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WILDLIFE CRIMES AND FORENSICS: CHALLENGES AND ADVANCES IN ENFORCEMENT

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Abstract

This study examines the pivotal contribution of forensic science to combating wildlife crime, an expanding transboundary phenomenon with serious ecological and legal consequences. With the proliferation of illicit wildlife trafficking and deforestation, conventional enforcement tools are frequently inadequate to deliver convictions. This study seeks to assess the efficacy of forensic techniques in investigating wildlife crime, weigh current challenges, and identify ways to strengthen enforcement and conservation. The paper starts by outlining the international legal framework for wildlife conservation, focusing on international conventions and local laws that regulate the enforcement of wildlife crimes. It then initiates a comprehensive discussion of forensic methods such as DNA profiling, toxicology, and fingerprinting. These techniques are vital for species identification, verifying evidence, and linking suspects to crimes. The study also examines conservation strategies for flagship species in India, assessing successes and continuing challenges. Core barriers such as infrastructural shortcomings, availability of resources, and gaps in forensic competence, form a crucial part of the study. Further, community participation and preventive forensic measures and their role in reducing wildlife crimes are discussed. A doctrinal research approach is followed where the analysis draws on legal tools, forensic case studies, academic literature, and government documents. It looks at this through the prism of gaps in forensic infrastructure, an assessment of the status of wildlife forensic science in India, and recommendations for improving investigative and enforcement capacities. The paper concludes by calling for policy reforms, greater investment in forensic labs, and greater international cooperation to enhance the role of forensic science in enforcing wildlife crime.

***Keywords**: Wildlife crime; Forensic science; Conservation strategies; Law enforcement*

INTRODUCTION

Hunting has been an integral aspect of human societies since ancient times, tracing its roots back to the era of hunter-gatherers. It has historically served as a means of survival, providing food, clothing, and tools. Over time, however, hunting practices evolved, with some becoming deeply embedded in cultural and recreational activities. In the contemporary world, hunting—motivated by luxury, status symbols, and commercial trade—has increasingly been categorized as wildlife crime due to its adverse consequences, including endangerment of species, animal cruelty, and the facilitation of illicit trafficking of wildlife and its products, as well as the destruction of wildlife habitats. Wildlife forensics, therefore, refers to applying scientific methodologies to assist wildlife law enforcement agencies in detecting crimes and their subsequent prosecution.

In an effort to combat wildlife offenses, various regulations have been enacted globally to protect endangered species and preserve diverse ecosystems. International agreements such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) have played a pivotal role in regulating wildlife trade and curbing illegal activities. Despite these efforts, significant challenges remain, largely because perpetrators frequently evade legal consequences, as the victims—wildlife—cannot advocate for themselves.

In India, substantial progress has been achieved through various legislative measures, including the Wildlife Protection Act (1972), the Forest Conservation Act (1980), and the Environment Protection Act (1986). Additionally, establishing sanctuaries, national parks, and conservation reserves has further contributed to these advancements. Institutions such as the Wildlife Crime Control Bureau have been

established to enhance protective and conservation initiatives. Nevertheless, data from the National Crime Records Bureau suggests that the number of cases registered under the Wildlife Protection Act has significantly decreased in recent years, with only 296 cases documented in 2023.(1)

The effectiveness of stringent laws and policies has not deterred offenders, as evidenced by low conviction rates, primarily attributed to a lack of evidence and the considerable financial incentives involved. Often, these culprits are linked to larger organized crime networks, which are driven by significant monetary gain. The United Nations Office on Drugs and Crime (UNODC) published a report in May 2024 about global wildlife crime. The report shows that traffickers target over 4,000 species, and illegal wildlife trade occurs in more than 80% of countries around the world.(2) This illegal activity is fueled by demand for various reasons, such as medicine, pets, bushmeat, decorative plants, and trophies. It is important to note that 40% of the mammals, birds, reptiles, and amphibians that were seized are considered threatened or near-threatened species. The UNODC points out that wildlife crime causes great damage to nature, affecting people's livelihoods, public health, governance, and the ability of our planet to fight climate change. Even though there are international efforts to stop this crime, the report states that we are not on track to meet the UN Sustainable Development Goal of ending wildlife trafficking of protected species by 2030.(3)This underscores the need to integrate advanced scientific tools into wildlife crime investigations to dismantle these networks and bring offenders to justice.
To thoroughly understand wildlife crime and to conduct comprehensive wildlife forensic examinations, the collection and preservation of evidence is essential. Such crimes are typically concealed, often discovered long after their occurrence, or the actual form of the wildlife organisms involved is altered. The complexity of addressing these issues is further compounded by the challenges associated with gathering sufficient evidence. For evidence to be admissible in court, it must be properly handled, documented, and preserved. The nature of evidence varies depending on the type of crime and the species involved, encompassing whole organisms—both living and deceased—as well as animal parts such as fur, feathers, bones, and organs, in addition to derived products like jewellery, processed meats, clothing, ornaments, and medicines.(4) Advances in wildlife forensics have largely paralleled developments in human forensics, with certain cases inspiring innovative techniques and solutions specifically designed for animal-related investigations.(5) Samples obtained from animals and crime scenes can include a diverse array of materials, such as snake venom, turtles, tortoises, seahorses, mynas, munias, tiger and leopard bones, ivory, elephant tusks, and rhinoceros horn.(6) Consequently, forensic laboratories must continuously adapt, update, and validate their methodologies and techniques to accommodate these evolving challenges.

GLOBAL FRAMEWORK FOR WILDLIFE PROTECTION

The international community has made significant strides in addressing wildlife crime through treaties and organizations aimed at conservation. CITES, established in 1975, has been instrumental in regulating the trade of endangered species and ensuring that international commerce does not threaten their survival. Over 185 countries are parties to this agreement, which monitors and restricts the trade of approximately 38,700 species of flora and fauna.(7)
Despite international frameworks like CITES, enforcement of wildlife protection laws remains inconsistent across nations, particularly in developing countries that often lack the necessary resources for full compliance. The illegal trade of pangolins—among the most trafficked mammals globally—continues to thrive despite protective measures. High-profile cases, such as the seizure of over fourteen tons of pangolin scales in Singapore in 2019, underscore both the successes of international collaboration and the persistent challenges. (8) Strengthening partnerships between nations and enhancing forensic capabilities is essential for more effective intervention against these crimes.
Recent incidents in India highlight the ongoing challenges in combating wildlife trafficking. In October 2024, authorities in Pune seized nearly 198 kilograms of illegal coral stones and two Macaw birds during raids on pet stores and households, indicating a rise in illegal wildlife trade in the region. (9)
Similarly, in June 2024, the Madhya Pradesh State Tiger Strike Force dismantled a trafficking ring, seizing exotic animals including Wall Pythons and Iguanas that were being transported illegally from Hyderabad. The investigation revealed a well-organized network operating across state lines, utilizing fake government accounts to mask their activities. (10)
These cases illustrate the persistent nature of wildlife trafficking and the need for continued vigilance and enhanced enforcement efforts to protect endangered species.

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TECHNIQUES INVOLVED

The application of forensic science to wildlife has led to significant advancements in combating crime. This progress is exemplified by the joint operations conducted by WCCB from 2014- 2021 related to a poaching and wildlife trafficking operation in India.(6) A concerning trend in drug addiction circles involves the use of snake venom, which not only endangers the animals but also poses serious health risks to users.(11) These cases present unique challenges for forensic scientists and investigators. Researchers are continually refining techniques to address complex evidence scenarios, such as identifying tanned hides or degraded materials and distinguishing powdered venom from illegal drugs.

In India, wildlife crime remains a pressing issue. According to a 2023 report by TRAFFIC and WWF-India, between 2018 and 2022, there were 342 seizure incidents involving pangolins, accounting for over 1,200 individuals poached and trafficked.

Additionally, data from the National Crime Records Bureau indicates that in 2022, Rajasthan recorded a 50% increase in wildlife crime cases compared to 2021, accounting for 30% of such cases nationwide. (12)

These statistics underscore the critical role of wildlife forensics in law enforcement. By employing advanced scientific methods, forensic experts can provide crucial evidence to identify and prosecute offenders, thereby contributing to the preservation of endangered species and the protection of biodiversity.

Given the diverse nature of crime samples, wildlife forensic scientists must have an in-depth understanding of various DNA methods, including PCR, DNA barcoding, and mitochondrial DNA sequencing for identifying species and individuals. DNA barcoding, for example, has been used to identify processed animal products like tiger bone wine or pangolin meat, helping law enforcement build strong cases against traffickers. Morphological analysis remains critical for examining physical traits and assessing conditions of seized materials, especially when DNA is degraded or unavailable. Additionally, chemical analysis, such as isotope analysis, determines the geographic origins of samples, aiding in tracing the source of poached animals or plants.(13)

Recent developments have included the use of fingerprinting in wildlife forensic exhibits such as eggshells, ivory, teeth, bones, leather, and antlers, showcasing its increasing usefulness and broader application in wildlife forensic investigations.(13) Additionally, blow fly eggs from deceased cubs were utilized to establish the time of death, contributing to a conviction in Canada regarding two young black bears that were found disembowelled.(14) Indian wildlife forensic scientists must prepare for similar challenges. Emerging technologies such as artificial intelligence (AI) and machine learning are being explored to automate the identification of species in large datasets and analyze patterns in wildlife trafficking networks. These innovations hold great promise for enhancing the speed and accuracy of investigations.

RECENT TRENDS AND TECHNOLOGICAL INNOVATIONS IN WILDLIFE FORENSICS

Recent years have witnessed a paradigm shift in wildlife forensic science with the integration of advanced technologies that enhance surveillance, evidence collection, and analytical accuracy. Unmanned Aerial Vehicles (UAVs) or drones have emerged as transformative tools in monitoring protected areas, mapping illegal encroachments, and detecting carcasses in remote terrains. Their real-time imaging capabilities significantly strengthen anti-poaching patrols and facilitate the documentation of crime scenes that are otherwise inaccessible.

Environmental DNA (eDNA) analysis represents another major advancement. By detecting trace genetic material from soil, water, or air samples, investigators can identify the presence of endangered or illegally traded species without physically encountering them. This method has proven particularly effective in tracking aquatic species such as turtles and dolphins, offering non-invasive evidence for enforcement agencies.

Artificial Intelligence (AI) and machine learning technologies are increasingly employed to identify species through automated image recognition, analyze trafficking networks, and predict poaching hotspots based on spatial and temporal patterns. Geographic Information Systems (GIS) and remote sensing complement these innovations by enabling habitat surveillance and the correlation of wildlife movements with illicit trade routes.

Other emerging practices include the use of **portable forensic kits** for rapid field testing of animal DNA and **blockchain-based traceability systems** for verifying the legality of wildlife products across supply

chains. Together, these developments illustrate a decisive move toward data-driven and technology-enabled enforcement, aligning wildlife forensics with global best practices recommended by INTERPOL, UNODC, and the Wildlife Crime Control Bureau (WCCB).

CONSERVATION EFFORTS FOR ICONIC SPECIES IN INDIA

India is home to a rich array of biodiversity, including some of the world's most iconic species like tigers, elephants, and rhinoceroses. Recognizing the importance of conserving these species, the government and various organizations have implemented dedicated initiatives to ensure their survival.

Tiger Conservation: Project Tiger, initiated by India in 1973, is a significant conservation program dedicated to safeguarding Bengal tigers and their habitats. As of December 2024, the initiative has expanded to include 57 tiger reserves across the country.(15)

These efforts have led to a notable increase in the tiger population, which reached approximately 3,682 individuals in 2023, accounting for nearly 75% of the world's wild tiger population. (16)

Despite these achievements, challenges such as habitat fragmentation and poaching persist. Forensic science plays a crucial role in combating poaching by enabling the identification of offenders through DNA analysis of seized tiger body parts, including skins and bones.

Elephant Conservation: Project Elephant, launched in 1992, focuses on protecting Asian elephants and their habitats. The program emphasizes mitigating human-elephant conflicts and securing migratory corridors. Forensic methods are crucial in combating ivory trafficking, with techniques such as isotopic analysis used to trace the geographic origins of ivory and identify poaching hotspots. Collaborative efforts with international organizations have also been pivotal in tackling cross-border ivory trade.(17)

Rhinoceros Conservation: The Indian Rhino Vision 2020 (IRV2020) was launched in 2005 with the ambitious goal of increasing Assam's greater one-horned rhinoceros po 885upulation to 3,000 by the year 2020, distributed across seven protected areas. (18)

As of 2024, Assam's one-horned rhinoceros population has surpassed 3,000, a significant increase from approximately 600 in the 1960s. (19)

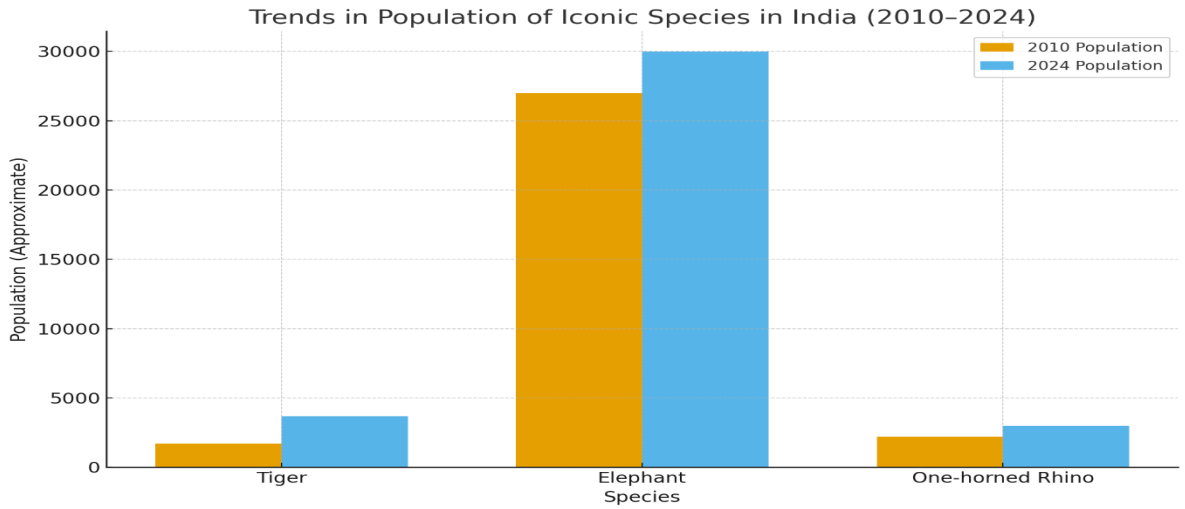
This success is attributed to effective conservation strategies, including translocation efforts and enhanced anti-poaching measures. Despite these achievements, challenges persist, particularly concerning the illegal trade in rhino horns.

Wildlife forensics, notably DNA profiling, plays a crucial role in tracing the origins of seized rhino horns and aiding in the prosecution of poachers.

The International Union for Conservation of Nature (IUCN) continues to classify the one-horned rhino as "vulnerable," indicating that ongoing vigilance and conservation efforts are essential to ensure the species' future. (20)

These conservation programs underscore the importance of integrating scientific research, community involvement, and robust legal frameworks to protect endangered species. Enhanced forensic methodologies can further strengthen these efforts by providing actionable evidence to combat wildlife crime.

Figure:1 Trends in Population and Poaching Incidents of Iconic Species in India (2010–2024)



Source: NTCA, MoEFCC, and Times of India (2024 data)

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OBSTACLES AND CONSTRAINTS

India is a vast nation where around 65% of the human population coexist with wildlife in protected areas. Instances often arise when animals venture into human territories in search of food, leading to their elimination under the justification of being man-eaters, which ultimately disrupts biodiversity.(6) Addressing these wildlife issues requires more than just forensic science; it calls for enhanced education and an environmental approach. Efforts should focus on encouraging public involvement in wildlife conservation and providing incentives for maintaining ecosystems and their associated biodiversity. Wildlife enforcement officers, non-governmental organizations, and the government must reconsider strategies to combat wildlife crime effectively.

The trade of wild and rare animals, birds, and ornamental plants is openly conducted in markets and online in India, often disguised as charms or symbols of good luck, creating significant challenges for enforcement officers. The Wildlife (Protection) Act of 1972 has limited provisions for controlling the trade of exotic species illegally smuggled across borders. (6)Therefore, rather than solely amending existing wildlife laws, there is an urgent need for awareness campaigns and incentives, alongside targeted efforts for the protection of endangered species and biodiversity. Consequently, preventive forensics plays a vital role in serving the public interest.

Crime scene investigation is a well-established field in routine cases, where scientists ensure effective evidence collection and preservation. However, in wildlife crime investigations, scientists face unique challenges due to the variety of potential victims and sources of evidence. Therefore, wildlife enforcement officers must be familiar with the extensive environments and diverse plant and animal life. This knowledge is crucial for proper evidence collection and preservation, preventing contamination, and thoroughly documenting every detail, as sound evidence management is necessary to withstand legal scrutiny. Local involvement from forest rangers, conservationists, and veterinarians can aid in managing wildlife crime scenes. (5)The international wildlife forensics community supports national agencies in developing standard operating procedures for evidence security and management.

THE NEED FOR INFRASTRUCTURE AND RESOURCES

Given the rise in wildlife crime and the rapid decline of species, there is a significant demand for wildlife laboratories across many states to enhance conservation efforts and address wildlife crimes. Currently, only one crime laboratory serves the vast and varied wildlife of India. The insufficient number of wildlife laboratories in many regions highlights the urgent need for government action to improve resources and expertise for advanced forensic analysis. A vital component of this effort is the comprehensive DNA database that reflects the genetic diversity and geographical distribution of India's various species. While resources like GenBank and the Barcode of Life assist in identifying commonly traded species,(5) developing databases focused on protected and endangered species poses additional challenges. Despite the effectiveness of DNA analysis in identifying species, issues such as degraded DNA samples often hinder analysis. As a result, a notable number of wildlife trade crimes may go unpunished due to forensic scientists lacking the tools or conducting tests based solely on law enforcement requests. There is an urgent requirement for standardized methods and protocols across various jurisdictions to ensure the consistency and reliability of forensic evidence. To enhance the impact of wildlife forensic science; collaboration among scientific, enforcement, and environmental sectors is vital.

COMMUNITY INVOLVEMENT AND PREVENTIVE FORENSICS

Local communities are very crucial for wildlife conservation and preventing crime. They often have valuable knowledge about animals and their habitats, which can help scientists. When communities take action, like patrolling forests or reporting suspicious activities, it can greatly reduce poaching in some areas. Education campaigns that raise awareness about the importance of wildlife are key to gaining public support for conservation. Furthermore, encouraging community involvement through eco-tourism or payment for services can help the economy and create a sense of responsibility for protecting wildlife.

Preventive forensics also aims to stop crimes before they happen. By analyzing past wildlife crime patterns, researchers can find hotspots and predict future threats. This helps law enforcement use their resources wisely to prevent crimes. Using technology, like GPS tracking for endangered species and monitoring forests with drones and satellite images, improves surveillance and enforcement. Working

together, governments, NGOs, and local communities can strengthen these preventive efforts and ensure that wildlife conservation is sustainable in the long run.

LEGAL AND TECHNICAL RECOMMENDATIONS FOR STRENGTHENING WILDLIFE FORENSIC ENFORCEMENT

Although India has achieved considerable progress through legislative and institutional measures, the effective prosecution of wildlife crimes continues to be constrained by procedural deficiencies, infrastructural gaps, and evidentiary weaknesses. The strengthening of wildlife forensic enforcement, therefore requires both legal reform and technological consolidation. From a legal perspective, it is essential to codify clear forensic admissibility standards under the Wildlife (Protection) Act, 1972, harmonising them with the provisions of the Indian Evidence Act so that expert testimony from wildlife laboratories attains full judicial credibility. Establishing a uniform national chain-of-custody protocol specific to wildlife specimens would prevent tampering and ensure evidentiary reliability during prosecution. In addition, the creation of a central wildlife DNA database under the Wildlife Crime Control Bureau or the National Forensic Sciences University would provide a validated reference for species identification and support inter-agency cooperation. Amendments to investigative guidelines should make the inclusion of forensic experts mandatory in all major wildlife crime inquiries, akin to the role of medical experts in homicide cases. As wildlife trafficking increasingly operates across borders, India should also institutionalise legal arrangements under CITES and the South Asia Wildlife Enforcement Network (SAWEN) to facilitate cross-border exchange of forensic data and evidence.

From a technical standpoint, the expansion of regional wildlife forensic laboratories integrated with state forensic infrastructures would substantially reduce delays and backlogs. The formulation of standard operating procedures for sample collection, analysis, and reporting, consistent with UNODC and INTERPOL manuals, is crucial for maintaining uniformity and reliability of results. Specialised training modules for forest and enforcement officers in evidence handling, preservation, and forensic documentation are equally important to avoid procedural lapses. Further, the adoption of digital surveillance systems—such as drones, GIS mapping, and AI-based detection—should be institutionalised within routine enforcement. Continuous collaboration between scientific institutions, law-enforcement agencies, and judicial authorities will enhance methodological integrity and strengthen the evidentiary value of wildlife forensics within the criminal justice system.

CONCLUSION

Wildlife forensics has become an indispensable pillar of modern conservation enforcement, bridging the domains of scientific inquiry and legal accountability. The integration of technologies such as drones, eDNA, artificial intelligence, and blockchain has revolutionised the detection, investigation, and prosecution of wildlife crimes. Yet these scientific tools can yield meaningful results only when supported by a coherent legal and institutional framework. India's legislative initiatives, including the Wildlife (Protection) Act and programmes such as Project Tiger, have laid a strong foundation; however, the absence of uniform forensic standards and limited infrastructural reach continue to impede effective enforcement. Strengthening statutory provisions, expanding laboratory networks, and promoting inter-agency cooperation remain essential to achieve credible and consistent outcomes. A coordinated policy that unites law, science, and technology will not only enhance conviction rates but also reaffirm India's commitment to global biodiversity conservation and the pursuit of justice for wildlife.

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