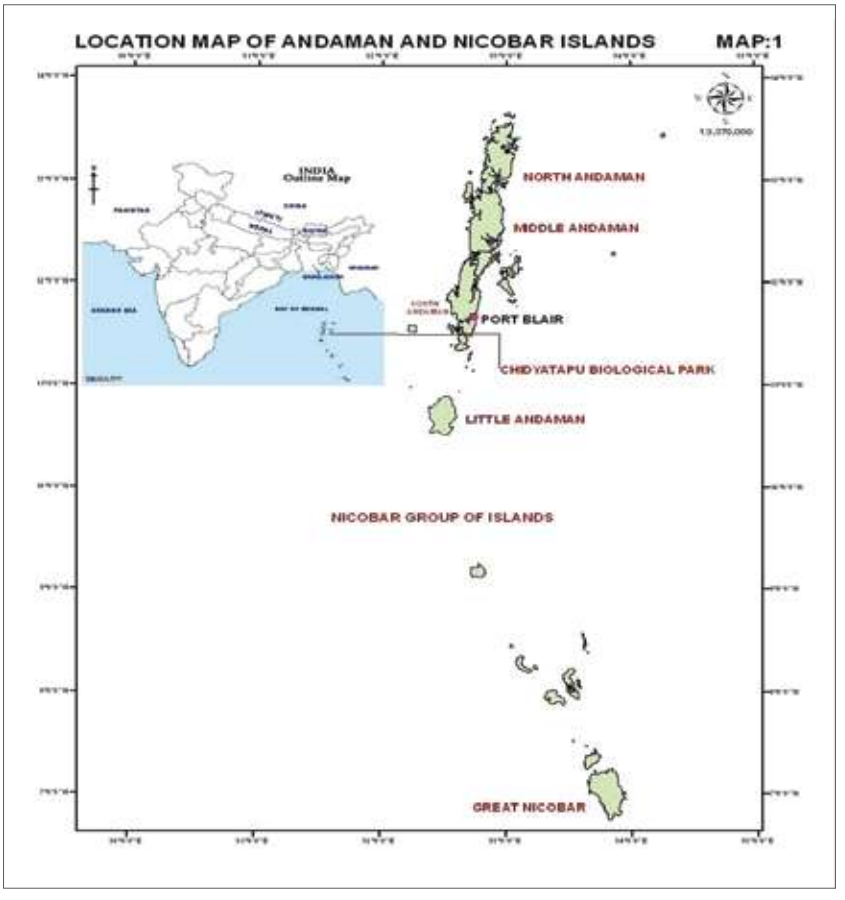


Fig 1: Map of Andaman and Nicobar Islands and Location Map of Biological Park in A&N Islands(India)

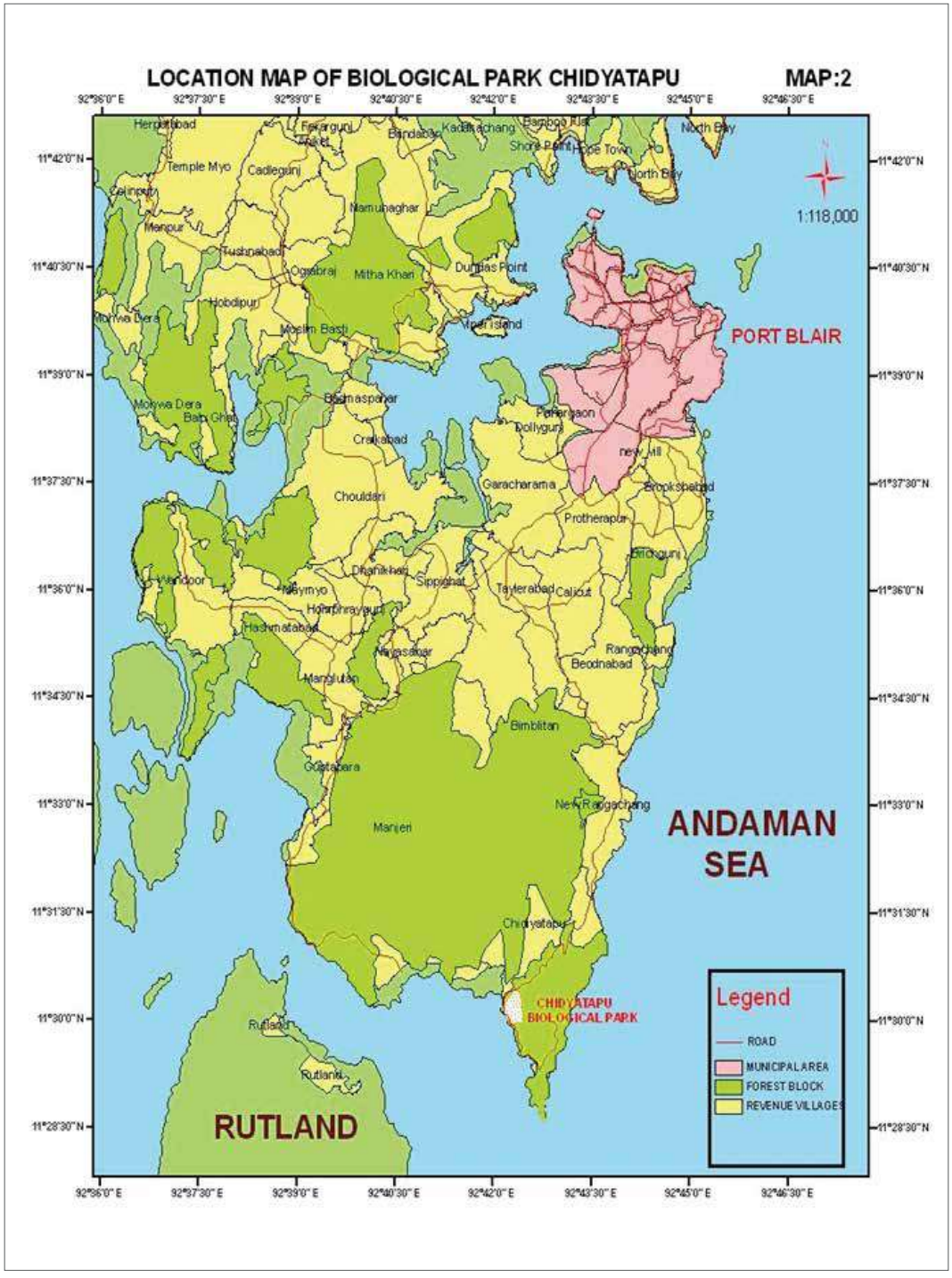


Fig 2: Location Map of Biological Park Chidiyatapu on the southernmost tip of South Andaman

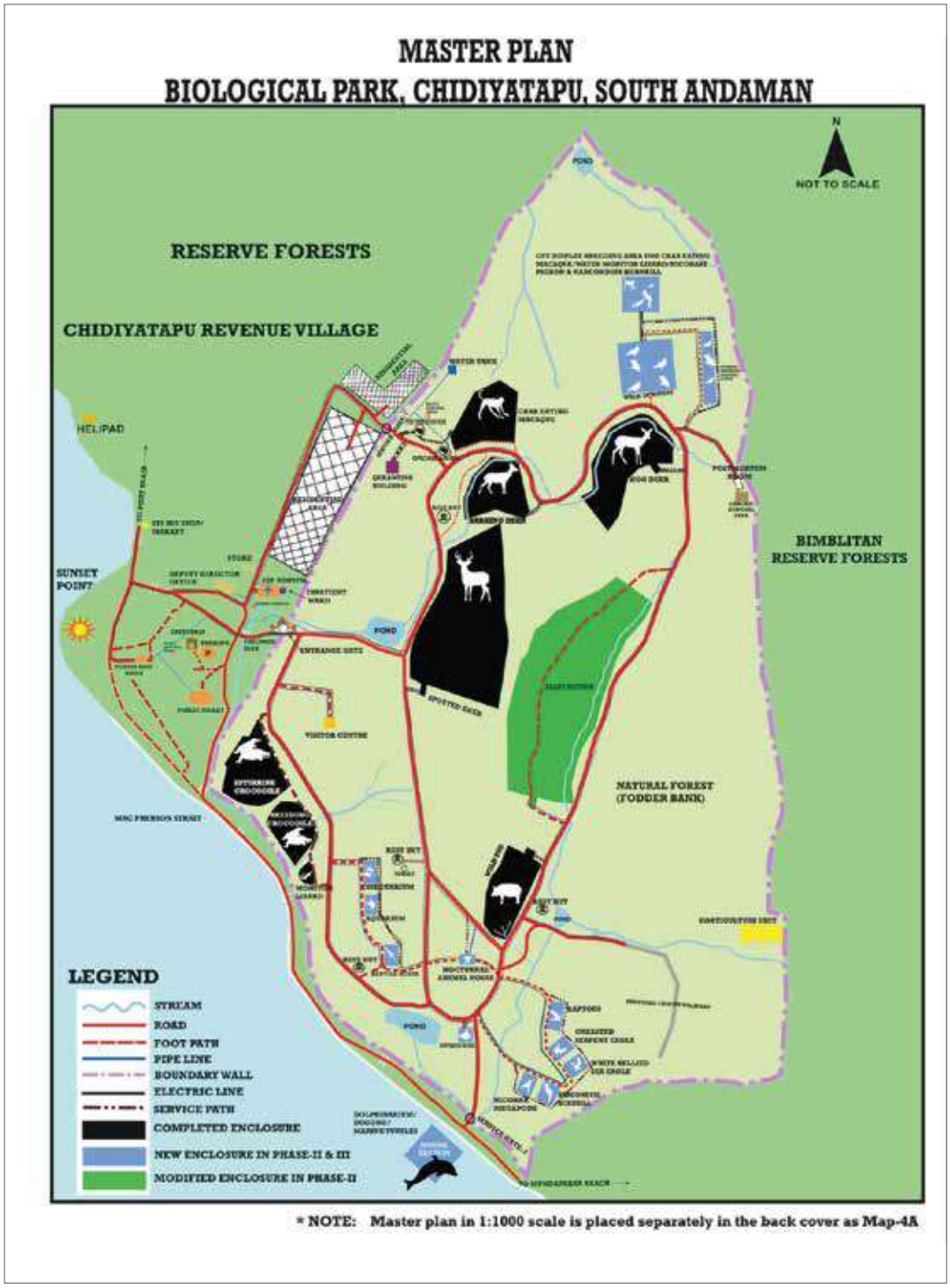


Fig 3: Showing the breeding site of the Nicobar pigeon enclosure (North East side of the park)

Male Nicobar Pigeon: The male NP, is larger in size than the female. It has a broader chest, longer hackles than the female (Brown 1983), a bigger cere, a broad triangular head when observed from the top, more colourful, less elongated neck, tails longer than female and legs are thicker and sturdier than females. The feathers of the male have ruffled appearance, with extraordinary iridescence. The gait of the male is straight and slow while walking. Males are heavier than females, and taller in height compared to the female. Males have a longer tail than female.

Photograph 1. Male (left) and 2. Female (right) Nicobar Pigeon

Female Nicobar Pigeon: The female Nicobar pigeon is smaller in size, has a narrow chest , shorter hackles (Goodwin 1970), narrow elongated head, when viewed from the top ,with duller colour, (Ali and Ripley, 1981) smaller cere, narrow elongated body , gait is cat like and swift, tails shorter, elongated legs which are less sturdy and less thicker and has elongated neck than an adult male NP. The feathers are not ruffled for females. Females moult in the month of July in the neck region which lasts till November and regains its plumage by December.

Photograph no. 3, Male and female Nicobar pigeon standing together (For comparison)

ENCLOSURE DESIGN

The enclosure is inside a semi evergreen forest with the enclosure dimensions of 10 m length x8 m width and 12 m height. It has small animal house of dimensions 1.5 m x2 m x.1.8 m height with two door for entry of the animal attenders and staff. The mesh is made of stainless steel with 2.5 cm opening. The roof of the enclosure is covered 1/4th by roofing sheet towards the rear part of the enclosure, to allow the birds to take cover and protection during heavy rain. It has a water pond and feed is provided in the feed trough. There are native wild pole crops located inside enclosure of heights 2-3 m and 1m, with small herbs, shrubs and grasses at some corners which provide shade, nesting area, and also ample sunlight for them in the morning. The entire ground is covered with soil, with pebbles in different areas and grasses of uniform growth found in patches inside the enclosure. No concrete surface is provided on the ground except for the water trough which is made of cement.

The design of the enclosure is given in photograph no. four and photograph no five .

Photograph no. 4: The Nicobar Pigeon Enclosure (Front View)

Fig 5 Photograph of the ground plan of the enclosure

BREEDING BEHAVIOUR OF NICOBAR PIGEON

During the courtship period only adlibitum sampling was done to observe the random mating behavior during breeding season and notes were taken by observation. By using focal sampling, the nesting behavior of the male and female NP was observed for a period of 45 minutes (15 minutes each in the morning, afternoon and evening hours and night observation done for 3 days at 8 pm for 15 minutes. Thus the birds were observed 1305 minutes i.e. for 22 hours in a period of 28 days. The pair did not breed for a period for four years, but laid an egg on 23/05/2022. But the egg did not hatch, and there was a failure in breeding in the year 2022. But the next year, the female laid an egg on 07/06/2023, and the egg was hatched successfully by the birds, and the squab was seen in the nest on 05/07/23. The incubation period was found to be exactly 28 days. During the breeding season, it was observed that male NP and female NP, engage in elaborate courtship displays to attract potential mates. The courtship behaviors which were observed during the breeding which included allopreening (male and female preening each other with their bills), courtship begging(female puts its beak into the males beak , with females head lower down the males and makes a gu gu sound), bowing (the male rotates its head downwards as if the beak touches the chest), chasing (male chases the female, with the male spreading its wing , and makes gu gu sounds, with its head in a down ward position), and hopping (the male makes a sudden flight i.e. jump in the air ,with stretched legs) These observations are similar to the breeding behaviour observed in Lincoln zoo with slight variations (Shauna .S. Robserts, 1984, dissertation). The male and female spend much time sitting at the prospective nest site, and the females begs for the crop milk by inserting her beak into the male NP beak. In addition to this the male lifts the tail, and stands before the female for few seconds. Sometimes, the male chases the female, and male moves its head up and down, and female shows submissive behaviour by lowering its head below the male. The pigeon, both male and female bring their beaks together. Male shows a head throbbing behavior and makes a gu gu sound/pig grunting voice (Whitman, 1919) when threatened by the approaching female during this period. Sometimes as a duet, they make *gu gu* sounds together, and the female

fans the tail, and male lifts the tail up and down and bobs the head up and down. Mounting and copulation could not be observed between the male and female NP. Treading behaviour (rhythmic raising of legs at nest site) shown by males for selection of nest site and for attracting of females was not observed in BPCT, Chidiyatapu, South Andaman.

As the founder population consisted of only one male and one female, and there was no extra individual of males and females, could be the likely reason for lack of treading behavior in males. Due to 1:1 sex ratio, the female accepted the male, and there was no competitive behaviour as seen in females, as described in the Lincoln zoological park, (Shauna .S.Robserts, 1984, dissertation).

For building a nest collection of twigs is not only carried out by males, but also by females, and most of the nest building is done by females. The nest building continues, even after the egg is laid and this is consistent with the findings of Lincoln zoological park, (Shauna .S.Robserts, 1984, dissertation) . Once the egg is laid, the couple takes more effort in the nest maintenance. Both female and male contributes to give final shape to the nest. The nest building appears to have occurred in night as the male NP was seen sitting on the nest in the morning , that is first appearance of nest in the enclosure.

BEHAVIOUR DURING NESTING

It was observed that the male sits on the nest, continuously for 8 -10 hours, while the female forages on the ground. If the male leaves the nest for feeding, then it consumes it feed as quickly as possible, and quickly returns back to incubate the egg. The following behavior is observed in males during nesting. The male will sit still for hours together, but from time to time will do preening with its beak on its chest, back, tail, shoulders, and will scratch his head, with one of its leg, and sometimes stretches its wing and leg only on one side. It spreads its white tail sometimes, and while incubating keeps the tail in an obtuse angle to the ground surface, which can be assumed to be an erect tail posture.. The male NP changes its direction from time to time, in the nest in a circular 360 degree rotation. Male shows tremble shoving behaviour (thrusting a stick downward usually into the nest, while sitting in the nest, and vibrates its head for few seconds). The male will also stand up from time to time, and will push the egg beneath its chest. This shoving of egg is done many times, which could be, to provide proper incubation and heat to the egg. It was also observed once, that the female and male were found sitting together in the nest during the day, but the female left the nest very soon. Both the male and female, are usually guarding, and roaming around the nest during the entire incubating period. Thus the male spends more time, incubating in the daylight hours and whereas female during the night and in early morning hours. The nesting was done on ground, in the year 2022 and in the year 2023 and not on tree branches or artificial nests, which were provided inside the enclosure. So this observation differs from the belief that most of the time NP breed at height of three metres or six to ten metres (Hume 1890).

The photograph of male sitting on the nest is shown in photograph no. six, seven and photograph of male (sitting in the nest) and female (guarding the nest) is shown in photograph no. eight. Observation of nesting behavior for 28 days is given in Table No 1.

Photograph 6: Male Nicobar pigeon sitting on the nest (Ground)

Photograph 7: Male Nicobar pigeon in the nest

Photograph 8: Male sitting on the nest and female standing guard in front of the nest

Table 1 : Nesting behaviour of male and female Nicobar Pigeon

DATE OF NESTING	NESTING BEHAVIOUR OF MALE AND FEMALE	REMARKS IF ANY
7.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
8.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
9.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
10.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
11.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
12.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
13.06.2023	9 AM	Male nesting, and the female is seen walking and foraging on the ground. Early morning, before 9 am, the female was nesting, and the male was foraging, and subsequently, the male took over the nest at 9 am.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
14.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
15.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground; the male leaves the nest for feeding and comes immediately to the nest after feeding.

16.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
17.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
18.06.2023	9 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
19.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
20.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
21.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	-do-
	4 PM	Male nesting and female is seen walking and foraging on the ground.
22.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
23.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
24.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
25.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.

26.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
27.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
28.06.2023	7.30 AM	Male nesting, and the female is seen walking and foraging on the ground. The female and male are sitting together for a few seconds.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
29.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
30.06.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
1.07.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
2.07.2023	7.30 AM	Male nesting and female is seen walking and foraging on the ground.
	12 PM	Male nesting and female is seen walking and foraging on the ground.
	4 PM	Male nesting and female is seen walking and foraging on the ground.
3.07.2023		-D0
4.07.2023		-D0
5.07.2023		**Eggs Hatched**

Table 2 : Size and thickness of twigs, lianas, dried grasses and leaves

SR. NO.	TWIGS, LIANAS, DRIES GRASS AND LEAVES	NO. OF TWIGS	IN INCHES
1.	Twigs of length 30 cm	07 nos.	11.8 inches
2.	Forked twigs of length 27.5 cm	04 nos.	10.82 inches
3.	Twigs of length 19.5 cm	42 nos.	7.8 inches
4.	Twigs of length 11.5 cm	60 nos.	4.5 inches
5.	Twigs of length 9.5 cm (thick category)	05 nos.	3.7 inches
6.	Twigs of length 9.5 cm (thin category	16 nos.	3.7 inches
7.	Twigs of length 6 cm (medium thickness)	26 nos.	2.36 inches
8.	Twigs of length 4.5 cm(thick)	06 nos.	1.77 inches
9.	Twigs of length 4cm (thin)	21 nos.	1.57 inches
10.	Twigs of length 3cm (medium thickness)	18 nos.	1.81 inches
11.	Dry climbers 55 cm long	19 nos.	21.65 inches
12.	Dry grasses38 cm long	35 nos.	14.96 inches
13.	Grass leaves 16 cm long	01 nos.	7.08 inches
14.	Very dry leaves	06 nos.	
15.	Green leaves	02 nos.	
16.	Light dry leaves	06 nos.	
17.	Broken particles of the above items	25-30 gms	
18.	Feathers of birds	02 nos.	

STRUCTURE OF NEST :

Though it is believed that the pigeons build the nest haphazardly, a study of the nesting pattern, reveals that nesting is done in a proper pattern; with twigs of different length, arranged in criss-cross pattern, and the inner lining consisting of dried grasses of different length, and leaves, feathers, found in the inner surface of the nest. Few feathers were also found inside the nest. The choice of hard twigs on the bottom surface of the nest and soft grasses and leaves on the top inner surface, shows an intricate geometric pattern in the nest designing of NP .The size of the egg was found to be 4.5 cm x 3.2 cm (Baker 1913).

The top view, lateral view of NP nest and the picture of egg is given in photographs eight, nine and ten.

Photograph 8: Top view of the nests

Photograph 9: Lateral view of the nest

Photograph 10: Egg inside the nest

SQUAB REARING BY NICOBAR PIGEON

To observe the rearing of squab, by male and female NP, focal sampling method was used, and the squabs were observed for 25 days in the morning for 15 minutes at 9 am in the morning. Thus, a total of 375 minutes, equivalent to 7 hours was done for one month to get an understanding of rearing of squabs by NP. The squab was not visible from the nest, and the male guarded the squab, by covering it fully in the morning hours, and it is assumed that the female guardeds and covered the squab at night. The NP were apprehensive and did not display the squab. Both the male and female NP, kept the squab covered for a period of 25 days, and alternatively the male, and the female fed the squab with the crop milk. The male and female pigeons, continues to brood /giving warmth to the young hatchling for a period 25 days. During this period, the feathers begin to develop, with dominant greyish to brownish red soil colour on the body. After a week of the hatching, the squab develops plain grey luster less, but clean feathers over its crest, wings and tail, and the colours changes into dark grey tone in a few days. By thirteenth

day, the brown red luster shade develops in the wings, which appears similar to the Red collared dove with a brownish red like colour on the body. The young squab by fifteenth day peeks out from the nest and is visible during the feeding of the crop milk by the male. By the end of 20 days, the squab undergoes rapid transformation and appears as young pigeon (similar to other pigeon with lack of hackles on its head and a dark tail). The bird fledged by first month and started feeding on the grain, provided in trough and started pecking the ground surface.

DISCUSSION

The study revealed key insights, into the reproductive breeding behaviour, nesting behaviour, squab rearing behaviour and ecological niche requirements of NP in ex-situ conditions and population dynamics of NP Breeding pairs. The findings, highlight the first successful breeding of NP, in ex-situ conditions of A& N islands. It will help us to highlight the various parameters, needed by these birds, for breeding in tropical conditions of A & N islands. The knowledge of ex-situ breeding in NP will help us to understand how small island species survive, and give an insight on - how this iconic species be conserved.

CONCLUSION

The NP, with its unique characteristics and cultural significance, serves as a flagship species for conservation in the Andaman and Nicobar Islands. It also serves as an educational opportunity for visitors to learn about the importance of conservation efforts. The breeding behavior of NP at Biological Park, offers a captivating glimpse into the intricacies of avian courtship and parental care. By understanding their breeding behaviour and population dynamics, we can implement targeted conservation strategies to safeguard their habitat and ensure the long-term viability of this iconic bird species.

REFERENCES

All, S.& ripley,S.D.1981. Handbook of Birds of India and Pakistan. Delhi : Oxford university press

Altmann, J.1974. Observational study of behavior : sampling methods. Behaviour, 49, 227 -267

Baker, E.C.S.1913. Indian pigeons and Doves. London :Witherby and Co.

Baker, E.C.S.1928 . The fauna of British India , 2ndedition . Volume V, Birds . London: Taylor and Francis

Bell, K.J.1981.Breeding and hand rearing the Nicobar pigeon *(Caloenas nicobarica)* at the Lincoln park Zoological Gardens . Int. Zoo Yb . 21, 217 -219

Bird life international 2012. Species factsheet: *Caloenas nicobarica*

Brown, K.1983. Captive management of the Nicobar pigeon at the Lincoln Park zoo. Paper presented at American Federation of Aviculture meeting , Chicago, Illinois

Dagar, J.C.,Mongia, A.D. &Bandopadhyay,A.K.1991. Mangroves of Andaman and Nicobar islands. Oxford & IBH Publ. Co. New Delhi.

Goodwin , D. 1970. Pigeons and Doves of the World . London : Trustees of the British museum.

Goodwin, D.1983. Behaviour. In: Physiology and Beahaviour of the Pigeon (Ed.by M.Abs), pp 285-308. New York:Academic Press.

Hume, A.O.1874. Contribution to the ornithology of India : the islands of the Bay of Bengal. Stray feathers , 2, 29-324

Hume,J.P., et al. 2004. Plaeobiology: Dutch

diariesand the demise of Dodo

Linne, C.Von.1758.System naturae, 10th Edition. London : Trustees of the British museum . 1939 facsimile

Saldanha, C.J. 1989. Andaman ,Nicobar & Lakshadweep.An enviromntal impact assessment . Oxford &IBH Publ.Co.delhi

Salvador I, T.1893. Catalog of birds in the British Musesum volume 21. London: British Museum.

Shapiro, B,et .al.2002. Flight of the Dodo. Science 295: 1683.

Shauna Roberts, S. (1984): Reproductive beahaviour of captive Nicobar pigeon, *(Caloenas nicobarica)* Phd thesis North western University , USA

Singh,N.I.1978.The Andaman story .Vilas Publ.House.New Delhi.

Whitman, C.O.1919. Posthumous works. The Behaviour of Pigeons , Volume 3. Washington, DC: Carnegie Institute Publication

16

Husbandry and Veterinary Protocols for Reptiles in Captivity

Dr. Nikhil Whitaker[1a], Dr. Ruchika Lakshmanan[1b], Angeline Samuel[1c], Dr. Bhushan Krishnamoorthy[1d]

[a] Curator, The Madras Crocodile Bank Trust and Centre for Herpetology, Chennai, Tamil Nadu, India

[b] Senior Veterinarian, The Madras Crocodile Bank Trust and Centre for Herpetology, Chennai, Tamil Nadu, India

[c] Assistant Curator, The Madras Crocodile Bank Trust and Centre for Herpetology, Chennai, Tamil Nadu, India

[d] Junior Veterinarian, The Madras Crocodile Bank Trust and Centre for Herpetology, Chennai, Tamil Nadu India

[1]The Madras Crocodile Bank Trust and Centre for Herpetology, Vadanemmeli Village, East Coast Road, Perur Post, Mamallapuram – 603 104, Chennai, Tamil Nadu, India.

Email:

nikhil@madrascrocodilebank.org, ruchika@madrascrocodilebank.org

angeline@madrascrocodilebank.org, JuniorVet@madrascrocodilebank.org

ABSTRACT

Research on captive animal care has been mainly focused on mammals and birds, with non-avian amphibians and reptiles considered "non-domesticated"- hardwired for life in nature, not in captivity. Reptile husbandry has since been worked on to master the skill of maintaining these cold-blooded animals in captivity and measures to treat manifesting illness. Through behavioural and physiological assessment of animals, environmental and mental enrichment needed for captive-rearing reptiles has been standardised, changing regularly with new inputs from zoos and reptile keepers. This review is a short brief of current practices, highlighting modern veterinary protocols developed for reptiles.

INTRODUCTION

Animal welfare in zoos and aquaria has through the ages been constantly researched in both husbandry and veterinary aspects, making them institutions rooted in science. With the evolution of veterinary procedures, it was reported 70% of reptile illnesses have been caused due to improper husbandry (Leob, 2018; Azevedo et al., 2021). Therefore, in a zoo environment, basic husbandry, along with related principles of enrichment and education for both physical and mental well-being of reptiles has to be constantly evolving. Below is a comprehensive brief of the current husbandry practices and veterinary protocols for reptiles at MCBT.

HUSBANDRY AND UPKEEP OF CAPTIVE REPTILES

Husbandry of reptiles in captivity is focused on meeting a) primary factors of space, provision of substrate, water and feed; b) secondary factors of UV light, temperature, humidity; c) hygiene, basking/climbing areas, ventilation (Zwart, 2001). A good enclosure must be curated to mimic natural habitat of the species- few key factors to consider when housing and caring for reptiles are summarised with the commercially available products tabulated (Table 1).

Substrate: Choosing a reliable substrate is a key factor in upkeep of reptiles, keeping in mind temperature and humidity required and ease of sterilization (Table 2). With any substrate, a gradient of heat/moisture has to be maintained (Fig 1a and 1b).

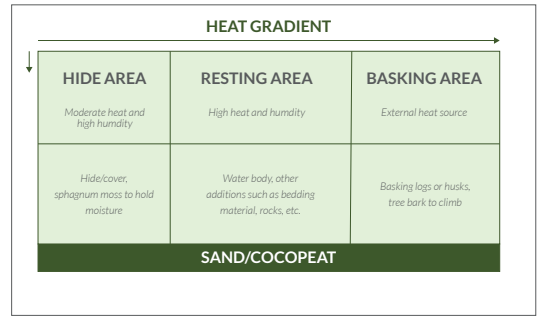


Figure 1a: Enclosure arrangement for a closed sand/coco-peat substrate set-up

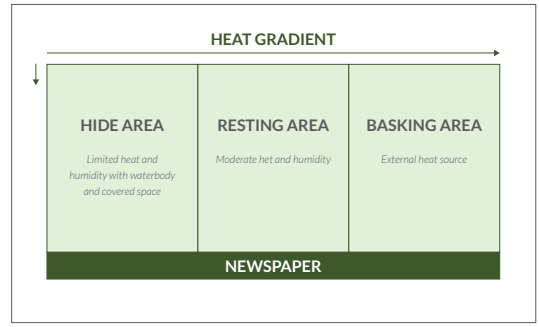


Figure 1b: Enclosure arrangement for a closed newspaper substrate set-up

Care should be taken to not introduce any substrate that can be ingested by the animal. A rough surface such as rocks can be included to enable healthy shedding. Hide spaces should

Table 1. Commercially sold products to enhance reptile care in captivity

APPLICATION	PRODUCT	REMARKS
UV without heat	ExoTerra bubls and tubes, USA	Must be kept at short distance from enclosure
UV with heat	Osram bulbs, Germany	Distance of atleast 90cm from enclosure
Turtle feed	Taiyo	Occasional feed only
Cocopeat and sphagnum moss	Available locally	Has to be washed and sterilised before use
Insects - super-worms/ roaches	Promeal, Bangalore	A culture can be maintained once purchased
Temperature / Humidity monitoring	Onset- HOBO Tidbits, USA Davis weather station, USA	Wireless, bluetooth and USB models to transmit parameters recorded in set intervals.
Hot air oven	Scientific equipment dealer	Other alternatives include boiling with water or microwaving

be constructed to safely extract the animal with no harm to keeper or the individual.

Temperature, humidity and UV: Temperature and humidity, determined by substrate, go hand-in-hand to maintain a habitable enclosure (Table 2). Heat can be maintained by high voltage bulbs and UV bulbs with heating. A good UV bulb for reptiles provides UVA and UVB, UV index required for most captive reptiles has to be regulated with reference to species requirement and photoperiod needed. In open-air enclosures, leafy flora and shade cloth or a constructed den/shed can allow animals to seek shelter to avoid overheating.

FEED PLAN FORMULATION

Formulating feed plan, in addition to providing base feed, has to be designed to provide for extra supplementation that the species ingest in the wild, paying attention to calcium:phosphorous ratio in selection of feed items (Table 3); size and presentation of feed has to be regulated based on animal needs to avoid choking hazards.

Calcium supplementation can be done through commercially available supplements; for chelonians, cuttlefish bone can be introduced which has also proven to reduce the chances of beak or overgrowth.

The feed plan and pattern often varies between juveniles and adults, with the juveniles getting fed more frequently on higher amounts. The feed quantity, though standardised based on animal metabolism, activity and dietary requirements, can vary based on these factors- seasons with

decreased natural UV/temperatures, during mating and nesting season and during ecdysis.
Feed items that need to be frozen should be properly sealed in containers/bags, with proper labelling- date of freezing, type of feed and number of items. For prior thawing (24 hours ahead), feed can be moved from freezer to the fridge; defrosted feed is placed at room temperature for 30 minutes.
For immediate/emergency thawing, feed from the freezer is placed in water until completely defrosted. Once the items are soft (thawed), they are to be placed in warm water before feeding. Precautions to keep in mind when freezing feed: thawed items should not be frozen again. Meat/rats should be frozen only for 4-6 months or less.

ENRICHMENT FOR CAPTIVE REPTILES:

The well-being of captive animals can be a measure of their ability to display natural tendencies, the improvement of mental and physical wellness by stimulation (Howard and Freeman, 2022). The effective of enrichment methods have been shown to vary between
methods have been utilised as olfactory and visual stimuli: shed skins of snakes placed in lizard enclosures, icicles with meat or blood, blood trails, hidden feed in boxes (Table 4).

Table 2. Substrates for reptiles

SUBSTRATE	HUMIDITY	ANIMALS	FUNCTION	STERILITY
Newspaper	None to moderate	Juvenile snakes/lizards Animals undergoing treatment	Easy monitoring of feed/defecation	High- can be removed and cleaned entirely
Sand/dry cocopeat	Moderate, can be increased using plants/moss, requires less external heat	Dry climate snakes- cobras, saw-scaled and Russell's viper, sand boas	Mimics natural environment, enables burrowing.	a) daily spot cleaning b) heat sterilisation in a hot air oven c) replacement, frequently for animals with high-feed/defecation rate (juveniles) and less frequently for adults.
Wet cocopeat	High, requires extrenal heat	Skinks, kraits	Good for humidity and moisture loving species.	
Predominantly aquatic	-	Juvenile turtles, monitors	Varying depths of water and sandy bottom for burrowing, dry space for climbing/basking.	Periodic replacement of water, sand and basking logs (or other items).

Table 3: Feed plan for reptiles

ANIMAL	DIET	PROPORTION
Herbivores Lizards/ tortoises	Greens, fruits, vegetables	90:10:20
Omnivores or Scavengers	Protein source fish, chicken or organ meat, boiled/raw eggs, rat pinkies	10-20% of total meat
	Supplementary gut-loaded insect diet	Based on requirement
Strict insectivores	Gut loaded, calcium dusted insects	100
Turtles	Fish, greens/vegetables	80:20
	soya chunks and commercial feed	occasional supplement
Carnivores	Fish, chicken and organ meat	100

Table 4: Olfactory and visual stimuli for reptiles at MCBT

STIMULI	BEHAVIOUR	ANIMAL
Snake shed	Curious or defensive/ territorial	Skinks, other snakes, Varanids
Wiffle balls with live insects	Head shaking, efforts to obtain feed as seen in the wild	Skinks
Live insects/ fish	Visual stimuli to catch moving prey	Juvenile crocodiles, turtles
Controlled basking with or without conspecifics	Curiosity, new olfactory stimulus	Snakes
Cardboard box with feed	Foraging and scavenging, mimic of tearing through large prey	Varanids
Scent trails with bloodied water from soaking/thawing meat	Hunting and predation instincts triggered	Varanids

REPRODUCTIVE BIOLOGY IN THE REPTILIA AS IT RELATES TO CAPTIVITY

Development of the hatchling (egg laying = oviparous reptiles) and foetus (live bearing = viviparous reptiles) begins within the female, with eggs taking a fair amount of time to pass through the oviducts. Embryonic development does occur at this time, facilitated by favourable temperatures, the ability to exchange respiratory gases, ways to expel nitrogenous waste, and a source of water. Therefore, at the time of egg laying, reptile embryos are in a varied stage of organogenesis. Chelonians and crocodilian eggs have not passed the stage of gastrulation. Lizards and snakes (Squamates) are usually several embryonic stages further developed (Packard et al. 1977).

With regards to the female with her compliment of two (in geckos) to over a 100 (sea turtles), nutrition, the ability to thermoregulate, cage design, and cage mates, amongst other factors are crucial factors to consider particularly in a captive environment.

Closer to the period of egg laying, a number of "unusual" behaviours are observed, including upside down basking in rock python females (also described in the Childrens python, Sonneman, 2000). Hole nesting crocodiles (the gharial and mugger crocodile in India) will dig test holes (Lang et al. 1989), prior to laying their eggs. Amongst chelonians, Travancore tortoise females at MCBT have been seeing digging "fake" nests; an excavation is made into the substrate and is then covered without the laying of eggs.

Eggs, incubation, and monitoring development:

There are essentially two different modes of reproduction in reptiles: viviparous (live-bearing, as in Russel's vipers) and ovoviviparous (egg-laying). This review is restricted to discussing ovoviviparous reptiles, readers interested in the evolution of viviparity from oviparity are directed to the works of Andrews & Mathies (2000), Blackburn (1992), amongst others. Reptile eggs can be found underground, as in crocodiles and chelonians (Köhler, 2005), under bark/rocks, as could be the case of geckos, and even underwater, as has been described for crowned river turtles (Hardella thurjii; Basu, 1998).

Reptile eggs are laid at various stages of development, lizards and snakes being the most advanced. Upon candling, within the first day, vasculature is visible through an illuminated light source (Fig.2; Table 5). Incubation periods vary considerably, with some species of turtles taking only 55-60 days to hatch (Red-crowned roof turtle and three striped roof turtle), to sometimes over a year (Ganges softshell turtle; Whitaker, 2000). Temperature and humidity are primary factors that allow the development of viable eggs from laying to hatching. The transfer of eggs from the enclosure to the incubation lab is detailed below:

i. Nests are located by loose soil, roots broken by the female, and sand on nearby low-lying vegetation (caused by the female's excavation process).

ii. Once located, eggs are carefully removed, and horizontal orientation is maintained; at the time of collection, it is necessary to mark the uppermost surface with a small "x."

iii. Once removed, eggs are placed in Tupperware trays and carefully taken to the lab for processing.

iv. Once at the lab, eggs are given a unique ID number, length, width, and weight are measured, and viability determination is

attempted.

v. Eggs are then placed in Tupperware containers with small holes for ventilation, and it is essential to include a temperature and humidity meter. These instruments come in various price ranges, and Hobo TM produces accurate temperature thermometers. Substrates we have found to work well are soil material from the nest site itself, vermiculite, and coco-peat.

Monitoring the development of eggs: Some species of geckos and snakes (in particular, the pythons) may lay " glued " eggs to one another. The best way to deal with these clutches is not to attempt separation until one or more eggs appear infertile or have ceased development. They will appear brown, be hard in texture, and have a foul-smelling liquid on the egg's surface, as compared to healthy well-developed eggs which are pearl white and turgid (not shrunken; see Fig. 3.). At this stage, chicken egg albumen can be poured in small amounts over the area where the eggs are connected, and the affected egg is gently pried loose with tweezers.

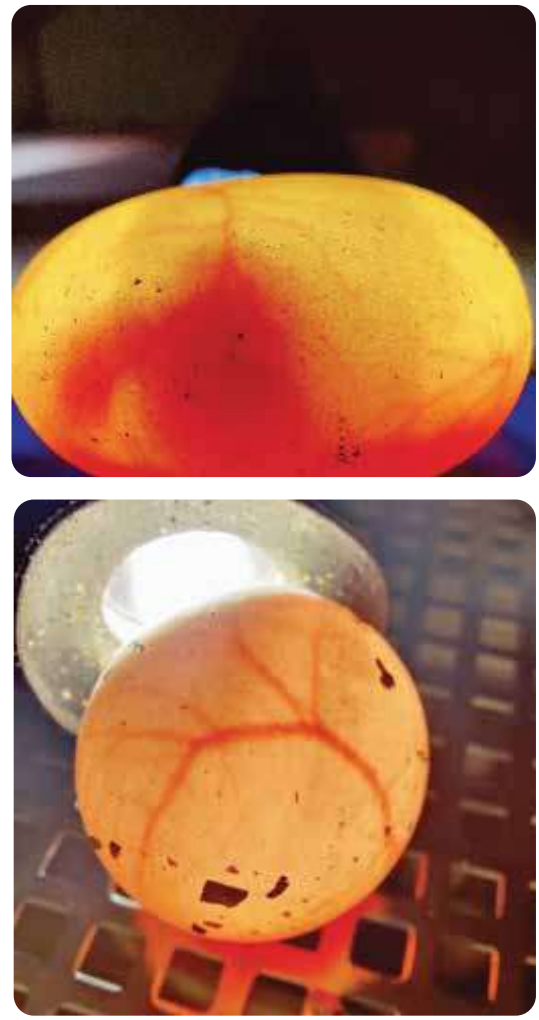


Figure 2. Healthy, developing eggs of the black pond turtle (Melanochelys trijuga) and flap shell turtle (Lissemys punctata) as observed before a focused candling light

Table 5 : Select incubation regimes and incubation periods of reptiles observed at MCBT

SPECIES	EGG LAYING PERIOD	INCUBATION TEMPERATURE/HUMIDITY	INCUBATION PERIOD
Gharial	February to May	28-33 C, 90%	65-90 Days
Red crowned roof turtle	December to April	26-31 C, 90%	55 - 60 Days
Water monitor Lizard	April to May	27-32 C, 90%	150 - 300 Days
Trinket snake	August	26-27 C, 80%	55 Days

Figure 3. Infertile (left) and fertile (right) trinket snake eggs; note the brown discoloration in the infertile egg

Figure 4. A female Indian rock python coiled around her clutch of eggs

Parental care: Reptiles show varying degrees of parental care (of both nest sites and offspring), ranging from none in most chelonians (an exception is the Impressed tortoise, which makes a mound nest and defend it, Das, 2002). Conversely, there is very active defence of the nest site by saltwater crocodiles and their allys. Egg collection from saltwater crocodile enclosures needs to be planned carefully, with at least three keepers entering the enclosure to collect the eggs; one to open the nest and collect the eggs, and two people watching the female. Females may leave the nest site after an initial prodding with a long stick, but they will usually return to the nest site. Caution is required. Rock python females will coil around their eggs, presumably to protect them and also use thermogenesis by shivering (Ramesh & Bhupathy, 2010), to raise egg temperatures, and maintain stability of clutch temperature (Fig.4). In some situations, it may be necessary to take the eggs away from the python, two people can gently do this, once gently unravelling the mother from the eggs, and another person carefully collecting the clutch en mass making sure the clutch stays in the same orientation.

Hatching: Once incubation is complete, the process of hatching occurs. Hatchlings must leave the egg soon after hatching, as they need to start breathing atmospheric oxygen. Some reptiles like tortoises and turtles, like to stay within the egg for a period of 2-3 days following hatching, to absorb the nutritive portion of the energy (the yolk; Fig.5). Others such as monitor lizards are ready to burst from the egg within minutes of hatching (Fig.6). Some eggs may not hatch as embryos have died early in incubation, or close to the hatching state. Others may need assistance in emerging. Common causes include improper arrangement of the egg contents, for example the umbilical cord being wrapped around the snout in crocodiles, and weaker reptile hatchlings not being able to pierce the egg shell. It is not uncommon to have particularly in first time breeders, a large percentage of infertile eggs.

Figure 5. A Travancore tortoise (Indotestudo travancorica) hatchling; external yolk can take up to three days to be absorbed.

Figure 6. A water monitor (Varanus salvator) hatching after a period of 215 days incubation; incubation is long and highly variable in monitors.

ANIMAL CARE IN CONSERVATION EDUCATION

At MCBT, conservation education has been focused on creating awareness of conservation and animal care, aiming to use modern methods with no stress imparted to animals. Education with virtual animals- virtual reality (VR) acts as a "mobile zoo" enabling the educators to take the virtual reptiles to the schools. Nelson et al., 2020 state that VR was shown to increase empathy, moving people to contribute to environmental causes. A simple analysis of the pre-session and post-session surveys conducted for 800+ students who participated in the outreach programs this year revealed that 90.44% showed an improved understanding of reptiles and their significance.

VETERINARY CARE IN CAPTIVE REPTILES

Clinical nutrition: Basal metabolic requirement (BMR) is the amount of energy a body requires necessarily to function, specific to species and age. For example, young, growing and sick animals require more energy compared to healthy individuals. Reptiles during illness lose more than 10% of their body weight rapidly, more than 20% of their body weight slowly or the ones that are unable to self-feed ingest at least 85% of their BMR (Divers, S. J. & Stahl, S. J., 2018). They need to be supported nutritionally either by change in feeds, critical care formulas, commercial diets, hand feeding, force – feeding or re – feeding enterally or parentally. In reptiles, most health problems arise due to improper care in terms of poor feeding management, including inappropriate foods which cause undernutrition and malnutrition. Nevertheless, reasonable

estimates of calorie and nutrient intakes, with advice on appropriate foods, can be made from published information based on observations of these species in the wild, from extensive data on species with analogous feeding habits, and from practical feeding experiences with captive reptiles (Scott P.W., 1992; Baer D.J., 1994; Allen M.E. & Oftedal O.T., 1994; Donoghue S. & Langenberg J., 1996; Zentek J. & Dennert C., 1997).

Metabolic rates and calorie intakes relate to body size, physiological status and activity. Daily energy requirements for a reptile are calculated with the formulae, 32 X (B.W) 0.77 Kcal/day (Donoghue S., 1998; Donoghue S., 1999). For the reptiles which are fed on a weekly basis the requirements are calculated for a week, hence multiplied by seven. Energy requirements are met only through the feed source and not water. It is essential to consider energy per gram of a feed for meeting the requirements. Further, with these fractional increases of the metabolic rate needs to be taken into consideration depending on the species.

Diagnosis:

Tests: As captive wild animals are threatened by infectious diseases it is always necessary to run routine diagnostic tests to achieve goals in health and welfare of captive wildlife. It also gives us an insight into the overall health of animals especially the ones maintained in large numbers. At our facility we test various samples from our reptile fauna to assess their health condition and treat them accordingly; presence of pathogens is estimated both quantitatively and quantitatively (Table 6). We use both invasive and non-invasive sampling methods to obtain samples from our animals. The non-invasive samples include faeces, urine, copulatory plugs, shed skins, etc. while invasive sampling includes blood collection, cloacal swabs, etc. Apart from this, routine samples from the enclosure environment (water, substrates) are being collected regularly. Feed testing gives an additional information on the overall wellbeing of animals.

The analysis of corticosterone (CORT), the main glucocorticoid in reptiles, via blood or faeces provides an index of hormone concentrations over a relatively short period.

Blood: In case of reptiles, blood collection is generally a blind technique. Quantity of blood collected in reptiles often varies based on the age, gender, species, environment, temperature, nutrition, breeding status, hibernation, and disease status. Appropriate syringe – needle combination aids in collection of required blood amount. This becomes important to consider due to low blood pressure, slow heart rate, and large but relatively sturdy osmotic nature of blood cells in reptiles. Ideally, the blood volume in reptiles is 5-8% of their body weight and 10% of the total blood volume of a healthy individual can be collected (Jenni J., 2012; Allender, M.C. & Fry, M.M., 2008; Divers S.J., 2019). Therefore, approximately 1 ml of blood can be collected from an animal weighing 100 gm but the quantity reduces to half for a debilitated animal. Most reptiles typically require 22-24 G needles, though the needle size may vary between 1.5–2 inch depending on the size of the animal. Lithium heparin is used as a default anticoagulant as chances of blood cell lysis have been recorded by using ethylenediaminetetraacetic acid (EDTA) particularly in chelonians (Dessauer, H.C., 1970; Harr, K.E., et.al., 2005; Dyer S.M. & Cervasio E.L., 2008; Divers S.J., 2019;

Campbell, T.W., 2022). In case of chelonians ideal venepuncture site is the jugular vein as lymph contamination is less common. But the drawback with this site is that the head needs to be restrained which may lead to stress and injuries. Hence, sub-carapacial venous sinus and caudal veins being most accessible are preferred, but needs to be carefully done to prevent lymph contamination, vascular laceration and prolapses. In snakes, caudal veins are the ideal site but structures like hemipenis and scent glands can be avoided by utilizing the caudal 75% of the tail during caudal vein venipuncture. Intra-cardiac route site in snakes is not preferred due to potential cardiac damage it might cause to the animal. In lizards, the caudal or ventral tail vein is the primary vessel utilized for venipuncture whereas in the crocodiles supraoccipital sinus or ventral tail vein are the preferred site for blood collection. The blood samples collected are subjected to tests which include analysing blood smears and for assessing haematological parameters and serum biochemical parameters. The blood smears are usually stained using Wright- Giemsa stain, and Differential quick stains. The RBC and WBC are estimated manually using the Natt and Herricks method and other parameters are may be estimated using IDEXX ProCyte Dx for haematology and Catalyst One for biochemistry. The standardisation of biochemistry parameters like cardiac function tests, progesterone, thyroid function tests, etc. for different reptile species becomes an important part of a reptilian zoo due to very limited established literature for the taxa.

Faeces:Routine faecal examination aid in assessing the reptile's health and is front liner for diagnostics. Unlike mammals in reptiles' faecal samples are usually collected from the substrates and water ponds therefore the contamination risk of these samples is usually high. Thus, having a standardized practice and protocol to check the subsequent sample and cloacal swabs in case of detrimental organisms is essential to avoid false positive results. The prescribed standardized procedures of sedimentation and floatation to detect parasitic ova/oocysts in a sample are being followed. Faecal microbiota is usually examined by fixed smears stained by Lugol's iodine, Grams stain and Acid-fast stains.

Other samples: Apart from faeces and blood which form the major part of routine diagnosis, other body fluids secretions and excretions analysis are important. For example, skin sheds can be examined for fungal organisms and external parasites while the copulatory plugs help in analysing the spermatozoa. Feed sample monitoring forms the basis to assess the quality of the feed that has been fed to animals. It includes gross examination, taking impression smears of the cut sections, faecal samples of the prey animals to estimate the parasite load thereby preventing infections through an indirect life cycle, herbivores and insect feed sample analysis, etc. Enclosure substrate and water samples monitoring helps in identifying organisms having direct life cycles and after confirmed diagnosis eliminating them by choosing the right disinfection protocol.

SAMPLE TYPE	TESTS PERFORMED
Blood	· Blood smear- Wright and Giemsa, Differential quick Staining · Whole Blood- CBC · Serum- Biochemical parameters
Faecal sample	· Whole Faeces- Direct smear, Floatation, Sedimentation · Faecal smears- Grams stain, Acid Fast Staining
Feed	· Meat samples- Impression smear of the organs that are stained with Grams and Differential quick · Prey samples- Faecal samples that undergo the same parasitological examinations as above · Plant and fruit samples- Impression smear in Grams and Acid fast, and parasitological examinations
Substrate/ water	· Parasitological examination-Floatation, sedimentation ·Microbiological examination- Grams, Diff quick, and acid-fast staining
Skin sample	· Skin scraping examination
Copulatory plug	· Direct and Eosin staining to visualize live spermatozoa

Minimal invasive diagnostic imaging

It includes radiography (X-ray) and ultrasonography. Since years, they have proved to be effective tools for diagnosing illness in animals. Both techniques provide useful information about a range of common problems that can cause emergency situations, including trauma, dystocia, circulatory collapse, pericardial effusion, etc. and can be undertaken without anaesthesia in most cases, thereby minimizing stress to the reptiles.

A) Digital Radiography: Radiology is an important diagnostic method for evaluation of gravid status, as well as skeletal and tissue structures of reptile. It even helps to analyse the development inside the egg, movement of eggs insitu, development of ovoviviparity at various stages. The anatomical and physiological characteristics of reptiles differ, hence the accepted principles used to interpret mammalian radiographs must be modified in interpretation of radiographs of reptiles. In larger reptiles due their osteoderms high frequency digital radiography is preferred. With DR the image is converted to digital data in real-time and is available for review within seconds. It provides a high definition wireless output in as quick as five seconds, consequently improving diagnosis because more images can be taken and processed in the small amount of time.

B) Ultrasonography: Ultrasonography can be used to investigate soft tissue masses thus, enabling differentiation between neoplastic processes, inflammatory reactions, fluid accumulations and follicular stasis; it should be adapted to the special requirements of the reptiles due to variation in the integument structures. Requirement of different transducers play essential part due to morphological and physiological variations. One of the important applications of it is in pregnancy diagnosis, thereby helping us to understand the stage of follicular development. Echocardiography plays an important role for assessing the heart conditions of the reptiles and standardizing the parameters in reptiles is the utmost priority. Whenever possible, each organ should be scanned in two planes: usually transverse and sagittal/longitudinal; oblique scanning is even preferred. Better images are obtained if the skin is moistened with warm water before the application of coupling gel as it improves the contact. Moreover, in reptiles water even serves as the best medium for ultrasonography. An examination glove filled with warm water can particularly be used as a medium especially in chelonians as it can easily conform to the desired shape. Ideally, ultrasonography over animals under ecdysis will not serve the purpose due to the poor penetration of sound waves because of air trapped between the skin layers.

Invasive diagnostic imaging

A definitive diagnosis is important to maximize treatment success, but reptile cases are frequently mismanaged simply because of a failure to identify a specific problem and provide precise treatment. Tissue samples offer the most expedient means to definitive diagnosis, and endoscopy offers an ante-mortem method to collect such material. The use of endoscopy helps to examine or retrieve foreign objects from the gastrointestinal tract, along with case descriptions of coelioscopy, bronchoscopy and urogenital endoscopy. In particular, validation of endoscopy/laparoscopy procedures in reptiles for explorative diagnostics, gender

identification under minimal anaesthesia with minute operative procedures have helped confirm the safety and diagnostic value of this approach.

Necropsy: Necropsy is important as it will provide more insight into the death of the animal and will prevent future mortalities. It will also help us learn the unique anatomy of these under-studied groups. In a captive setup, a necropsy should be done as soon as possible to prevent contamination from environmental pathogens which are collectively high in this group as most of them are housed in predominantly water enclosures; in general, it's very difficult to get fresh dead specimen. With dissecting and harvesting the organs to obtain samples, impression smears of the organs are obtained that are stained with Gram's, Differential quick, and Acid-fast staining to identify pathogenetic organisms. In cases of animals observed to be in an autolyzed state, a necropsy is ignored to prevent false positive results. Samples are preserved according to prescribed format either in 10% formalin, ethanol, -20 degree Celsius, 4 degree Celsius, etc.

THERAPY

Deworming: Deworming in captive wildlife is essential for removing internal and external parasites. Although this is routinely followed in other taxa, in reptiles it is significant to see that dewormers usually cause wide range of pathology in higher doses (Boyer, 1992; Donald, 2005; Rivera, 2016). Therefore, caution needs to be exercised when deworming and should only be done in case of established worm-loads. The established parameters might vary across zoos due to several factors like individual immunity, environment, substrates, husbandry, etc. Presence of internal parasites as common commensals in reptiles is proven (De la Navarre B., 2008; Rataj. et. al., 2011; Šlapeta J. et. al., 2017; Valolahti A. V., 2022) hence any treatment should be administered only with the initiation of clinical manifestations. Common parasitic drugs used are fenbendazole, pyrantel, praziquantel and metronidazole depending on the type of parasites.

Fluid administration: Fluid therapy is an important component for managing animals of any taxa. However, the management of fluid therapy in reptiles differs as their dehydration status is difficult to ascertain in reptiles visually and with skin turgor (Divers, S. J. & Stahl, S. J., 2018; Mitchell, 2014). Packed cell volume is a good indicator of assessing dehydration in reptiles but variation within species needs to be considered and always correlated with the physical examination (Mitchell M.A., 2014). Fluid therapy should depend on the type of dehydration encountered in the reptile as it will influence the volume and type of fluid to be given to the reptile. The fluids commercially available usually tend to be aligned to the osmolarity of mammalian counterparts and therefore caution is exercised when used in reptiles due to their varied anatomy and physiological mechanisms including the difference in plasma osmolarity (Divers, S. J. & Stahl, S. J., 2018). The maintenance fluid rates of reptiles vary between 10-15ml/kg/day (Divers, S. J. & Stahl, S. J., 2018). Additional dehydration deficit is also warranted for correction and is replaced over a 72-96-hour period (Mitchell M.A., 2014). In general, Dextrose 5% in dilution along with Ringer's Lactate is a fluid of choice because of the

variation in osmolarity. DNS is contraindicated for use in reptiles. Fluid therapy should be done in warmer environment as the metabolic rates in reptiles go very low during debilitated conditions.

Drug administration: Drug administration in reptiles is achieved by various invasive and non-invasive methods. The invasive methods of administration include enteral (oral and cloacal) and injectables (Divers, S. J. & Stahl, S. J., 2018). Non-invasive methods of administration include medicines in feed, water, nebulization, and topical routes. Other less frequent routes include intrathecal, intralesional, and transdermal therapy (Sykes IV, J. M. & Greenacre, C. B., 2006). Nebulization proves to be effective in critically ill reptiles. Although most drug formulations are available commercially for domestic animals they should be segregated according to the given size and weight of the animals. Large animal boluses might come in handy for larger crocodiles and smaller reptiles might benefit more from small animal formulations. In case of using unfamiliar or unknown drugs that have no reference ranges to be used in reptiles allometric scaling can be used to correlate to calculate and arrive at the needed dosage to treat (Divers, S. J. & Stahl, S. J., 2018).

Well-known animal dose / Well-known animal MEC = Patient dose / Patient MEC,
where MEC is the Minimum Energy Cost = K x Bodyweight 0.75

K = 10 reptiles, K = 49 marsupial mammals, K = 70 placental mammals, K = 78 non-passerine birds, and K = 129 passerine birds.

BIOSECURITY

Reptiles have been documented to carry many potential pathogens that, under the right conditions, can cause infections in humans; however, the recovery of such an organism from the reptile does not mandate that the pathogen will be passed to the human and cause disease (Mitchell M.A., 2011). Potential pathogenic zoonotic agents have been identified in the reptiles. Biosecurity plays a vital role in preventing disease transmission to maximum extent. Effective sanitation and fumigation of the hospital and equipment every time after use helps to control bio hazards. In general, with response to spread of diseases in between different taxa, handling of animals is being taken care of in following order Snakes – Lizards – Crocodiles – Chelonians, as chelonians being vector of potential diseases, they are handled at the last. Moreover, sick or critically ill reptiles are treated at the last to prevent possible spread of infection. Similarly, management of young/neonatal reptiles is considered as priority before handling juveniles, sub-adults or adults. Personal hygiene plays important role while handling reptiles, therefore, use of sanitizers should be encouraged before touching different reptiles. Bio-waste management forms a crucial part of it. Segregation of bio-waste at the hospital premises and wherever essential in the zoo, pertains to methodological waste disposal by govt. recognized bio-waste agencies. Waste segregation into different colour coded bags specific for a procedure of disposal should be meticulously followed at the zoo as per the guidelines given.

CONCLUSION

The captive care of reptiles is a dynamic field with constant animal well-being assessment and subsequent husbandry and veterinary means to ensure comfortable not living in wild captivity. Progresses in reptile care with contributions from several reputed members in the field of herpetology will help Indian zoos striving to achieve world-class practices in zoo upkeep. As a Centre for Herpetology, MCBT aims to enrich and sustain research and development toward the betterment of reptiles in captivity, contributing to conservation of their wild counterparts.

ACKNOWLEDGEMENTS

We would like to extend our gratitude to the Trustees of the Madras Crocodile Bank Trust for encouraging us at every step. Our sincerest thanks to Romulus Whitaker, Ajay Katik (Greens Zoological Rescue and Rehabilitation Center), Gerry Martin and Lisa Gonsalves (The Liana Trust), Adam Radovanovic (Birmingham Wildlife Conservation Park), Benjamin Tapley (Zoological Society of London) for their invaluable husbandry inputs and continual support. We are grateful for the veterinary suggestions of Dr. Paolo Martelli (Ocean Park), Dr. Sally Isberg (Centre for Crocodile Research), Dr. Cathy Shilton, (Berrimah Veterinary Laboratory), Dr. Kelsie Stovall (Naples Zoo), Dr. Sridhar (TANUVAS), Matthew Shackleton (Shackleton Veterinary Physiotherapy). Special thanks to our Zoo Educator, Timple Madhumitha D, for her contributions to this review. The practices mentioned in this paper were brought to fruition and diligently implemented with the support of our animal keepers. The purchase and use of equipment for our reptiles was made possible through the funding given through Coromandel International Ltd.

REFERENCES

Allen, M. E., & Oftedal, O. T. (1994). The nutrition of carnivorous reptiles. Captive management and conservation of amphibians and reptiles, 11, 71-82.

Allender, M. C., & Fry, M. M. (2008). Amphibian hematology. Veterinary Clinics of North America: Exotic Animal Practice, 11(3), 463-480.

Andrews, R.M. & Mathies,T. (2000). Natural History of Reptilian Development: Constraints on the Evolution of Viviparity. BioScience. 50(3), 227–238.

Azevedo, A., Guimarães, L., Ferraz, J., Whiting, M., & Magalhães-Sant'Ana, M. (2021). Pet reptiles—are we meeting their needs?. Animals, 11(10), 2964.

Baer, D. J. (1994). The nutrition of herbivorous reptiles. Captive Management and Conservation of Amphibians and Reptiles. Contributions to Herpetology, 2, 83-90.

Bashaw, M. J., Gibson, M. D., Schowe, D. M., & Kucher, A. S. (2016). Does enrichment improve reptile welfare? Leopard geckos (*Eublepharis macularius*) respond to five types of environmental enrichment. Applied animal behaviour science, 184, 150-160.

Basu, D. (1998). Female reproductive cycle in *Hardella thurjii* Gray from northern India. Hamadryad 22, 95-106.

Blackburn, D.G. (1992). Convergent Evolution of Viviparity, Matrotrophy, and Specializations for Fetal Nutrition in Reptiles and Other Vertebrates. American Zoologist. 32(2), 313–321.

Boyer, D. M. (1992). Adverse ivermectin reaction in the prehensile-tailed skink, *Corucia zebrata*. Bulletin of the Association of Reptilian and Amphibian Veterinarians, 2(2), 6-6.

Campbell, T. W., & Grant, K. R. (2022). Exotic

animal hematology and cytology. John Wiley & Sons.

Das, I. (2002). A photographic guide to snakes and other reptiles of India. [U.S. edition.] Sanibel Island, Florida: Ralph Curtis Publishing, Inc.

De la Navarre, B. (2008). Common parasitic diseases of reptiles and amphibians. CVC in San Diego proceedings.

Dessauer, H. C. (1970). Blood chemistry of reptiles: physiological and evolutionary aspects. Biology of the Reptilia, 3(1), 1-72.

Divers, S. J. (2022). Clinical Procedures for Reptiles. MSD Veterinary Manual

Divers, S. J., & Stahl, S. J. (Eds.). (2018). Mader's reptile and amphibian medicine and surgery. Elsevier Health Sciences.

Divers, S.J. (2019). Diagnostic techniques and sample collection. In: Mader's Reptile Medicine and Surgery (eds. S.J. Divers and S.J. Stahl), 405–421. St. Louis: Elsevier Inc.

Divers, S.J. and Stahl, S.J. (eds.) (2019). Mader's Reptile Medicine and Surgery. St. Louis: Elsevier Inc.

Doneley, B., Monks, D., Johnson, R., Carmel, B., & Wiley, J. (Eds.). (2018). Reptile medicine and surgery in clinical practice (pp. 425-439). Oxford, UK: Wiley Blackwell.

Donoghue, S. (1998, July). Nutrition of pet amphibians and reptiles. In Seminars in Avian and Exotic Pet Medicine (Vol. 7, No. 3, pp. 148-153). WB Saunders.

Donoghue, S., & McKeown, S. (1999). Nutrition of captive reptiles. Veterinary Clinics of North America: Exotic Animal Practice, 2(1), 69-91.

Dyer, S. M., & Cervasio, E. L. (2008). An overview of restraint and blood collection techniques in exotic pet practice. Veterinary clinics of North America: exotic animal practice, 11(3), 423-443.

Eric, K. (2008). Reptile Nutrition. American Association of Zoo Veterinarians Conference Proceedings.

Gary, C., Packard, C., Tracy, R., & Roth, J. (1977). The physiological ecology of reptilian eggs and embryos and the evolution of viviparity within the class Reptilia. Biological Reviews. 52, 71 – 105.

Gibbons, P. M. (2009, October). Critical care nutrition and fluid therapy in reptiles. In Proceedings of the 15th Annual International Veterinary Emergency & Critical Care Symposium (pp. 91-94).

Graham, J. E., Doss, G. A., & Beaufrère, H. (Eds.). (2021). Exotic Animal Emergency and Critical Care Medicine. John Wiley & Sons.

Harr, K. E., Raskin, R. E., & Heard, D. J. (2005). Temporal effects of 3 commonly used anticoagulants on hematologic and biochemical variables in blood samples from Macaws and Burmese pythons. Veterinary Clinical Pathology, 34(4), 383-388.

Howard, D., & Freeman, M. S. (2022). Overlooked and under-studied: a review of evidence-based enrichment in Varanidae. Journal of Zoological and Botanical Gardens, 3(1), 32-43.

Jenni, J.P. (2012). Hematologic Evaluation of Reptiles: A Diagnostic Mainstay.

Kirkwood, J. K. (1991). Energy requirements for maintenance and growth of wild mammals, birds and reptiles in captivity. The Journal of nutrition, 121, S29-S34.

Köhler, G. (2005). Incubation of Reptile Eggs: Basics: Guidelines: Experiences. Krieger Publishing Company, Malabar, Florida. Pp 214.

Lang, J. W., Andrews, H. & Whitaker, R. (1989). Sex determination and sex ratios in Crocodylus palustris. American Zoologist. 29 (3), 935 – 952.

Loeb, J. (2018). Reptile illness is caused by bad husbandry. Vet. Rec, 183, 581.

Lyman Jr, R. A. (1945). The anti-haemolytic function of calcium in the blood of the Snapping turtle, *Chelydra serpentina*. Journal of Cellular and Comparative Physiology, 25(1), 65-73.

Mader, D. R. (Ed.). (1996). Reptile medicine and surgery (pp. xx+-512).

Mader, D. R., & Divers, S. J. (Eds.). (2013). Current therapy in reptile medicine and surgery. Elsevier Health Sciences.

Melissa, K. (2000). Basal Metabolic Requirements for Reptiles.

Mitchell, M. A. (2011). Zoonotic diseases associated with reptiles and amphibians: an update. Veterinary Clinics: Exotic Animal Practice, 14(3), 439-456.

Mitchell, M. A. (2014). Drink up! Fluid therapy for reptiles. 20143185521.

Music, M. K., & Strunk, A. (2016). Reptile critical care and common emergencies. Veterinary Clinics: Exotic Animal Practice, 19(2), 591-612.

Neiffer, D. L., Lydick, D., Burks, K., & Doherty, D. (2005). Hematologic and plasma biochemical changes associated with fenbendazole administration in Hermann's tortoises (*Testudo Hermani*). Journal of Zoo and Wildlife Medicine, 36(4), 661-672.

Nelson, K. M., Anggraini, E., & Schlüter, A. (2020). Virtual reality as a tool for environmental conservation and fundraising. Plos one, 15(4), e0223631.

Ramesh, C. & Bhupathy, S. (2010) Breeding biology of *Python molurus molurus* in Keoladeo National Park, Bharatpur, India. Herpetological Journal. 20,157–163.

Rataj, A. V., Lindtner-Knific, R., Vlahović, K., Mavri, U., & Dovč, A. (2011). Parasites in pet reptiles. Acta Veterinaria Scandinavica, 53, 1-21.

Rivera, S. (2016). Novel medications for reptiles: the latest and greatest.

Scott, P.W. (1992). Nutritional diseases. In Beynon PH (ed): Manual of Reptiles. Gloucestershire, British Small Animal Veterinary Association. pp: 138-152

Šlapeta, J., Modrý, D., & Johnson, R. (2017). Reptile parasitology in health and disease. Reptile medicine and surgery in clinical practice, 425-439.

Sonnemann, N. (2000). A breeding history of a captive Children's python (*Antraesia childreni*). Journal of the Victorian Herpetological Society. 11 (1), 6-8.

Stacy, N. I., Alleman, A. R., & Sayler, K. A. (2011). Diagnostic hematology of reptiles. Clinics in laboratory medicine, 31(1), 87-108.

Sykes IV, J. M., & Greenacre, C. B. (2006). Techniques for drug delivery in reptiles and amphibians. Journal of Exotic Pet Medicine, 15(3), 210-217.

Valolahti, A. V. (2022). Prevalence of internal parasites in pet and zoo reptiles in Estonia (Master's thesis, Eesti Maaülikool).

Whitaker, N. (2000). Incubation of the Ganges soft shell turtles (*Aspideretes gangeticus*) eggs and long-term sperm storage in females. Hamadryad. 25(2), 198 – 200.

Wilkinson, S. L. (2015). Reptile wellness management. Veterinary Clinics: Exotic Animal Practice, 18(2), 281-304.

Zentek, J., & Dennert, C. (1997). Feeding of reptiles: practice and problems. Tierarztliche Praxis. Ausgabe K, Kleintiere/heimtiere, 25(6), 684-688.

Zwart, P. (2001). Pathophysiology: Assessment of the husbandry problems of reptiles on the basis of pathophysiological findings: A review. Veterinary Quarterly, 23(4), 140-147.

17

Dimensions/ Measurements of rescued leopards *(Panthera pardus fusca)* maintained at Satellite Rescue Facility for Leopards at Greens Rescue and Rehabilitation Centre, Jamnagar

[1]Dr. Ankush Dubey, [1]Dr. Navnath Nighot, [1]Dr. Jorge, [1]Shubham Chhapekar, [1]Jerald V. Lobo, [1]Naman Dani and [1]Dr. Ajay Deshmukh

Greens Zoological Rescue and Rehabilitation Centre, Jamnagar, Gujarat 361280

Email: gzrrc@outlook.com

INTRODUCTION

The phenotypic characterization through morphological studies is a useful tool to understand the age group, sex, growth rate and general health condition of animal. These have proved to be helpful in determining determininge the taxonomic connections between different species (Werdelin, 1987; Caumu and Polly, 2005) and the osteological indicators like forelimb to hindlimb ratios can help in revealing changes in locomotor and predatory behavior (Gonyea, 1976; Anyonge, 1996).

The present study aims to characterize important bodily measurements of the leopard that would help in developing baseline information and form a good reference.

MATERIALS AND METHODS

Examination of Leopard morphometry: The body weight and the detailed body measurements of leopards were recorded following immobilization of the animal at Satellite Leopard Rescue and Rehabilitation Centre under Green Zoological Rescue and Rehabilitation Centre (GZRRC), Jamnagar, Dist Gujarat, India. The complete procedure of measure was performed in about 10 minutes, recording the respective body measurements and ascribe recording of the data.

i. Body weight: The leopards were weighed on an electronic scale to the nearest 0.5 kg. The scale consisted of a metal platform rested on two electronic pressure cells connected to an electronic head, powered by battery (M. POLO Digital scale, Model - PET 208, Class - III).

ii. Body length: Body length was measured with a measuring tape (fiber made) from tip of the nose, over the nose, following a central line between the eyes over the head – along the contours of the body (linea mediana dorsalis) to tip of the last sacral vertebra (bony tip of the tail, excluding the tail tuft).

iii. Tail length: Tail length was measured from proximal base of the tail, to tip of the last caudal vertebra (tail), as described for body length (Plate 2.1).

iv. Neck girth: The circumference of the neck, was recorded by using the standard measuring tape (Plate 2.2).

v. Chest girth: A standard measuring tape was used to note down the circumference of chest, immediate caudally to the front limbs, just behind the margo tricipilatis muscle from above the thorax (Plate 2.3).

vi. Abdominal girth: The circumference of abdomen, immediate cranially to the hind limbs was taken into account for measurement.

vii. Forelimb length: The front leg length from the elbow (tip of the olecranon process) to tip of the longest (third) digit, without the claw (sine unguis) was considered for morphometric analysis (Plate 2.4).

viii. Forelimb circumference: The widest proximal part of forelimb (just below the elbow joint) was measured for reading.

ix. Hindlimb length: The hind foot length was measured from the heel (tip of the calcaneous) to tip of the longest (third) digit, without claw (sine unguis) (Plate 2.5).

x. Front and hind paw length: The distance from

the posterior part of the sole pad to tip of the longest digit (third), without claw (sine unguis), was measured.

xii. Front and hind paw width: The widest part across the outer digits (second and fourth) of the manus and the pes was measured.

RESULTS AND DISCUSSIONS

The present section describes the results based on morphometric analysis in leopards.

1. Phenotypic measurements recorded in captive adult leopard: Forty (40) male leopards and sixty one (61) female leopards, thus totalling 101 (one hundred and one) in all were subjected to the morphometric analysis for recording various phenotypic measurements in adult leopards from captivity.

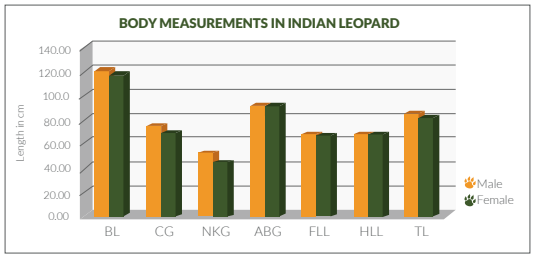


Figure 2.1 : Sex wise body measurements in Captive rescued Leopards.
BL - Body length, CG - Chest girth, NKG - Neck girth, ABG - Abdominal girth, FLL - Forelimb length, HLL - Hindlimb length and TL - Tail length.

The body measurements including body length, tail length, length of forelimb and hindlimb, abdominal girth, neck girth, chest girth, tail circumference, forelimb circumference, forelimb paw width, forelimb paw length, hindlimb paw length and hindlimb paw width etc. were observed and recorded as per the table no. 2.1

Age and sex-wise body weight of leopards in captivity were also recorded in the present study (Table 2.2).

Age group-wise data for body weight in captive leopards, suggests that males tend to be heavier than females across all age groups (Table 2.2).

MORPHOMETRY OF PAW RECORDED IN CAPTIVE LEOPARDS

Morphometric analysis (Figure 2.2) in the present study clearly indicates the range of forelimb paw width ranging between 5.5 - 7.6 cm. (male 6.91 ± 0.17, female 6.61 ± 0.19), paw length 9 - 10.3 cm (male 9.73 ± 0.24, female 9.70 ± 0.27). Measurements of the hindlimb paw length ranged between 6.5 – 8.3 cm. (male 7.41 ± 0.20, female 7.36 ± 0.21), whereas the hind limb paw width ranged between 5.5 - 6.3 (male 5.73 ± 0.14, female 5.91 ± 0.16).

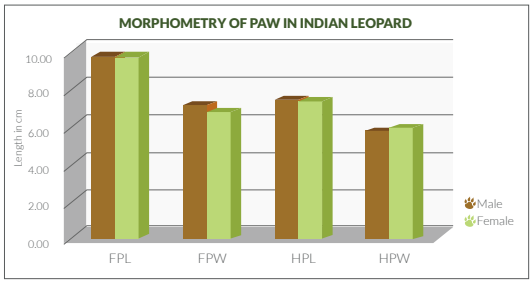


Figure 2.2 : Morphometry of paw recorded in Captive Leopards.
Where FPL - Forelimb paw length, FPW - Forelimb paw width, HPL - Hindlimb paw length and HPW - Hindlimb paw width.

The measurements of paw recorded in captive leopards, suggests that there may be some differences between males and females, although there is some overlap in the ranges.

Table 2.1 : Phenotypic measurements recorded in captive adult leopards.

SR. NO.	PHENOTYPIC TRAIT	RANGE (CM)	COEFFICIENT OF VARIATION	MALE (N=40)	FEMALE (N=61)	POOLED MEAN
1.	Body length	113-126	3.03	120.53 ± 3.01	117.34 ± 3.32	117.5 ± 2.02
2.	Tail length	71.5-89	4.30	83.84 ±2.09	80.72 ± 2.31	81.24 ± 1.42
3.	Tail circumference	14-17	3.79	15.87 ± 0.40	15.54 ± 0.44	15.53 ± 0.27
4.	Neck girth	41-54.3	9.52	51.14 ± 1.29	43.18 ± 1.42	45.99 ± 0.89
5.	Chest girth	63-79.6	6.16	73.88 ± 1.87	67.46 ± 2.05	69.44 ± 1.24
6.	Abdominal girth	90-96.8	2.09	91.00 ± 2.29	90.66 ± 2.51	89.97 ± 1.53
7.	Forelimb length	60-78	4.88	67.37 ± 1.74	66.13 ± 1.89	66.04 ± 1.15
8.	Forelimb circumference	25-30.4	3.72	28.86 ± 0.72	28.51 ± 0.80	28.39 ± 0.49
9.	Forelimb paw length	9-10.3	2.46	9.73 ± 0.24	9.70 ± 0.27	9.62 ± 0.16
10.	Forelimb paw width	5.5-7.6	6.54	6.91 ± 0.17	6.61 ± 0.19	6.67 ± 0.12
11.	Hindlimb length	63.8-77	3.99	66.80 ± 1.70	66.47 ± 1.87	66.00 ± 1.14
12.	Hindlimb paw length	6.5-8.3	6.94	7.41 ± 0.20	7.36 ± 0.21	7.31 ± 0.13
13.	Hindlimb paw width	5.5-6.3	3.59	5.73 ± 0.14	5.91 ± 0.16	5.78 ± 0.10

Table 2.2 : Age group wise Body weight (Kg.) in captive leopards.

AGE GROUP	RANGE	MALE (N=40)	FEMALE (N=61)	POOLED (N=101)
Upto 5 Years	28-65	51.43 ± 2.47	34.50 ± 2.91	55.08 ± 1.96
5-10 Years	3-=80	54.43 ± 1.67	37.69 ± 0.66	36.78 ± 2.00

Table 2.3: ANOVA for effect of sex, age and Sex X Age interaction on various traits.

SR. NO.	TRAIT		SEX	AGE	SEX X AGE
1.	Chest girth	MSS	406.17	43.25	37.39
		Significance	**	**	*
2.	Body length	MSS	373.21	28.14	46.25
		Significance	**	NS	*
3.	Tail length	MSS	70.16	21.84	36.15
		Significance	**	NS	*
4.	Forelimb length	MSS	9.63	27.27	24.19
		Significance	NS	NS	NS
5.	Hindlimb length	MSS	0.24	11.89	27.79
		Significance	NS	NS	*
6.	Abdominal girth	MSS	26.18	3.73	3.61
		Significance	**	NS	NS
7.	Neck girth	MSS	669.39	4.40	15.45
		Significance	**	NS	*
8.	Tail circumference	MSS	1.31	0.05	0.327
		Significance	NS	NS	NS
9.	Forelimb circumference	MSS	1.95	0.19	0.68
		Significance	NS	NS	NS
10.	Forelimb paw width	MSS	4.22	1.57	1.09
		Significance	**	**	**
11.	Forelimb paw length	MSS	0.21	0.087	0.008
		Significance	NS	NS	NS
12.	Hindlimb paw length	MSS	0.23	0.04	1.46
		Significance	NS	NS	*
13.	Hindlimb paw length	MSS	0.49	0.18	0.09
		Significance	**	*	NS
14.	Body weight	MSS	3782.09	242.52	24.14

Table 2.3 shows the results of an ANOVA analysis performed to determine the effects of sex, age, and the interaction between sex and age on various phenotypic traits in captive adult leopards. The traits measured include chest girth, body length, tail length, forelimb length, hindlimb length, abdominal girth, neck girth, tail circumference, forelimb circumference, forelimb paw width, forelimb paw length, hindlimb paw length, hindlimb paw width, and body weight.

The results showed that sex has a significant effect on body length, chest girth, abdominal girth, neck girth, fore limb paw width, and body weight. Age has a significant effect on Fore limb paw width and Hind limb paw width. The sex vs. age interaction has a significant effect on chest girth, body length, tail length, hind limb length, neck girth, fore limb paw width, hind limb paw length and hind limb paw width.

Overall, these results suggest that sex, age, and their interaction play a role in determining the physical traits of captive adult leopards. The study has helped in developing the baseline data on bodily measurements.

REFERENCES

Athreya, V. and Belsare, A. (2006): 'Carnivore Conflict': Support provided to leopards involved in conflictrelated cases in Maharashtra. Wildlife Trust of India, New Delhi. p. 9.

Bailey, T. N. (1993): The African leopard: a study of the ecology and behaviour of a solitary felid. Columbia University Press. New York. pp 429.

Bewley, J. M., Peacock, A. M., Lewis, O., Boyce, R. E., Roberts, D. J., Coffey, M.

P., Kenyon, S. J. and Schutz, M. M. (2008): Potential for estimation of body condition scores in dairy cattle from digital images. J. Dairy Sci. (91): 3439–3453.

Brody, S. (1964): Bioenergetics and growth, Hafner Publishing Company Inc., New York. pp 1023.

De Waal, H. O., Combrinck, W. J. and Borstlap, D. G. (2004a): A comprehensive procedure to measure the body dimensions of large African predators with comments on the repeatability of measurements taken from an immobilized African lion *(Panthera leo)*. J. Zool. 262: 393-398.

De Waal, H. O., Osthoff, G., Hugo, A., Myburgh, J. and Botes, P. (2004b): The composition of African lion (*Panthera leo*) milk collected a few days postpartum. Z. Saugetierkd. 69(6): 375-383.

Hunter, L. (2015): Wild cats of the world. Bloomsbury Publishing. New York, 240 pp.

Johansson, O., Agvaantseren, B., and Jackson, R. Snow Leopard Reports, 1 (2022): 1-6.

Keep, M. E. (1973): Factors contributing to populations crash of Nyala in Ndumu Game Reserve. The Lammergeyer 19: 16-23.

Lawrence, T. L. J. (1980): Growth in animals, Butterworths, London, Boston. pp 308.

Ozkaya, S. (2012): Accuracy of body measurements using digital image analysis in female Holstein calves. Anim. Prod. Sci. (52): 917–920.

Roth, V.L. and Mercer, J.M. (2000): Morphometrics in development and evolution. Amer. Zool. 40(5): 801-810.

Smuts, G. L., Robinson, G. A. and Whyte, I. J. (1980): Comparative growth of wild male and female lions *(Panthera leo)*. J. Zool. 190(3): 365-373.

Swatland, H. J. (1984): Structure and development of meat animals, Prentice-Hall, INC., Englewood Cliffs, New Jersey. pp 624.

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

Press. Chicago. pp. 452.
Warheit, K. I., Rohlf, F. J. and Bookstein, F. L. (1992): Proceedings of the Michigan Morphometrics Workshop. Syst. Biol. 41: 392.
Wilson, D. D. and Mittermeyer, R. A. (2009): Handbook of the mammals of the world. Volume 1. Carnivores. Lynx Ediciones. Barcelona. pp.727
Winiar P. B., Maria F. A., Nuraini, H. and Priyanto, R. (2016): Application of digital image technique for morphometrics measurement on Bali and Ongole Cattle. J. Ilmu Pertan. Indonesia (21): 63-68.

18

Husbandry of Smooth-Coated Indian Otter in Captivity

Dr.Rajesh Patel (B.V.Sc. & A.H.,PGCVH)

Address: Dr.Shyamaprasad Mukherjee Zoological Garden
Surat Municipal Corporation, Surat, (Gujarat)

INTRODUCTION

There are total of 13 different otter species around the globe; out of thirteen species, only three are found in India are **Eurasian otter *(Lutra lutra)*, Smooth coated otter *(Lutrogale perspicillata)*** and **Small-clawed otter *(Aonyx cinereus)*** The Smooth-coated otter occurs in most of the Indian subcontinent and Southeast Asia, with a disjunct population in Iraq. It has been listed as vulnerable on the IUCN Red List since 1996 and is threatened by habitat loss, pollution of wetlands, and poaching for the illegal wildlife trade. There is a sizable population of Smooth-coated otters in the wild forests in the South Gujarat region.


Congo clawless otter

DETAIL OF SPECIES

Name of Animal: Smooth coated otter
Scientific name: *Lutrogale perspicillata*
Conservation status: Vulnerable (Population decreasing)
Gestation period: 62-65 days
Mass: 8-9 kg (Adult) & 120-150 gm (puppies)
Order: Carnivorous
Family: Mustelidae
Kingdom: Animalia

MATERIAL / METHOD

Dr. Shyamaprasad Mukherjee Zoological Garden, Surat, is proud to be one of two zoos in India having successful captive breeding of Smooth coated otter. Three injured otters (1:2) were initially received in 2006. They wer rescued post the -city flood and were kept together in the open moated enclosure which was 725 sq mts. in area with huge water body in the zoo. Captive breeding started in 2008, and from 2008 to date, 42 puppies have been successfully born and reared in captivity.

DISCUSSION

Behaviour in captivity: Over the last 15 years, we have observed that otters are very social and playful animals and have noticed a social group of 16 animals. The group have only one Alfa male and one Alfa female who dominate all other members within the group. Further, we have noticed severe infighting in the group while challenging to the Alfa male or female. Life threatening fighting within two male or two female in the group has been noted.

Till date there have been two incidences of serious infighting among two females within a group. In one instance a female succumbed due to severe infighting injuries group and in the second instance the severely injured female was saved due to timely separation from the group.

Breeding History of smooth-coated otter in Surat Zoo: Gestation period is 62-65 days. Initially blind puppies are delivered in the burrows made by parents, Litter size is from one to four puppies.. The pups, open their eyes at the

age of 10- 15 days.

The breeding season in captivity is August to December some time up to January. The species exhibits very good parental care and both male and female take very good care ofof the puppies. Till date 41 pups have been successfully bred in captivity at the Dr. Shyamaprasad Mukherjee Zoological Garden, Surat. Presently the collection in the zoo is 23 individuals (9 males, 5 females and 9 unsexed individuals) .

Keeping in view the behaviour of species in captivity the zoo has initially constructed three quarantine/ off exhibit breeding enclosure facilities and kept one pair of animals in each enclosure. On successful breeding at off exhibit quarantine / breeding facility further three more off exhibit enclosures were constructed and now total six pair of animals are kept for off exhibit breeding and one pair kept in public display enclosure.

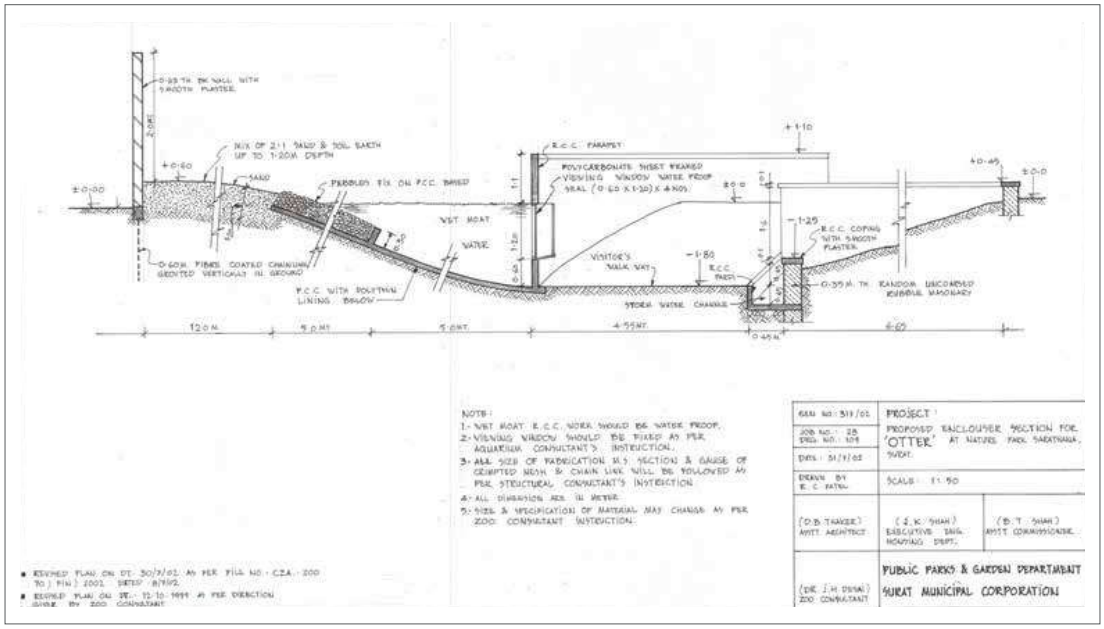
Feeding: In captivity the Otter are fed small size 4-5" fresh dead fish, sometime live cat fish is also offered after through washing / dipping in 1 % Chlorine Dioxide (ClO2) solution. Average 1 to 1.5 kg fish is offered daily per animal in captivity.

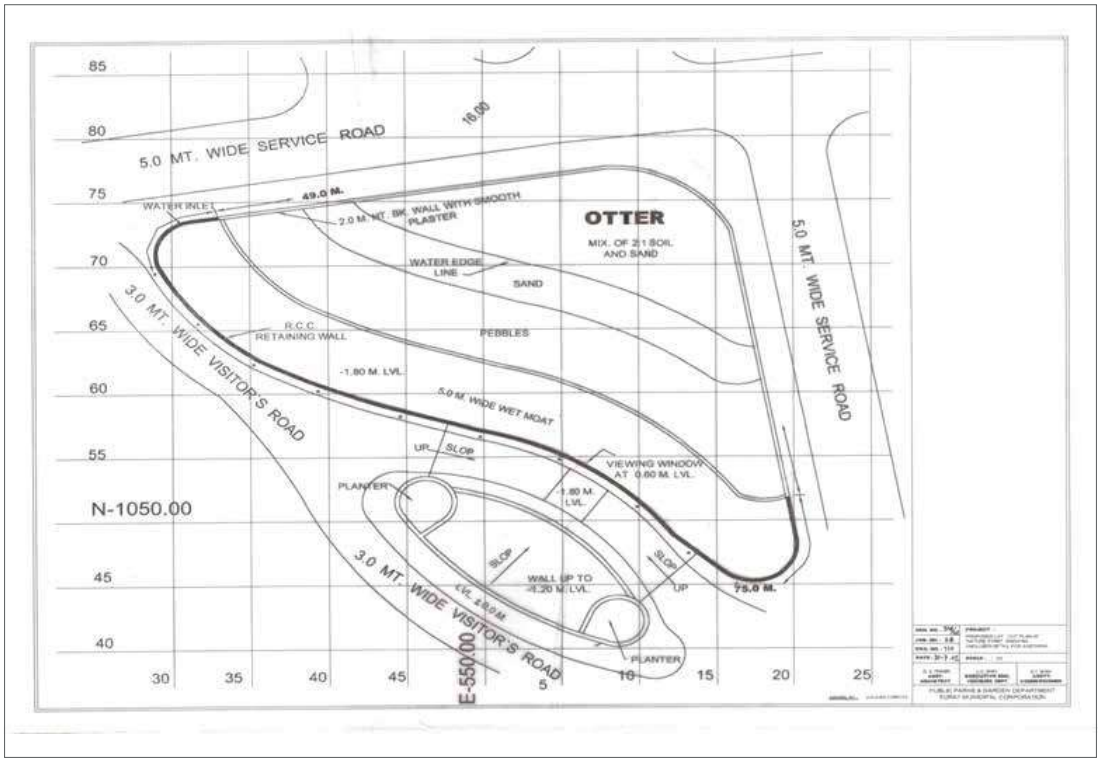
Veterinary Care and Management: Deworming is done regularly every three months with rotational anthelmintic drugs in fish. Water body in open moated enclosure is cleaned weekly and at off exhibit Quarantine /Breeding enclosure facilities on a daily basis. All the water bodies are drained and cleaned with bleaching powder fortnightly.

Till date vaccine has been given to the Otters to this animal in captivity. Very few occasion treatment is required mainly for Respiratory infection, Infighting injuries and Maggot wounds.

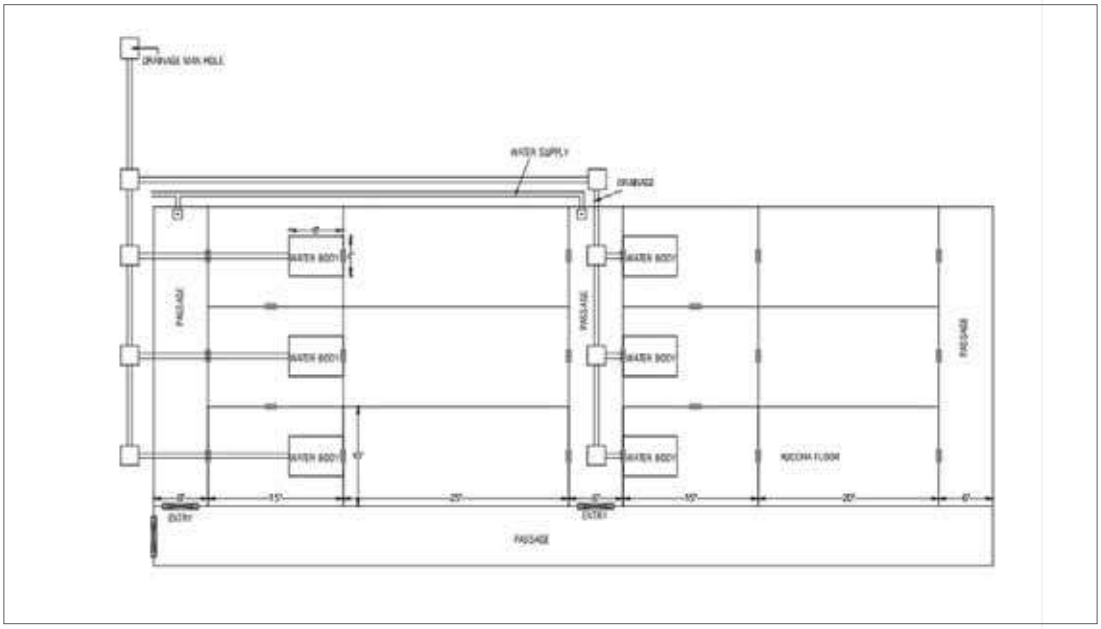
The longest lived Otter was 15 years old.

Design of enclosure in Zoo for smooth coated otter for display.





Layout of the otter enclosure



Off Exhibit quarantine / Breeding enclosure design.

Inventory Report For smooth coated otter At Surat Zoo

YEAR	OTTER	BIRTH	DEATH	TOTAL	EXCHANGE	EXCHANGE WITH ZOO
2006-07	1+2+0=3	0	0	3	00	
2007-08	1+2+0=3	0	0	3	00	
2007-08	1+2+0=3	2	0	5	00	
2009-10	2+3+0=5	3	1	7	00	
2010-11	3+4+0=7	3	1	9	00	
2011-12	3+4+2=9	0	0	9	00	
2012-13	3+4+2=9	0	0	9	00	
2013-14	3+4+2=9	3	0	12	00	
2014-15	6+4+2=12	3	0	15	01	Ahmedabad
2015-16	5+4+5=14	2	0	14	02	Hyderabad
2016-17	4+3+7=14	0	1	13	02	Chandigarh
2017-18	2+2+7=11	1	0	10	02	Mysuru
2018-19	1+1+8=10	1	0	11	00	
2019-20	1+2+8=11	4	0	15	00	
2020-21	6+9+0=15	3	1	16	02	Raipur
2021-22	5+7+3=15	4	0	17	02	Rajkot
2022-23	8+5+4=17	6	0	19	04	Jamnagar + Mysuru + Raipur
2023-24	10+6+3=19	6	0	23	02	Jaipur
TOTAL	**9+5+9=23**	**41**	**04**	**23**	**17**	

Smooth coated otter at Dr. Shyamaprasad Mukherjee Zoological Garden, Surat.

Otter family in the water pool

19

Lion-tailed macaque in Zoos: History and Future Perspectives. A Model for Conservation Breeding

Dr. Nilofer Begum, E 103, Loharuka Green Island, Parthanagari, Lalkuthi, Gopalpur I, 700136, Kolkata

Email: niloferbegum3@gmail.com

A RICH CONSERVATION HISTORY

The Endangered Lion-tailed macaque *(Macaca silenus)*, endemic to the Western Ghats Mountain range of southern India, is a flagship species for many endemic and threatened species of the biodiversity hotspot. The wild population at present is estimated to be about 4,000 individuals, distributed in 47 isolated subpopulations (Singh et al. 2020). Lion-tailed macaque is one of the best-studied macaque species, both in the wild and in captivity (see Singh 2019). In situ - ex situ linkages and cooperation between prominent American, European and Indian scientists like Dr. Donald Lindburg, Dr. Werner Kaumanns, Prof. Dr. Mewa
Singh, and Dr. Ajith Kumar, were realised quite early. Some of their students continue to work on the Lion-tailed macaque. Various studies on the species in its natural habitat in India were financially supported by the German Primate Center, Volkswagen Foundation, and various American and European zoos. Many studies on the species both in situ and ex situ resulted in a large number of publications that cover various aspects of the species biology, population dynamics, husbandry and management, and conservation (Lindburg 2001, Kumar et al. 2001, Singh & Kaumanns 2005, Kaumanns et al. 2006, 2013, Kumara et al. 2014). The species has a long conservation history and is regarded as a high priority species for captive propagation (Singh et al. 2009).

Lion-tailed macaques (LTM) have been kept in zoos worldwide since more than a hundred years (Begum et al. 2022, 2023). The global captive population of the LTM is one of the oldest, most dispersed, and largest managed primate populations. It was one of the first species for which in the 1980s systematically managed breeding programmes were established in North America (Species Survival Plan, SSP) and in Europe (European Endangered Species Programme, EEP) (Kaumanns et al. 2013). The breeding programmes were intended to establish a reserve population to support the wild population and its conservation (see Heltne 1985). It is also among the first primates for which Regional Studbooks (Gledhill 1983) and International Studbooks (Gledhill 1987) were established. Since the 2000s, National Studbooks have been developed and maintained in the species' country of origin, India, initiated under the collaborative research projects of the Central Zoo Authority (CZA) and Wildlife Institute of India. LTM was one of the first species prioritised for the coordinated Conservation Breeding Programmes initiated by the CZA.

Fig 1: An adult Lion tailed macaque in its natural habitat. Thier female bonded social system is regarded as a key for management.

CURRENT STATUS OF THE GLOBAL CAPTIVE POPULATION: UNCERTAIN BUT SOME POTENTIAL

The information on the status of the global captive population in this article is based on the recent edition of the International Studbook for the LTM (Sliwa & Begum 2019) with historical records on 2,734 individuals distributed in 366 institutions in 47 countries over 119 years. It also covers the Indian captive population. The International Studbook provides suggestions for the future management and development of the global population. These suggestions have been published in an extended version in the Journal of Threatened Taxa (Begum et al. 2021). The publication is a part of a recent comprehensive study on the conservation potential of the global captive population of the LTM (Begum 2023) and emphasises the role of the Indian captive population and Indian zoos in the context of the conservation of the species. The basic information provided in this article is based on the publication by Begum et al. 2021. For most of its 100 year history, the captive population of the LTM was constituted by the North American and the European subpopulations. Fig. 2 shows the important role North America played in the growth of the global population till about the mid 199g, and the change of importance thereafter towards the European population, and the smaller subpopulations, especially India and Japan (for details see Begum et al. 2022). The current global population as of 2018 comprises 516 individuals in 98 zoos mainly constited by Europe (62%), followed by Japan (c.15%), India (c.10%) and North America (c.6%) (Sliwa and Begum 2019). The population had its origin in wild-caught LTMs that were imported from India to North America and Europe mainly between 1950 and 1970 (Fig. 3).

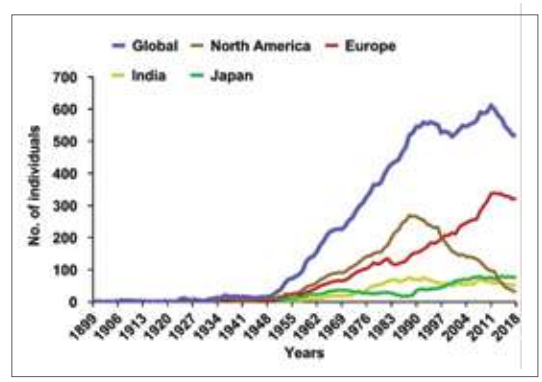


Fig 2: Development of the Global Historical Population
Reproduced from Begum et al. 2021, published in JoTT (Creative Commons Attribution 4.0 International License)

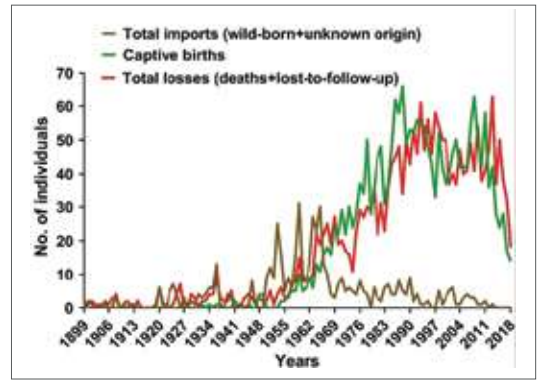


Fig 3: Annual number of imports, births and losses in the global historical population
Reproduced from Begum et al. 2021, published in JoTT (Creative Commons Attribution 4.0 International License)

From the1970s the global population grew via breeding alone; wild caught imports were limited to Indian zoos (Begum et al.2022.) The North American population under the SSP was initiated in 1983 with 163 individuals. After reaching a size of 269 individuals in 198 large scalpopulation control measures in the 1990s, led to a sharp decline in size and loss of breeding potential. From one of the most productive LTM populations, the American population is currently reduced to a small ageing stock of 31 individuals. The European population under the EEP (established in 1989) grew slowly but steadily and played a

dominant role in terms of size and productivity since the mid-1990s. The number of births and population size in Europe, however, has been decreasing drastically since 2012, due to management-induced birth control to deal with space problems in their zoos. The decrease in Europe is reflected in the strong decline in population size (Fig. 2) and the number of births in the global population (Fig. 3). The Japanese population has remained stable in the last decade but currently suffers from a declining and ageing population. The Indian captive population as of 2018, is small, comprising 51 individuals in 10 zoos. Since 2008, the population has been declining with a brief increase during 2013-2014, breeding is low, and regular births are restricted to 1-2 zoos only. Arignar Anna Zoological Park, Chennai is the coordinating zoo for the Conservation Breeding Programme of the species under CZA. Between 2003 and 2018, the zoo contributed to 75% (n= 45) of births in Indian zoos (n= 60). National Zoological Park, New Delhi, contributed to breeding mainly in the 1970s–80s. An ongoing analysis based on the International Studbook reveals a low potential for long-term survival in terms of population development, reproductive output, and gene diversity retained in the Indian captive population (Begum et al. in prep.). The overall status in India urgently requires improvements (Singh et al. 2012, see also Krishnakumar & Manimozhi 2000). With 322 individuals, the European population is currently the largest and most productive of the LTM subpopulations globally. However, space problems have resulted in management decisions to reduce breeding in a large number of females and groups, respectively (Sliwa et al. 2016).

FUTURE PERSPECTIVE: INDIA

The global captive population of more than 500 animals forms 11% of the total global wild and captive population of the Lion-tailed macaque, and therefore, should be regarded as a "reserve" to support the declining wild population and contribute to its conservation (see Begum 2023).

The Endangered status of the species with increasing fragmentation of its habitat, strongly calls for a viable captive population, especially in its country of origin, India. Measures and new steps are urgently required to stabilise the European, and thus the global captive population, and prevent a loss of its reproductive potential, as it happened in the American population.

Fig 4: Lion Tailed Macaques are aboreal and habitat specialists; a group is widely dispersed when foraging.

Future perspectives and solutions for problems on both sides may be achieved by strengthening the ongoing cooperation between Indian and European zoos and corresponding zoo associations. Large Indian zoos with the advantage of native food resources and climate can provide the spaces for a few European groups to grow and contribute to the establishment of a larger, viable Indian population. Indian zoos still keep a

few wild-born individuals that could improve the genetic status of the global population. Indian zoos can serve as interfaces between captive and wild populations. A viable Indian captive population can be used for conservation purposes, like reintroduction, in the long run, but also to carry out research and develop know-how of the procedures of reintroduction (see Lindburg et al. 1997).

A global conservation management plan including mainly the Indian and European captive populations should be established following the principles of adaptive management. The aim would be the development of an "Indo-European Lion-tailed macaque Reserve Population" that can support the declining wild population when needed. The project should have an integrated in situ – ex situ/ one-plan approach that can be realised with a close cooperation between the CZA, European Association of Zoos and Aquaria (EAZA), selected Indian zoos in the range states of the species, experts, and research institutions from India and Europe. It should include the establishment of appropriate infrastructural conditions and training of personnel in selected Indian zoos for breeding LTMs and possibly for their reintroduction. The work could be based on the approaches discussed in various publications (e.g., Kaumanns et al. 2013) and LTM-congresses (e.g., Heltne 1985; Schwibbe et al. 2000, 2001), but also take hints from the inter-regional management of other populations of Endangered species such as the Golden lion tamarin Leontopithecus rosalia and the Red panda Ailurus fulgens.

A comprehensive analysis of the current Indian LTM population with data based on an updated National Studbook, and a thorough assessment of primate husbandry and captive living conditions in Indian zoos are necessary. A framework for such an assessment for the Indian Conservation Breeding Programmes is currently being discussed and developed at the CZA.

International breeding programmes, especially the EEP, was explicitly managed by integrating the knowledge on the bilogy of the species gained from field studies in India Conservation programmes in Indian Zoos and profit from the long-term management experiences there. The management of the EEP (Kaunanns et al. 2006, 2013), and a recent study on the global breeding patterns on the global population (Begum et al. 2023) reveal that for successful breeding, the species typical female bonded social system has to be regarded as a key trait for management (Kaunanns et al. 2020). Captive groups that come close to those in the wild,

in terms of size, demographic structures, and dispersal patterns are likely to be more productive (Begum 2023). LTM groups in the wild typically have sizes of 16-21 individuals constituted by clans of related females that have permanent relationships and strong bonds with each other, and usually have one adult male (see Kumar 1987, Singh 2019). Males disperse at subadult ages; females prefer the new males (Kumar et al. 2001). Groups are composed of individuals of varying age-sex classes and generations that provide socialisation conditions relevant for the development of social competence and behavioural patterns typical of the species (see Kaumanns et al. 2006). The species' reproductive system is embedded in their social way of life like in most primates and requires utmost consideration for their management (see Singh and Kaumanns 2005). Under captive conditions therefore groups

should be allowed to grow undisturbed to modal group sizes in the wild, females in a group should not be split and only males (after appropriate socialisation) should be transferred between groups (for details on husbandry see Kaumanns et al. 2006). Other aspects of their life relevant for management in zoos refer to the species' arboreal life in the canopy, a varied diet including faunal components, wide dispersion and individualised foraging patterns (see Fig. 4), and the species' high cognitive capacities (see Kumar 1987, Krishnamani & Kumar 2000, Singh et al. 2001, Sushma & Singh 2006, Kumar et al. 2008). A critical aspect for the management is the recent finding of two genetically distinct subpopulations of LTM in the Western Ghats (Ram et al. 2015). Currently, it is proposed to manage the two types as separate conservation units. Separate management would have to be based on large-scale genetic testing of the captive population.

The future of the global captive population of the LTM strongly depends on progress made in India. A successful project with Indian zoos as collaborators in international metapopulation management plans could serve as a model for the many other species that currently face sustainability problems (see Powell et al. 2019). The Lion-tailed macaque, which has a history of conservation and scientific collaboration since more than five decades, continues to be threatened, both in the wild as well as in captivity. The Indian zoo and science community is viewed with a lot of hope internationally, in their role to contribute to the persistence of this iconic Indian species in zoos and in its natural habitat.

REFERENCES

Begum N. 2023. "Primates under Altered Living Conditions: Development and Conservation Potential of the Captive Lion-tailed macaque *(Macaca silenus)* Population". PhD dissertation. Freie Universität Berlin, Berlin, Germany.

Begum N, Kaumanns W, Sliwa A, Singh M. 2021. The captive population of the Lion-tailed macaque *(Macaca silenus)*. The future of an endangered primate under human care. Journal of Threatened Taxa 13(9): 19352–19357.

Begum N, Kaumanns W, Singh M, Hofer H. 2022. A hundred years in zoos: History and development of the captive population of the Lion-tailed macaque *(Macaca silenus)*. Long term persistence for conservation? Primate Conservation 36: 155–172.

Begum N, Kaumanns W, Hofer H, Singh M. 2023. A hundred years in zoos II: Patterns of reproduction in the global historical captive population of the Lion-tailed macaque *(Macaca silenus)*. Primate Conservation 37.

Gledhill LG. 1983. North American Regional Studbook for the Lion-tailed macaque *(Macaca silenus)*. Woodland Park Zoo, Seattle

Gledhill LG. 1987. Lion-tailed macaque *(Macaca silenus)* International Studbook. Woodland Park Zoo, Seattle.

Heltne PG, ed. 1985. The Lion-tailed macaque: Status and Conservation. Monographs in Primatology, vol. 7. Alan R. Liss.

Kaumanns W, Krebs E, Singh M. 2006. An endangered species in captivity: Husbandry and management of the Lion-tailed macaque *(Macaca silenus)*. MyScience 1: 43–71.

Kaumanns W, Singh M, Sliwa A. 2013. Captive propagation of threatened primates – the example of the Lion-tailed macaque *(Macaca silenus)*. Journal of Threatened Taxa 5: 4825– 4839.

Kaumanns W, Begum N, Hofer H. 2020. "Animals are designed for breeding": Captive population management needs a new perspective. Journal of Zoo and Aquarium Research 8(2): 76–85.

Krishnakumar N, Manimozhi A. 2000. What ails captive breeding programmes in India – Lion-tailed macaque (ltm) – A case study. Zoos' Print Journal 15: 421–422.

Krishnamani R, Kumar A. 2000. Phyto-ecology of the Lion-tailed macaque *(Macaca silenus)* habitats in Karnataka, India: Floristic structure and density of food trees. Primate Report 58: 27–56.

Kumar A. 1987. The Ecology and Population Dynamics of the Lion-tailed macaque *(Macaca silenus)* in South India. PhD dissertation. University of Cambridge, Cambridge, United Kingdom.

Kumar S, Kumara HN, Singh M. 2008. Observations on tool use in captive Lion-tailed macaque *(Macaca silenus)*. Current Science 94(7): 925–929.

Kumar MA, Singh M, Kumara HN, Sharma AK, Bertsch C. 2001. Male migration in Lion-tailed macaques. Primate Report 59: 5–18.

Kumara HN, Sasi R, Suganthasakthivel R, Singh M, Sushma HS, Ramachandran KK, Kaumanns W. 2014.

Distribution, demography, and conservation of Lion-tailed macaque *(Macaca silenus)* in the Anamalai Hills Landscape, Western Ghats, India. International Journal of Primatology 35: 976–989

Lindburg DG. 2001. A century of involvement with Lion-tailed macaques in North America. Primate Report 58: 51–64.

Lindburg DG, Iaderosa J, Gledhill L. 1997. Steady-state propagation of captive Lion-tailed macaques in North American zoos: A conservation strategy. In: Primate Conservation: The Role of Zoological Parks, J. Wallis (ed.), pp.131–149. Special Topics in Primatology, Volume 1. American Society of Primatologists, Chicago, IL.

Powell DM, Dorsey CL, Faust LJ. 2019. Advancing the science behind animal program sustainability: An overview of the special issue. Zoo Biology 38: 5–11.

Ram MS, Marne M, Gaur A, Kumara HN, Singh M, Kumar A, Umapathy G. 2015. Pre-historic and recent vicariance events shape genetic structure and diversity in endangered Lion-tailed macaque in the Western Ghats: Implications for conservation. PLOS ONE 10: e0142597.

Schwibbe M, Singh M, Kaumanns W, Knogge C, eds. 2000. Proceedings of the Fifth International Symposium on Lion-tailed macaque, Mysore, India, Part 1. Primate Report 58. German Primate Center.

Schwibbe M, Singh M, Kaumanns W, Knogge C, eds. 2001. Proceedings of the Fifth International Symposium on Lion-tailed Macaque, Mysore, India, Part 2. Primate Report 59. German Primate Center.

Singh M. 2019. Management of forest-dwelling and urban species: Case studies of the Lion-tailed macaque *(Macaca silenus)* and the Bonnet macaque *(M. radiata)*. International Journal of Primatology 40: 613–629.

Singh M, Kaumanns W. 2005. Behavioural studies: A necessity for wildlife management. Current Science 89: 1230–1236.

Singh M, Kumara HN, Kumar MA, Sharma AK. 2001. Behavioural responses of Lion-tailed macaque *(Macaca silenus)* to a changing habitat in a tropical rainforest fragment in the Western Ghats, India. Folia Primatologica 72: 278–291.

Singh M, Sharma AK, Krebs E, Kaumanns W.

2006. Reproductive biology of Lion-tailed macaque *(Macaca silenus)*: An important key to the conservation of an endangered species. Current Science 90: 804–811.

Singh M, Kaumanns W, Singh M, Sushma HS, Molur S. 2009. The Lion-tailed macaque *(Macaca silenus)* (Primates: Cercopithecidae): Conservation history and status of a flagship species of the tropical rainforests of the Western Ghats, India. Journal of Threatened Taxa 1: 151– 157.

Singh M, Kaumanns W, Umapathy G. 2012. Conservation-oriented captive breeding of primates in India: is there a perspective? Current Science 103(12): 1399–1400.

Singh M, Kumar A, Kumara HN. 2020. *Macaca silenus*. The IUCN Red List of Threatened Species 2020: e.T12559A17951402. (26 July 2024; www.iucnredlist.org)

Sliwa A, Begum N. 2019. International Studbook 2018 for the Lion-tailed macaque *(Macaca silenus)*, 1758, vol. 9. Edition 2018. Zoologischer Garten Köln, Cologne.

Sliwa, A, Schad K, Fienig E. 2016. Long-term Management Plan for the Lion-tailed macaque *(Macaca silenus)* European Endangered Species Programme (EEP). Zoologischer Garten Köln, Cologne, Germany and European Association of Zoos and Aquaria (EAZA), Amsterdam, Netherlands. 60pp.

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

20

Use Of Tiletamine-Zolazepam-Mmedetomidine for Immobilization of Indian Muntjac *(Muntiacus muntjak)*

Jayakumar M[1]., Boon allwin[1]., BK Gupta[2]., Sreejith S[1].

[1]Veterinary officer GZRRC, [2]Director GZRRC

Email: gzrrc@outlook.com

ABSTRACT

This study evaluated the efficacy of a Tiletamine-Zolazepam-Medetomidine (TZM) combination for the chemical immobilization of Indian muntjacs *(Muntiacus muntjak)*. Data from six animals at the Greens Zoological, Rescue and Rehabilitation Centre (GZRRC) were analyzed. The research assessed key parameters including onset of sedation, induction time, duration of sedation, recovery time, and vital signs such as heart rate, respiratory rate, rectal temperature, and blood oxygen saturation (SpO2). Animals received a combination of tiletamine-zolazepam (1.37 ± 0.07 mg/kg body weight) and medetomidine (0.033 ± 0.002 mg/kg body weight).

The addition of medetomidine to tiletamine-zolazepam resulted in rapid induction, stable sedation, and quick recovery. These characteristics suggest that the TZM combination provides improved conditions for field immobilization of Indian muntjacs. Our findings indicate that this drug protocol offers an effective and safe method for chemical restraint in this species, potentially benefiting both wildlife management and veterinary care in field settings.

INTRODUCTION

The Indian muntjac *(Muntiacus muntjak)* is a small deer species belonging to the Cervidae family, found throughout Southeast Asia. The International Union for Conservation of Nature (IUCN) classified it as 'Least Concern' in 2016. Despite its widespread distribution, there's a lack of research on immobilizing these animals. Wild animals are often captured for various reasons, including medical treatment, relocation, and scientific studies. To minimize stress during handling, experts recommend using immobilizing drugs (Arnemo et al., 1993). Researchers have documented the use of several anaesthetics for deer species, including zoletil, ketamine HCl, medetomidine, and xylazine HCl (Dematteis et al., 2009). Zoletil, a 1:1 mix of tiletamine HCl and zolazepam HCl, is popular for wildlife anaesthesia due to its effectiveness in small doses, wide safety margin, and ability to induce smooth, rapid anaesthesia. However, when used alone, it often leads to prolonged and rough recovery periods (Murray et al., 2000). Medetomidine, a more specific α2-agonist than xylazine, tends to have fewer side effects (Murphy et al., 2010). Despite this, there's limited information on the best drug combination for safely immobilizing Indian muntjacs.

MATERIALS AND METHODS

This study was conducted using data from the Greens Zoological, Rescue and Rehabilitation Centre (GZRRC) in Jamnagar, Gujarat, India. Researchers analysed the anaesthetic effects of a tiletamine-zolazepam-medetomidine combination (Fig. 1a to d). The animals were given immobilizing drugs via pneumatic darts and blowpipes (Fig. 1e and f).

Throughout the immobilization process, vital signs were regularly monitored (Fig. 3). The animals received doses of tiletamine-zolazepam at 1.37 ± 0.07 mg/kg body weight and medetomidine at 0.033 ± 0.002 mg/kg body weight. Vitals such as heart rate (beats per minute-BPM) and oxygen saturation (SpO2 in percentage) were measured using a multi-parameter monitor with pulse oximetry. Respiratory rate per minute (RR) calculated by watching chest movements and took rectal temperature in degrees Celsius (°C) using a digital thermometer at various intervals during immobilization.

Fig. 1: Anaesthetic drugs (a-d) and restraining devices (e and f) used to anaesthetize Indian muntjac.

Fig. 3: Monitoring of vitals during immobilization procedure using rectal probe (a) and multipara patient monitor (b)

The onset of sedation was timed (in minutes) from when the drug was given until the animal showed signs like lowering its head, relaxing its tongue, and being unable to stand (Fig. 2). Induction time was measured from drug administration until the animal was fully sedated, showing signs such as lateral recumbency, ataxia, had a relaxed jaw, didn't respond to pain, and medial rotation of eyeballs (Fig. 2). Sedation duration was calculated from induction time until the first signs of recovery, like regaining the ability to swallow or move limbs. Recovery time was measured from when the reversal drug was given until the animal could stand, lift its head, and respond to external stimuli (Fig. 4).

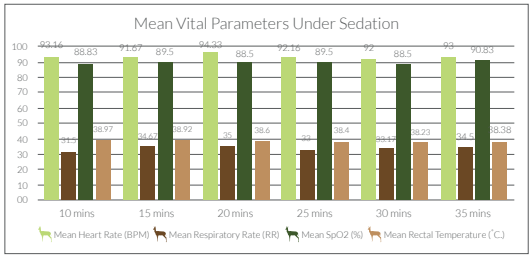
Fig. 2: Stages in the induction and onset of sedation in Indian muntjac showing lowering of head (a) and lateral recumbency (b). The animal is immediately blind-folded (c). Medial rolling of eyeballs (d) can be seen.

Fig. 4: Stages of recovery after administration of reversal drug (a), resulting in regaining of reflexes (b) and recovery from sedation (c)

RESULT

The heart rate of all 6 animals recorded at the interval of 5 minutes and the mean value of 93.00 ± 6.5 Beats Per Minute obtained, similarly the mean respiratory rate was 34.00 ± 1.00, SpO2 was at 89.00 ± 2.00 %, and the rectal temperature was 38.60 ± 0.30 °C.

The mean onset time of tiletamine-zolazepam-medetomidine combination is 1.55 ± 0.27 min with the induction time of 3.40 ± 0.42 min and the duration of sedation lasting to 47.67 ± 6.56 min and recovered in 3.50 ± 0.55 min after atipamezole injection.



DISCUSSION

In our study, we observed that the Indian muntjacs exhibited a fluctuating but generally elevated heart rate, averaging 93 ± 6.5 beats per minute (BPM). This finding aligns with previous research by Caulkett et al. (2000), who used similar anaesthetic combinations on wood bison. They noted that while heart rates didn't change significantly over time, the use of medetomidine did lead to more fluctuations. Importantly, despite these fluctuations, the heart rates remained within a safe range.

Regarding respiratory rates, our sedated animals maintained an average of 34 ± 1 breaths per minute. This observation is consistent with several earlier studies, including those by Bollwahn et al. (1970), Fessl (1970), Khamis and Saleh (1970), Kreeger et al. (1986), and Arnemo et al. (1993). While Morán et al. (2000) reported a common decrease in respiratory rates when α 2-adrenoceptor agonists like medetomidine were used in cervids, which aligns with our findings.

The mean blood oxygen saturation (SpO2) in our sedated animals was 89.00 ± 2.00%. This level is encouraging when compared to human medical standards, where Tremper & Barker (1989) define hypoxemia as SpO2 below 85%. Lower SpO2 values also can be attributed to the effect of medetomidine on peripheral system causing vasoconstriction (FB Joerger, et al. 2023) Our results also echo those of Schwertner et al. (2002), who found that medetomidine combinations typically maintained SpO2 levels above 85%, outperforming xylazine combinations in this regard.

As for body temperature, we recorded a mean rectal temperature of 38.60 ± 0.30 °C. This closely matches Nielsen's (1999) reported normal temperature for deer at 38.4°C. Additionally, our findings support Schwertner et al.'s (2002) suggestion that medetomidine combinations, with their shorter downtimes, may reduce the risk of hyperthermia in sedated animals.

In our study of Indian muntjacs, we observed a notably quick onset of sedation when using the tiletamine-zolazepam-medetomidine (TZM) combination. This aligns with previous research, such as Tiwari et al. (2012), who reported an onset time of 1.98 ± 0.26 minutes using medetomidine and ketamine in dogs. Similarly, Timothy et al. (2010) noted a 3.00 ± 1.50 minute onset in guanacos using a medetomidine-ketamine-butorphanol mix. Our findings suggest that combining medetomidine with tiletamine and zolazepam may further reduce onset time.

The mean induction time we observed with TZM was 3.40 ± 0.42 minutes, which is faster than the 5.10 ± 3.10 minutes reported by Timothy et al. (2010) in guanacos using a different drug combination. This rapid induction aligns with Kuusela et al.'s (2000) findings on medetomidine's quick absorption when administered intramuscularly. Our results indicate that adding medetomidine to the anaesthetic protocol leads to smoother and faster induction.

Regarding the duration of sedation, our results weren't statistically significant, likely because recovery time was more dependent on the administration of the reversal agent. This is consistent with previous studies, such as Jalanka (1989, 1990), who observed sedation lasting approximately 45-60 minutes in various species when using medetomidine-based combinations. Morán et al. (2000) noted that while tiletamine-zolazepam combined with medetomidine or xylazine provides excellent analgesia, using tiletamine-zolazepam alone results in prolonged recovery.

The reversal time in our study was quick, which we attribute to rapid drug elimination. This aligns with Kuusela et al.'s (2000) findings on medetomidine's pharmacokinetics. Murphy et al. (2010) also noted that medetomidine, being a more specific α2-agonist, has fewer side effects. Our observations of quick recovery with medetomidine support these earlier findings. Interestingly, Morán et al. (2000) found that xylazine combinations led to higher serum lactate and cortisol levels compared to medetomidine combinations, suggesting less physiological stress with medetomidine.

Table 7: Onset of sedation, time of induction, duration of sedation and recovery using tiletamine-zolazepam-medetomidine.

ANIMAL CODE	ONSET OF SEDATION (MIN)	TIME OF INDUCTION (MIN)	DURATION OF SEDATION (MIN)	RECOVERY (MIN)
A1	1.3	3	43	4
A2	1.7	3.5	58	3
A3	1.5	2.9	41	3
A4	2	3.3	49	4
A5	1.3	4	43	4
A6	1.5	3.7	52	3
Mean± SD	1.55 ± 0.27	3.40 ± 0.42	47.67 ± 6.56	3.5 ± 0.55

CONCLUSION

Our study demonstrates that the tiletamine-zolazepam-medetomidine (TZM) combination provides a safe and effective method for chemically immobilizing Indian muntjacs. The protocol offers several key advantages: stable vital parameters, rapid sedation onset, and smooth recovery, which are critical in field conditions.

The addition of medetomidine to tiletamine-zolazepam significantly enhanced the anaesthetic's safety profile, maintaining heart rate and other physiological parameters within normal ranges. The quick induction and recovery times are particularly beneficial for prey species like the Indian muntjac, potentially reducing risks in wild environments.

These findings suggest the TZM combination is a promising approach for wildlife management and veterinary procedures. While more research is needed to fully understand its broader applications, this study provides valuable insights into improving chemical restraint techniques for Indian muntjacs.

REFERENCES

Arnemo, J.M., S.R. Moe and N.E. Søli, 1993. Xylazine induced sedation in Axis deer *(Axis axis)* and its reversal by atipamezole. Vet. Res. Commun., 17: 123–128.

Bollwahn, W., T. Vaske and M.R. Rojas, 1970. Experiments and experiences with Bay Va 1470 (Rompum) in cattle of Rio Grande de Sul, Brazil. Vet. Med. Rev., 70: 131-144.

Caulkett, N.A., P.H. Cribb and J.C. Haigh, 2000. Comparative cardiopulmonary effects of carfetanil-xylazine and medetomidine-ketmaine used for immobilization of Mule deer and Mule deer/White-tailed deer hybrids. Can. J. Vet. Res., 64: 64-68.

Dematteis, M., D. Godin-Ribuot, C. Arnaud, C. Ribuot, F. Stanke-Labesque, J.L. Pépin and P. Lévy, 2009. Cardiovascular consequences of sleep-disordered breathing: contribution of animal models to understanding of the human disease. ILAR J., 50(3), pp: 262-281.

Fessl, L., 1970. Clinical experience with Bay Va 1470 (Rompum). Vet. Med. Rev., 70: 199-210.

IUCN. 2016. The IUCN Red List of Threatened Species. Version 2016-2. Available at: www.iucnredlist.org. (Accessed: 04 September 2016).

Jalanka, H., 1989. Medetomidine and ketamine induced immobilization of Snow leopard *(Panthera uncia)*, doses, evaluation and reversal by Atipamezole. J. Zoo. Wildl. Med., 21: 154-162.

Jalanka, H., 1990. Medetomidine and medetomidine-ketamine induced immobilization in Blue foxes *(Alopex lagopus)* and its reversal by atipemazole. Acta Vet. Scand., 31: 63-71.

Joerger, F.B., Wieser, M.L., Steblaj, B., Niemann, L., Turunen, H. and Kutter, A.P., 2023. Evaluation of cardiovascular effects of intramuscular medetomidine and a medetomidine–vatinoxan combination in Beagle dogs: A randomized blinded crossover laboratory study. Veterinary Anaesthesia and Analgesia, 50(5), pp.397-407

Khamis, M. Y. and M.S. Saleh, 1970. Contributions to use of the preparation Bay Va 1470 (Rompum) in the buffalo. Vet. Med. Rev., 70: 263-273.

Kreeger, T.G., G.D.D. Guidice, U.S. Seal and P.D. Karns, 1986. Immobilization of White-tailed deer with xylazine hydrochloride and ketamine hydrochloride and antagonism by tolazoline hydrochloride. J. Wildl. Dis., 22(3): 407-412.

Kuusela, Raekallio, Anttila, Falck, Mölsä and Vainio, 2000. Clinical effects and

pharmacokinetics of medetomidine and its enantiomers in dogs. J. Vet. Pharmacol. Ther., 23(1): 15-20.

Morán, F.J., J. Palomeque and V.I. Peinado, 2000. Medetomidine/ tiletamine/zolazepam and xylazine/tiletamine/zolazepam combinations for immobilization of Fallow deer (Cervus dama). J. Zoo Wildl. Med., 31(1): 62-64.

Murphy, K.L., J.V. Roughan, M.G. Baxter and P.A. Flecknell, 2010. Anaesthesia with a combination of ketamine and medetomidine in the rabbit: effect of premedication with buprenorphine. Vet. Anaesth. Analg., 37(3): 222-229.

Murray, S., S.L. Monfort, L. Ware, W.J. McShea and M. Bush, 2000. Anaesthesia in female Whited-tailed deer using Telazole® and xylazine. J. Wilidl. Dis., 36 (4): 670-675.

Timothy, A.G., B.J. Stephanie, K. Penny, P.C. Paul and M.F. Manuel, 2010. Evaluation of medetomidine-ketamine-butorphanol anaesthesia with atipamezole-naltrexone antagonism in captive male Guanacos (Lama guanicoe). J. Zoo and Wildl. Med., 41(2): 255-262.

Tiwari, S.K., S. Roy and U.K. Mishra, 2012. Medetomidine - Ketamine Anaesthesia in Canine and its reversal by Atipamezole. Ind. J. Anim. Sci., 68(11): 1140-1

21

Optimizing Precision immobilization of caracals *(Caracal caracal)*:

Adapting Tiletamine-Zolazepam (TZ), Medetomidine-Ketamine (MK)a comparative analysis.

Boon Allwin[1], Jayvin Kelaiya[1], Kalaignan. Pa[1], Sujay C Suresh[1],
Sandeep Muskham[2], Brij Kishor Gupta[3]
[1]Veterinary officer GZRRC,[2]Biologist GZRRC, [3]Director GZRRC.

Email: gzrrc@outlook.com

ABSTRACT

The immobilization of non-domestic small felines, such as caracals *(Caracal caracal)*, presents challenges due to biological variations, adaptive behaviors, and external stimuli. This study evaluates two anesthetic protocols—Tiletamine-Zolazepam (TZ) and Medetomidine-Ketamine (MK)—to determine their efficacy and physiological impact. Twelve caracals (n=12) were immobilized for therapeutic screening and transfers, with six individuals receiving each protocol. Darting was performed using a 1.5 ml dart syringe, targeting the thigh or lateral forelimb near the triceps. Physiological parameters, including heart rate, respiratory rate, oxygen perfusion, body temperature, and mucous membrane colour, were continuously monitored. The study highlights the comparative effects of these two protocols, concluding that MK provided enhanced analgesia, achieving a surgical plane of anesthesia, whereas TZ effectively immobilized the animals with good muscle relaxation but exhibited some involuntary somatic movements despite complete immobilization. These findings emphasize the need-based selection of protocols, optimizing immobilization strategies for different management and medical intervention requirements in captive caracals.

KEYWORDS

Tiletamine-Zolazepam (TZ),
Medetomidine-Ketamine (MK), Caracals

INTRODUCTION

Health assessment of non-domestic felids is essential in any zoological collection. Although the Physical restrain techniques, squeeze cages don't really help in blood collection and other preliminary health assessment in these smaller felids, chemical restraint is warranted at minimum annually to have a better perspective on dental health, renal functionality through scans, cardiac essentials and age-related changes attributed by a simple visual examination, blood work and Diagnostic imaging. In adapting to new anesthesia regimens, the anesthetist's role becomes more pivotal as it necessitates a constant awareness of the patient's physiological status from induction to recovery. Although with the recent advancements in monitoring technology that aid in the monitoring of cardio-vascular functions and respiration, a requirement a human unit is essential. Prior to any anesthetic procedure, it is critical to establish an anesthetic and monitoring plan tailored to the specific needs of the species with reference to its physiology. This plan should consider the anesthetic risk, the nature of the procedure, the procedural environment, and any potential complications. Monitoring frequency is a key consideration, and this paper aims at holistic approach of not only evaluation of anesthetic protocol but also comparative evaluation of the anesthetic monitoring regimen, in addition to one of the foremost usages of Tiletamine-Zolazepam, Medetomidine and Ketamine in caracals.

MATERIALS AND METHODS

This study evaluates two anesthetic protocols—Tiletamine-Zolazepam (TZ) and Medetomidine-Ketamine (MK)—to determine their efficacy and physiological impact. Twelve caracals were immobilized accordingly to the clinical need for evaluation at GZRRC during the period from April 2023 to December 2023 in which six were anesthetized with a combination of a Medetomidine @0.03 mg / kg and ketamine @2.5 mg/ kg with presentation of

20mg/ml and 100mg/ml respectively and another six animals were anesthetized with a combination of Tiletamine-Zolazepam@ 4 mg/kg.

The animals were darted by silent approach by a single person and to avoid pre-excitation with a 1.5ml dart Dan inject ® by a single person approach and the hind quarters was always preferred, the hip or thigh regions were targeted, fore limb was darted at rare instances. Feed and water withdrawal was appropriated in most of the instances with all chemical restraint between 8.00 A.M to 10.00 A.M as suggested by Beltrán, J. F., & Tewes, M. E. (1995). Immediately after a successful dart the animal was observed for signs of ataxia, sternal recumbency, lateral recumbency and the abolishment of the ear flick reflex (as an indicator to safely approach the animal) in coincidence with observations of Allwin et. al., (2018). The time taken for ataxia, time of lateral recumbency, time for abolishment of ear flick reflex, the duration of anaesthesia was recorded. The doses were computed on the estimated body size and the actual weight was measured post immobilization. The most fundamental things like patent Venous access, Endotracheal intubation and temperature monitoring were mandated in these procedures. Anesthesia monitoring was done with standard observations. The vital signs such as heart rate, respiratory rate, pulse rate and complete cardiovascular monitoring, oxygen saturation, temperature post induction were recorded at an interval of 5 minutes (Allwin et. al., 2018). The size of the ET tube was to be standardised in the immobilizations, which aids in the airway management. Oxygen therapy-a portable oxygen cylinder was used and kept handy along with the humidifier to avoid the drying of the drying of the nasal mucosa. The Spo2 falling below 95% warranted oxygen supplementation (West et. al., 2014).

RESULTS AND DISCUSSION

This study compares two widely used anaesthetic protocols Medetomidine - Ketamine (MK) and Zolazepam-Tiletamine (ZT) for immobilization in captive caracals. Both protocols provide safe and effective anaesthesia, but each has specific advantages and considerations based on physiological responses and procedural requirements. the findings are tabulated in Table1. The advantage of using a blow dart syringe capacitated a no noise administration and enabled a smooth delivery of the adequate value of the drug, however the mixing of the two drugs is inevitable and their dissociations are not within the scope of this study. All darts were freshly prepared and used with 5 mins of preparation. Proximity to humans, conspecific house mates were avoided to reduce pre-excitation via both physiological and psychological perceptions as opined by Allwin et. al., 2018. All inductions were confirmed by a negative ear flick reflex and was used as an indicator for safety approach as opined by Nielson (1999). The venous access was got by accessing the cephalic vein in the forelimb using a 20G, the endotracheal intubation was warranted to keep the control over the airways and during emergencies. An ET tube of size 5, 6 was adequately enough for animals weighing from 14-16 kg, 17-20kg respectively with fair to good intubation score. The use of bandages allowed controlling the opening of the oral cavity upper and lower, this enhanced the visualization and the safety of the intubation (West et. al., 2014). In this procedure we modified a needle cap to function as a gag,

ensuring the oral cavity remained open and confirmation of tracheal intubation was done visually during placement, tracheal tube expiration and the movement of the reservoir bag. The ECG (Electrocardiogram) probes were laden and a temperature rectal temperature probe was in place for constant temperature recording and regulations. The pulse oximeter was used to monitor and determine the oxygen saturation, in this case the placement was on the inner surface of the pinna, without any motion artifacts and to ascertain reliability the quality of the plethysmography waveform was checked, and it accounted to three quarters of the length (West et.al 2014). The heart rate was confirmed and compared with a stethoscope, ECG therefore co-relating to the relevant clinical observation produced by the device. The various standpoint parameters for monitoring anesthetic depth such palpebral reflex, corneal reflex and ocular globe positioning were systematically recorded in the Table 1.

A constant monitoring of temperature was essential, and hypothermia is a significant concern during prolonged procedures in this species that is due to their high surface area to volume ratio, relatively low body fat and adaptations to warmer climate. Also, suitable heating devices, warmer fluid therapy to be advised for longer procedures. There was relative dip in the temperature (Table 1) in both the protocols and this was contrary to the findings of Beltrán, J. F., & Tewes, M. E. (1995).

CONCLUSION

The doses used Medetomidine @0.03 mg/kg, Ketamine @3 mg/kg and Zolazepam-Tiletamine (ZT) @ 4 mg/kg one of the pioneering usage provided effective anaesthesia in caracals, each with distinct advantages. Zoletil is preferred for short procedures due to its rapid induction. The authors recommend that the Monitoring of temperature, respiration, and cardiovascular function is crucial in both protocols. Furthermore, pointers for significant monitoring are as follows, Loss of the corneal reflex can indicate excessive anaesthetic depth and potential risk of complications. Presence of a weak corneal reflex suggests an appropriate anaesthetic plane but requires monitoring. If the reflex remains brisk, anaesthesia may be too light, increasing the risk of movement or reaction to surgical stimuli. Therefore, the authors conclude that critical monitoring reduces the risks and acts a fail-safe with this magnificent species. Further intrinsic research is recommended for more concrete findings.

SEQUENTIAL FLOW OF EVENTS PERTAINING TO THE IMMOBILISATION OF CARACALS

Fig. 1: Darting using blow dart

Fig. 2: Successful darting and onset of anaesthesia

Fig. 3: Body weight measurement

Fig. 4: Visualisation of glottis and oral cavity

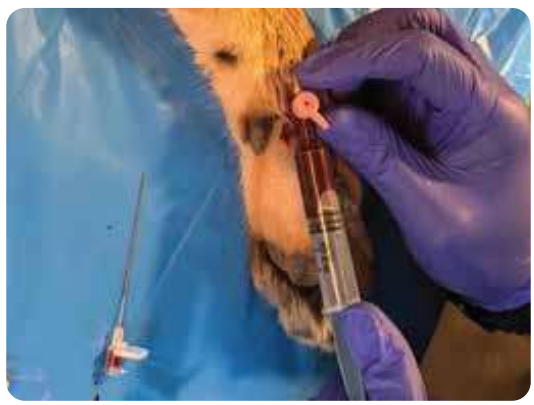


Fig. 5: Blood sampling

Fig. 6: Placement of intravenous catheter in cephalic vein

Fig. 7: Placement of SpO2 probe – ear lobe

Fig. 8: Placement of endotracheal tube- use of bandages to control the opening of the jaws

Fig. 9: Tracheal tube expiration seen-Validating conformation of intubation

Fig. 10: Placement of modified gag (needle cap)

Fig. 11: Blindfolding to avoid visual stimulation

Fig. 12: Vital signs monitoring

Fig. 13: Placement of rectal temperature probe

Fig. 14: Monitoring of cardiovascular and respiratory systems

Table 1: Comparative Analysis of the Two Protocols

PARAMETER	MEDETOMIDINE-KETAMINE (MK) N=6	ZOLETIL (ZOLAZEPAM-TILETAMINE) N=6
Dose*	Medetomidine: 0.03 mg/kg, Ketamine: 3 mg/kg	Zoletil: 4 mg/kg
Induction Time*	4.77 ± 0.18 min (ataxia), 7.31 ± 0.23 min (recumbency)	3.0 ± 0.11 min (ataxia), 4.76 ± 0.19 min (recumbency)
Duration of Anaesthesia*	40 ± 1.18 min	38.33 ± 1.36 min
Rectal Temperature*	101.65°F -> 100°F at 20 min	102.6°F ->99.3°F at 25 min
Heart Rate*	135 bpm (5 min) ->94 bpm (30 min)	168 bpm (5 min) -> 132 bpm (30 min)
Respiratory Rate*	58 bpm -> 25 bpm (30 min)	42 bpm -> 27 bpm (20 min)
Mucous Membrane*	Pale Pink throughout	Pale Pink throughout
Reversal Agent Available PARTIAL	Atipamezole @5mg/mg of Medetomidine used IM or S/C	Flumazenil @ 31-> g/Kg (Zolazepam) I/V
Muscle Relaxation	Good	Good to Fair
Corneal reflex	Initially present but sluggish. Depressed but present while attaining surgical plane.	Initially present but sluggish. Depressed but present while attaining surgical plane.
Palpebral reflex	Initially weak Significantly reduced to absent in surgical plane	Weakens with depth of anaesthesia
Ocular Globe position	Medial to Ventro-medial rotation at surgical plane	Usually remains Central in surgical plane.

***ANNEXURE TABLES**

Table 2: Final Recommendations: Best Protocol for validations

PROCEDURE TYPE	RECOMMENDED PROTOCOL	JUSTIFICATION
Short procedures (<30 min, e.g., minor wound care, physical exams, Imaging)	Zoletil (4 mg/kg)	Faster induction, shorter recovery, stable cardiovascular effects.
Longer procedures (30-60 min, e.g., dental work, minor surgery)	Medetomidine-Ketamine (0.03 mg/kg + 3 mg/kg)	Longer duration, good muscle relaxation, reversible with Atipamezole
Procedures requiring quick reversal (e.g., diagnostic imaging, capture-release.)	Medetomidine-Ketamine	Reversible with Atipamezole, better for planned awakenings
Cardiovascular-sensitive animals	Zoletil	Less bradycardia than Medetomidine-Ketamine
Procedures where thermoregulation is a concern	Medetomidine-Ketamine (with external warming)	Less temperature drops than Zoletil

REFERENCES

Allwin Boon, Jayathangaraj M.G., Latha Ravi Bhaskaran, K.Vijayarani, S.Vairamuthu (2018). Clinical evaluation of xylazine and ketamine for immobilization of the captive Bengal tigers (Panthera tigris tigris). Indian Journal of Animal Research. 52(8): 1236-1239. doi: 10.18805/ijar.B-3325.

Arnemo, J., Linnell, J., Wedul S.J., Ranheim, B., Odden, J. and Andersen R. (1999). "Use of intraperitoneal radio-transmitters in lynx Lynx lynx kittens: anaesthesia, surgery and behaviour," Wild. Bio., 5(4): 245-250.

Beltrán, J.F. and Tewes, M.E. (1995). Immobilization of ocelots and bobcats with ketamine hydrochloride and xylazine hydrochloride. J Wildl Dis., 31(1): 43-48.

Shindle, D.B. and Tewes, M.E. (2000). Immobilization of wild ocelots with tiletamine and zolazepam in southern Texas. J Wildl Dis., 36: 546–550.

Grassman, LI.Jr., Austin, S.C., Tewes, M.E. and Silvy. N.J. (2004). Comparative immobilization of wild felids in Thailand. J Wildl Dis., 40(3): 575-578.

Langan, J. N., Schumacher, J., Pollock, C. G., Orosz, S. E., Jones, M. P. and Harvey, R. C. (2000). Cardiopulmonary and anesthetic effects of medetomidine-ketamine-butorphanol and antagonism with atipamezole in servals (Felis serval). J. Zoo Wildl. Med., 31(3): 329-334.

Nielsen L. 1999. Chemical Immobilization of Wild and Exotic Animals. Ames: Iowa State University Press. 400 pp.

Schumacher J, Erdtmann J, Pollock C, et al. 1999. Comparative cardiopulmonary and

anesthetic effects of ketamine-medetomidine and ketamine xylazine in cougars (Felis concolor). Annual Conference of the American Association of Zoo Veterinarians, pp. 45–46.
West, G., Heard, D. and Caulkett, N. (Eds.). (2014). Zoo Animal and Wildlife Immobilization and Anesthesia (2nd ed.). Wiley-Blackwell. 976 pp. ISBN: 978-0813811833.

ANNEXURE TABLES

Table A: Dose evaluation of Medetomidine & Ketamine (MK) in captive caracals (n=06)

ESTIMATED BODY WEIGHT (KG)	ESTIMATED TOTAL DOSE		ACTUAL WEIGHT (KG)	TOTAL DOSE ADMINISTERED	
	MEDETOMIDINE(MG) @ 0.03 MG/KG	KETAMINE (MG) @ 3MG/KG		MEDETOMIDINE (MG/KG)	KETAMINE (MG/KG)
18	0.54	54	17.2	0.031	3.1
18	0.54	54	19.1	0.028	2.82
15	0.45	45	15.5	0.029	2.9
16	0.48	48	15.8	0.03	3.03
14	0.42	42	12.9	0.032	3.25
20	0.6	60	19.7	0.03	3.04
			16.7± 1.027	0.03±0.0005	3.02±0.061

Table B: Immobilisation related observations, Medetomidine & Ketamine (MK) in captive caracals (n=06)

OBSERVATIONS	TIME (MEAN ± SE) IN MINUTES
Time taken for ataxia	4.77±0.18
Time for lateral recumbency	7.31±0.23
Time for abolishment of ear flick reflex	10.04±0.37
Duration of anaesthesia	40±1.18

Table C: Vital parameters post induction in captive tigers (n=06) Medetomidine & Ketamine (MK)

	POST INDUCING MONITORING								
PARAMETERS	**05TH MINUTE**	**10TH MINUTE**	**15TH MINUTE**	**20TH MINUTE**	**25TH MINUTE**	**30TH MINUTE**	**35TH MINUTE**	**40TH MINUTE**	**45TH MINUTE**
Rectal Temperature (F)	101.65±0.45	101.7±0.9	100.85±0.85	100±1	100.55±0.75	100.8±0.6	100.9±0.3	101±0.2	101±0.6
Respiratory rate (breath/min)	58±2	42±3	39±1	37±3	34±5	25±2	28±4	35±6	41±3
Heart rate (breath/min)	135 (130-141)	124(120-130)	115(110-120)	101(95-105)	96(90-100)	94 (90-100)	96(90-100)	110(105-115)	116(110-120)
CRT	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs
Colour of the mucus membrane	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink

Table D: Dose evaluation of Zolazepam-Tiletamine (ZT)in captive caracals (n=06)

ESTIMATED BODY WEIGHT (KG)	ESTIMATED TOTAL DOSE ZOLAZEPAM-TILETAMINE (MG) @ 4 MG/KG	ACTUAL WEIGHT (KG)	TOTAL DOSE ADMINISTERED ZOLAZEPAM-TILETAMINE (MG) @ 4 MG/KG
18	72	18.8	3.82
15	60	16.1	3.72
17	68	16.6	4.09
19	76	18.5	4.1
20	80	20.1	3.98
15	60	15.7	3.82
		17.63± 0.71	3.92±0.064

Table E: Immobilisation related observations, Zolazepam-Tiletamine (ZT) in captive caracals (n=06)

OBSERVATIONS	TIME (MEAN ± SE) IN MINUTES
Time taken for ataxia	3±0.11
Time for lateral recumbency	4.76±0.19
Time for abolishment of ear flick reflex	6.93±0.0.18
Duration of anaesthesia	38.33±1.36

Table F: Vital parameters post induction in captive tigers (n=06), Zolazepam-Tiletamine (ZT)

	POST INDUCING MONITORING								
PARAMETERS	**05TH MINUTE**	**10TH MINUTE**	**15TH MINUTE**	**20TH MINUTE**	**25TH MINUTE**	**30TH MINUTE**	**35TH MINUTE**	**40TH MINUTE**	**45TH MINUTE**
Rectal Temperature (F)	102.6±0.3	102.1±1	101.2±0.5	99.9±0.1	99.3±0.75	100.2±0.6	100.7±0.4	101.1±0.7	101.6±0.8
Respiratory rate (breath/min)	42±3	37±1	31±4	27±2	28±5	34±2	32±1	36±6	44±4
Heart rate (breath/min)	168 (155-170)	147(140-150)	142(140-150)	144(140-1150)	138(130-140)	132(130-140)	136(130-140)	142(140-150)	146(140-150)
CRT	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs	<2 secs
Colour of the mucus membrane	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink	Pale Pink

22

Chemical Immobilization of Wild Nilgais *(Boselaphus tragocamelus)* with Medetomidine and Zoletil Combination for translocation of conflict animals.

Shubham Patil[1], Sujay Suresh[1], Boon Allwin[1], Kalaignan. Pa[1], Brij Kishor Gupta[2]

[1]Veterinary officer GZRRC, [2]Director GZRRC.

ABSTRACT

The chemical immobilization of Nilgai (Boselaphus tragocamelus) is crucial for managing human-wildlife conflicts. In these instances, we used a combination of Medetomidine (0.05 mg/kg) and Zoletil (1.5 mg/kg) for immobilization over a total anesthetic duration of 2.5 hours, with isoflurane 3% maintenance, before reversal with Atipamezole (administered at five times the total Medetomidine dose). A total of six Nilgais (four males and two females) were successfully sedated, monitored, and relocated to their natural habitat. Physiological parameters were recorded throughout the anesthetic period, ensuring stability and safety. The average induction time was about 14 minutes. The physiological responses of the Nilgai were as follows:

PARAMETER	AVERAGE VALUE
Heart Rate (bpm)	43
Respiratory Rate (breaths/min)	9.5
Body Temperature (°C)	39.4

Fig 1. An Immobilised Nilgai being attended by the veterinary staff

Atipamezole effectively reversed sedation, allowing smooth recovery before the Nilgai were released into protected areas. These immobilization protocol provides a standardized approach for Nilgai immobilization in conflict zones.

INTRODUCTION

Wildlife species like the Nilgai (Boselaphus tragocamelus), a large herbivore species native to the Indian subcontinent, often come into conflict with humans, especially in areas where their habitats overlap with agricultural zones or urban settlements. The Nilgai is listed as a species of 'least concern' by the International Union for Conservation of Nature (IUCN) and Sehedule 3, Wildlife Protection Act of 1972, but its growing populations in certain regions have led to an increase in human-wildlife interactions, including crop depredation, property damage, and even occasional injuries to humans.

To address such conflicts, wildlife authorities often resort to chemical immobilization, which provides a safe method of capturing and relocating animals without causing harm. The choice of anesthetic agents is crucial, as it determines the success of immobilization and minimizes the risks to both the animal and personnel involved in the procedure.

MATERIALS AND METHODS

A total of six Nilgai (4 males and 2 females) were immobilized at various locations around Jamnagar city, Gujarat, where these animals had entered human settlements, posing a risk to public safety and agriculture. The immobilization protocol involved the use of two agents: Medetomidine, an alpha-2 adrenergic agonist, and Zoletil (a combination of tiletamine and zolazepam), a dissociative

anesthetic commonly used in wildlife immobilization (Kumar & Pathak, 2020).

The dosage for Medetomidine was 0.05 mg/kg body weight (Bw), and Zoletil was administered at 1.5 mg/kg Bw together. The anesthetic combination was injected intramuscularly (IM) using a dart or syringe. Following the administration of the drugs, the Nilgais were monitored until they showed signs of sedation, which included reduced physical activity, muscle relaxation, and diminished responsiveness to external stimuli. Continuous oxygen supply above 10 bars pressure was supplied from time immobilized and Isoflorane 3% was started 45 min post immobilization for maintenance purpose as some eye reflex was noticed.

Atipamezole was administered IM at 150 minutes, resulting in full recovery within 14 minutes.

Fig 2. Nilgai being darted

Fig 3. A Nilgai after sedation

Table 1: Physiological Parameters Over 2.5 Hours

TIME INTERVAL (MINUTES)	HEART RATE (BPM)	RESPIRATORY (BREATHS/MIN)	BODY TEMPERATURE (°C)
0 (Pre-anesthesia)	-	-	-
20	50	12	40.5
30	44	10	40.1
60	42	8	39.8
90	41	8	38
120	40	9	38.5
150	39	10	39.3

DISCUSSION

The use of Medetomidine and Zoletil in immobilizing Nilgai has proven to be effective in providing a rapid and reliable sedation protocol. Medetomidine, as an alpha-2 agonist, offers several benefits, including sedation, analgesia, and muscle relaxation, while Zoletil, a combination of tiletamine and zolazepam, induces a dissociative anesthesia and analgesia that is suitable for handling large wildlife species (Rauch et al, 2022).

The physiological parameters remained stable throughout the procedure, as shown in Table 1, demonstrating minimal stress impact and a controlled anesthetic depth during the course of translocation. The administration of Atipamezole intramuscularly ensured smooth recovery with no adverse effects, in line with findings by Kumar & Pathak (2020) and Donaldson et al. (2023). Zolazepam was not reversed we did not want the animal to be excited during the release.

CONCLUSION

Chemical immobilization using a combination of Medetomidine and Zoletil is an effective and safe method for immobilizing Nilgai in human-wildlife conflict situations. The protocol demonstrated successful sedation, stable physiological parameters, and smooth recovery when combined with Atipamezole for reversing the effects of Medetomidine (Ministry of Forest and Climate Change, 2014). This study highlights the importance of proper anesthetic protocols in managing wildlife, ensuring both the safety of the animals and the personnel involved in their capture and relocation to their natural habitat.

REFERENCES

Kumar, R., & Pathak, M. (2020). Systemic Effects and Clinical Application of Medetomidine in Animals: A Review. Indian Journal of Animal Research, 54(9), 1063-1068.

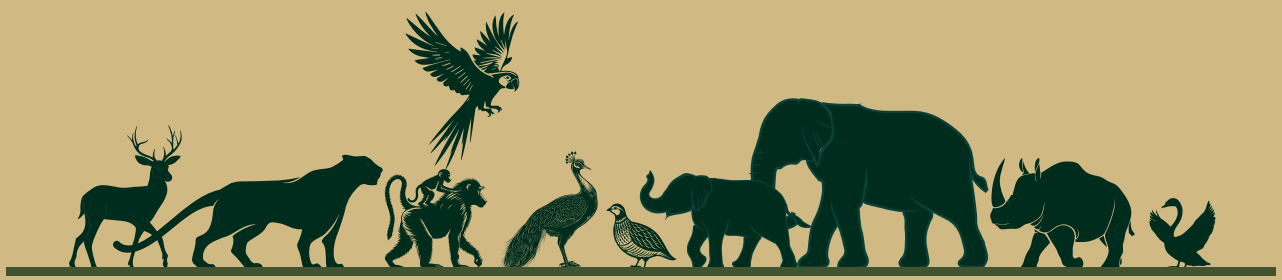
Ministry of Environment, Forest and Climate Change. (2014). Advisory on Human-Wildlife Conflict Management.

Rauch et al., Comparison of the Cardiovascular Effects of Two Medetomidine Doses Combined with Tiletamine-Zolazepam in Red Deer *(Cervus elaphus)*. (2022). Journal of Wildlife Diseases, 58(1), 188-198.

Donaldson et al., Comparison of the Cardiovascular Effects of Immobilization with Three Drug Combinations in African Lions *(Panthera leo)*. (2023). Conservation Physiology, 11(1), coac077.

Comparison with other large erbivores

SPECIES	MEDETOMIDINE DOSE (MG/KG)	ZOLETIL DOSE (MG/KG)	AVERAGE INDUCTION TIME (MIN)	AVERAGE RECOVERY TIME (MIN)
Nilgai	0.05	1.5	16	14
Sambar deer	0.05	1.5	20	16
Spotted deer	0.02	1	10	9



INDIAN ZOO DIRECTOR'S ASSOCIATION

◆

CENTRAL ZOO AUTHORITY

◆

GREENS ZOOLOGICAL RESCUE
& REHABILITATION CENTRE