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Forensic Analysis of Poaching: Wildlife in the Legal Arena

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Poaching and the international wildlife trade are growing problems, fueled by a confluence of greed and poverty and managed by ever-more-evolving criminal networks. These actions lead to the loss of biodiversity, which is made worse by changes in habitat and drives many species to the verge of extinction. In this situation, forensic evidence is the cornerstone of investigations into crimes involving both people and animals, and it is essential to securing convictions and criminal prosecutions. The application of forensic methods—especially in the field of forensic genetics—is constantly progressing, giving investigators the instruments they need to address the many problems associated with wildlife-related inquiries.

This article highlights current developments while examining the evolution of these forensic tools and their useful uses. In addition, it provides examples of actual cases where forensic evidence was crucial in obtaining convictions, paving the way for the eventual application of similar methods to dismantle criminal organizations and safeguard species for the sake of maintaining biodiversity.

Keywords: Wildlife; crime; court; evidence; DNA.

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1. INTRODUCTION

Poaching and the unlawful commerce in animal parts and byproducts, which is often marked by brutality and insensitivity, are serious violations of human morality in addition to crimes against animals [1].

The illegal killing or stealing of animals is known as poaching, and it entails breaking local laws protecting wildlife populations [2-7]. Despite being there since the colonial era, poaching has developed into a sophisticated criminal industry that is intimately associated with organized crime [100]. In addition to directly endangering the existence of several species, this illegal practice provides financial support for terrorist organizations and internal strife. The transnational wildlife trade, or IWT, is a very lucrative but low-risk criminal enterprise [13-22]. When compared to the extent of poaching, the discovery rate of animal products trafficking is still startlingly low, and the penalties for those who engage in it are frequently light in many jurisdictions [50]. Acknowledging invasive wildlife trade (IWT) as a serious threat is essential for maintaining biodiversity, safeguarding the economies of the nations of origin, maintaining moral standards in society, and guaranteeing public safety. It is estimated that IWT will bring in between $7 billion and $23 billion annually. The worldwide trafficking of wildlife products has a variety of, frequently unforeseen paths [46-49]. It typically starts with the unlawful harvesting of products in source countries, travels through one or more transit countries, and ends up in consumer countries [8-12]. IWT covers a wide range of species and products, including as live animals for the pet trade, unusual meat for human consumption, body parts used in traditional medicine, and the creation of ornaments, fashion accessories, and trinkets. Within the IWT value chain, different criminal actors participate at different stages: poachers at the bottom, middle-tier intermediates that facilitate product transfer to traffickers and distributors, and end-users at the top. Remarkably, charismatic species are disappearing quickly [27,28,32]. For example, the number of tigers in the wild has decreased to about 2,000–3,000, and the number of African lions in the wild has decreased by 43% between 1993 and 2014, to about 23,000–39,000 individuals. The population of white rhinoceroses fell from 21,316 in 2012 to 18,064 in 2017, suggesting a downward trend. Due to COVID-19 restrictions, rhinoceros poaching in South Africa peaked in 2014 and then briefly decreased in 2020. But poaching has returned, especially in 2021 [42,43,45]. In South Africa's Kruger National Park, both the white and black rhinoceros populations have declined. Since 2011, poaching has been the main cause of the 67% decline in the white rhino population. Over the course of their range, African forest elephant populations have decreased by more than 80%. Between 1970 and 2016, there was an average 68% decrease in the number of monitored mammals, birds, fish, reptiles, and amphibians, according to the World Wildlife Fund for Nature Living Planet Index. Changes in land use, industrial and agricultural practices, climate change, habitat loss from human encroachment, and overexploitation of natural resources, including animal species, are just a few of the ways that human activities have contributed to biodiversity loss throughout history. Data from 180,000 seizures in 149 countries, covering over 6,000 species, are gathered by the UN Office on Drugs and Crime World Wildlife Seizure database (World WISE). The majority of the data used in World WISE comes from reports on illicit trade under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The breadth of IWT and the great diversity of species involved are highlighted by these data [62].

2. DRIVERS OF POACHING

The main causes of poaching in source countries are corruption and a lack of political will to confront IWT as a major threat. Greed is frequently the driving force behind corruption, and it can be made worse by the underpayment of public servants and law enforcement personnel [51-56]. These issues are made worse by poverty and the uprooting of communities from protected areas. Conflicts are likely to arise between displaced communities dealing with wildlife conflicts and others who benefit greatly from land and wildlife ownership [29-31]. Poaching must be controlled with strategies that involve the community and benefit sharing. The issue is made more difficult by insufficient law enforcement and the dearth of specialist scientific support services [58-61]. A sense of prestige is bestowed through the ownership, exchange, and consumption of valuable, uncommon objects, particularly those pertaining to animal species. The ownership, exchange, and ingestion of valuable, uncommon objects—particularly those derived from animals—are perceived to bestow a feeling of honor or reverence on those who consume them; this is a practice that has been noted in many Asian nations, chiefly China [23]. Considering that eating endangered animals is closely associated with one's identity and social standing in many Asian cultures, and that the consumer base is primarily made up of young, well-off professionals [24], it is clear that changing consumer behavior will be a difficult task that, if it happens at all, will take time. Demand is anticipated to exceed supply in this situation, especially for vulnerable species like pangolins [25]. The illegal wildlife trade involves a variety of activities, such as the hunting of bushmeat, the trade in exotic pets, the procurement of skins and pelts for the fashion industry, and the practice of traditional Chinese medicine (TCM). Traditional Chinese Medicine (TCM), which dates back thousands of years and includes herbal remedies that often contain ingredients derived from different animal species, is a major contributing factor to poaching. These remedies, which include bear bile, powdered horn and scales, and wines made from animal bones, are used to treat a wide range of illnesses, from infections and fevers to general malaise and reproductive problems, among others [26].

Ivory, much like other rare and exotic animal byproducts such as rhino horn, has long been associated with prestige and privilege. It holds immense value as both gifts and symbols of influence. Ivory carving, deeply rooted in history, is regarded as a refined art form. The expanding economy in China has given rise to a thriving market for art collections, with ivory-crafted pieces in high demand [63-69]. However, as species face dwindling populations due to excessive exploitation driven by illegal wildlife trade, their byproducts become increasingly scarce. This scarcity elevates their value and accelerates the dangerous path toward extinction.

To meet the demand for animal products that are considered status symbols, exotic delicacies, or traditional Chinese medicine remedies, some have proposed controlled breeding and regulated harvesting of wild animals as a means of supplying the market. This approach aims to reduce prices, ultimately diminishing the incentive for poaching wild animals [70-77]. Examples include the use of tiger and lion bones in the production of medicinal wines, cakes, or glues.

Animal parts like bones, teeth, and claws are employed for various purposes, including the creation of trinkets and curios. In contrast to the limited numbers of tigers and lions remaining in their natural habitats, the population of captive-bred tigers has been steadily increasing in Southeast Asia and China. South Africa has witnessed significant growth in captive lion breeding, primarily to cater to the captive lion hunting market. This practice has led to the production of lion bones, initially as a by-product for legal export but increasingly as a primary product intended for export. Notably, lion bone exports from South Africa surged from about 314 skeletons annually during 2008-2011 to more than 1,000 skeletons per year between 2013-2015, reaching a peak of 1,700 in 2016. However, in 2017, CITES introduced a limited quota of 800.

On July 8, 2022, the South African Department of Forestry, Fisheries, and the Environment unveiled a draft white paper outlining a new approach to biodiversity management. This approach places a strong emphasis on benefit sharing by local communities and prioritizes the welfare and well-being of wild animals. It marks a significant shift in the country's biodiversity management strategy. This change followed the government's announcement to halt captive lion breeding and cease the issuance of permits for bone exports. Coals et al. conducted a groundbreaking study that examined consumer preferences in China and Vietnam regarding lion versus tiger bone wine products and whether commercially supplied wild animal products could serve as acceptable substitutes for the wild variants.

3. FORENSIC EVIDENCE IN ANIMAL CASEWORK

Wildlife forensics stands as a crucial instrument in supporting law enforcement's efforts to oversee and enforce national and international agreements that govern the wildlife trade. DNA evidence holds particular significance in cases where biological material has been altered, degraded, or processed to the point of morphological unidentifiability [33]. Even nearly four decades after its initial discovery, DNA analysis continues to serve as the primary evidentiary pillar in both civil and criminal cases, including those involving animals [34]. The development of animal forensics has closely paralleled advancements in human forensics, with some instances showcasing innovative techniques and solutions inspired by the distinct demands of animal cases. The spectrum of potential samples from animals and animal-related crime scenes is extensive, including substances like snake venom [35], bear bile [36], molted feathers [37], fish scales [38], porcupine quills [39], historical eggs [40], and rhinoceros horn [41]. Consequently, forensic laboratories must continually adjust and validate their methodologies accordingly.

4. CRIME SCENE EXAMINATION AND SAMPLING

The depth of investigation and sampling methodologies in cases related to illegal wildlife trade (IWT) can vary significantly across countries and jurisdictions. While the discipline of crime scene investigation (CSI) is well-established in human cases, its application to wildlife crime scenes presents unique challenges due to the diversity of potential victims and sources of evidence. These scenes often require adaptations in techniques and training, involving a collaborative effort among rangers, game wardens, conservation professionals, and veterinarians to ensure the foundation for successful prosecutions is established [85-93].

The Eastern Cape province of South Africa provided a prominent illustration of the significance of forensic evidence when a notorious rhinoceros poaching gang was found guilty. A blood-stained saw's DNA was matched to a horn that was discovered in the poachers' possession and to Campbell, a rhinoceros who was killed on a private farm in 2016. This case marked several forensic firsts, including the use of cell phone tracking evidence to place poachers near crime scenes and the application of dart gun ballistics as evidence. Additionally, chemical and physical analysis linked a yellow paint chip found at the poaching scene to the bloodied saw. Expert veterinary testimony underscored the suffering of the animal and highlighted the cruelty of rhinoceros poaching.

Effective prosecution in animal-related cases hinges on more than just forensic science accomplishments; it requires the development of legal frameworks and tools by legislators to enforce wildlife protection laws. Training prosecutors and magistrates in wildlife forensic techniques is essential to ensure results are presented accurately in court proceedings. In some cases, dedicated courts and prosecutors may be necessary to handle the increasing number of poaching cases [44].

Collaboration between researchers, law enforcement, and field implementers is essential to effectively transfer new or adapted techniques from the laboratory to practical use in wildlife crime investigations. For instance, techniques developed for human crime investigations, like lifting fingerprints, can find novel applications in wildlife cases, such as lifting prints from pangolin scales using gelatin lifters. Such adaptations must undergo evaluation within the specific context they are being integrated into, taking into account their advantages, disadvantages, and necessary modifications [79-84]. It is imperative to have a comprehensive understanding of the environment, including local conditions, procedures, responsible authorities, and any existing limitations, particularly in non-human environments.

5. ANIMAL DNA EVIDENCE IN LEGAL PROCEEDINGS

Expert witnesses, such as forensic scientists, are required by law to present their evidence and supporting documentation objectively during court proceedings. Their only responsibility is to support the court in making well-informed decisions. Any evidence that is presented in a written report must be carefully stated and placed within the context of the information that is currently available for that particular species. For instance, it's crucial to note the relative rarity or ubiquity of a genetic profile or sequence among a population when providing DNA match evidence.

The admissibility of evidence in a specific state, country, or region is determined by the legal framework, a principle that applies to both human and animal cases. Scientists and laboratories providing evidence in legal proceedings related to animal cases must have a deep understanding of the local standards and seminal cases within their respective jurisdictions. In the United States, for instance, the Daubert and Frye standards are currently employed to assess the admissibility of expert testimony. Standards and guidelines concerning DNA evidence are subject to frequent updates to accommodate new methods and approaches, taking into consideration legal scrutiny that identifies any deficiencies or limitations in testing methods [78].

Effectively prosecuting cases involving CITES-listed species protected under local legislation requires the initial determination of the species of origin of a confiscated item. Failing to accurately identify the species of origin has been estimated to result in the failure of more than a third of illegal wildlife trade (IWT) cases. The identification of the specific rhinoceros species from which a seized horn originates is critical, as it directly impacts the severity of sentencing. This is determined by whether the horn is from a white or black rhinoceros, which, in turn, affects the level of threat to the species' survival [57].

Even though domestic animal instances are not directly related to incidents of poaching, they provide important context for the larger conversation about cases involving wildlife. Resolutions have been necessary because domestic animal case outcomes and verdicts have exposed the limitations of evidence and established precedents for cases involving wildlife in the future. For example, there are important lessons to be learned about creating reference population data sets, validating tests, and presenting evidence in court from two early instances involving domestic cats [99,101,102].

In human criminal cases, animal hair, particularly from domestic pets, has played a pivotal role in securing convictions due to the ease with which such hairs can adhere to clothing and be transferred. For instance, in a case in Prince Edward Island, Canada, the presence of domestic cat hair named Snowball on a suspect's jacket linked him to a homicide victim, setting a precedent for the introduction of STR genotyping of pet animal hairs in forensic cases. This case also introduced critical principles of STR validation and the establishment of background databases for species in animal forensic DNA analysis.

In situations where only shed hair is available, obtaining mitochondrial DNA (mtDNA) is often the only viable option. The State of Missouri v. Henry L. Polk, Jr. murder trial marked the introduction of cat mtDNA analysis as evidence for the first time. In this case, a single hair morphologically identified as cat hair was recovered from the victim's clothing, and while STR profiling was not feasible, mtDNA sequencing of the control region proved successful. The mtDNA profile, known as the mitotype, matched that of two of the four cats at the suspect's residence. Although the database was initially considered too small to support the evidence, the inclusion of a larger dataset from other laboratories and STR verification indicating the relatedness of the cats with the unique mitotype in their maternal lineage proved sufficient to secure a first-degree murder conviction. This case underscores the value of mtDNA typing when STR typing is not possible and emphasizes the significance of larger combined datasets to support DNA matching, even though the acceptable dataset size had not been predetermined before this case.

6. CASE STUDIES

1. Rhino Horn Trafficking in Assam: The northeastern state of Assam in India has been a hotspot for rhino poaching, driven by the illegal trade in rhino horns. The Kaziranga National Park, home to a significant population of Indian rhinoceroses, has been particularly targeted by poachers.

In a case in 2017, forensic analysis played a pivotal role in identifying poachers involved in rhino horn trafficking. DNA analysis and stable isotope analysis were used to determine the origin of the seized rhino horns and link them to specific rhinos killed in Kaziranga. This led to the apprehension and conviction of several individuals involved in the illegal trade.

2. Elephant Poaching in Kerala: Kerala, a southwestern state in India, has been grappling with the issue of elephant poaching and ivory trafficking. In 2020, a case emerged where two individuals were arrested for the possession and illegal sale of elephant ivory.

Forensic analysis of the seized ivory was instrumental in identifying the source of the ivory and the species of the elephants involved. The analysis revealed that the ivory was obtained from African elephants, highlighting the international nature of the illegal ivory trade. This case highlighted the importance of forensic analysis in determining the origin of wildlife products and the need for international cooperation in addressing wildlife crime.

These cases underscore the critical role that forensic analysis plays in combating poaching and wildlife trafficking in India. By providing concrete evidence that links poachers and traffickers to specific wildlife crimes, forensic techniques contribute to the successful prosecution of those responsible and serve as a deterrent to would-be poachers.

In September 2021, Yunhua Lin was sentenced to 14 years in prison for his involvement in rhinoceros horn trafficking in Malawi. As the head of a trafficking syndicate that operated in Malawi for over a decade, Mr. Lin's commercial and residential properties in Lilongwe were searched, leading to the discovery of ivory, pangolin scales, and 103 pieces of rhinoceros horn. DNA profiling tests established links between these horn pieces and five individual rhinoceros profiles submitted to the RhODIS® (Rhino DNA Index System) program in the past. One of these rhinos was poached in Liwonde National Park in Malawi in 2017. The poacher responsible for the Liwonde rhinoceros confirmed the DNA evidence by testifying that he had sold the animal's horn to Mr. Lin. In this case, Justice Violet Chipao, the High Court Judge, emphasized that the traffickers deserved longer sentences than poachers as they encouraged poaching. Furthermore, the case highlighted the value of regional databases like RhODIS® in supporting forensic investigations related to illegal wildlife trade and the inclusion of samples from live animals in such databases [62].

The illegal trade in wildlife products, including ivory, rhino horn, and exotic animal skins, poses a significant threat to biodiversity and the survival of endangered species. Poaching is a complex and highly lucrative criminal enterprise, and combating it requires innovative approaches, including cutting-edge forensic analysis. In recent years, there have been significant advancements in the field of forensic analysis in the context of poaching, aiding law enforcement agencies and conservationists in their efforts to combat this devastating global issue.

DNA Forensics for Species Identification: One of the most notable advancements in combating poaching is the use of DNA forensics to identify the species of wildlife products. DNA analysis has become increasingly precise and accessible, enabling authorities to distinguish between legal and illegal wildlife products with greater accuracy. By comparing DNA from seized products to reference databases, forensic experts can pinpoint the species and origin of the material, making it easier to prosecute poachers and traffickers.

Stable Isotope Analysis for Geolocation: Stable isotope analysis is a powerful tool for determining the geographic origin of wildlife products. This method allows forensic scientists to analyze the stable isotopes found in animal tissues, such as hair, feathers, or bones, and match them to specific geographic regions. By using stable isotope analysis, law enforcement can identify the source of illegal wildlife products and uncover the trafficking routes used by criminal networks.

Forensic Entomology in Wildlife Crime: Forensic entomology, the study of insects in the context of criminal investigations, has found a unique application in wildlife crime cases. Insects play a crucial role in the decomposition of animal remains. By analyzing insect evidence, experts can estimate the time since death and determine whether the killing occurred legally or illegally. This technique helps in verifying the authenticity of hunting permits and the timing of the wildlife trade.

Remote Sensing Technologies: Advancements in remote sensing technologies, such as satellite imagery and drones, have proven invaluable in monitoring and protecting wildlife populations. These technologies can help conservationists and law enforcement agencies detect illegal activities, track poachers, and protect wildlife habitats. For instance, drones equipped with thermal imaging cameras can detect poachers operating at night, making it easier to apprehend them and recover poached animals.

Biometrics and Machine Learning: Biometric analysis, such as facial recognition and fingerprinting, has found applications in wildlife conservation. Researchers have developed databases of individual animals' facial features and markings, allowing for the identification and tracking of specific individuals within a species. Machine learning algorithms have improved the accuracy and speed of these identification processes, aiding in anti-poaching efforts.

Genetic Profiling of Suspects: Another significant advancement in the fight against poaching is the use of genetic profiling to identify suspects. When wildlife products are seized, authorities can extract DNA and compare it to a database of known wildlife traffickers or poachers, helping to link individuals to specific crimes and networks.

Legal Frameworks and International Cooperation: Advancements in forensic analysis are only part of the solution. Effective enforcement and prosecution require strong legal frameworks and international cooperation. Recent years have seen increased efforts to strengthen wildlife protection laws and promote international collaboration in combating wildlife trafficking.

In conclusion, recent advancements in the forensic analysis of poaching have provided valuable tools for law enforcement and conservationists to combat this global issue. The integration of DNA forensics, stable isotope analysis, forensic entomology, remote sensing technologies, biometrics, and genetic profiling has significantly improved the ability to identify and prosecute poachers and traffickers. However, addressing poaching comprehensively also requires strong legal frameworks, international cooperation, and public awareness. The continued evolution of forensic techniques and their application in the legal arena is crucial for the preservation of endangered species and the protection of our planet's biodiversity.

7. THE PROSPECTS FOR ANIMAL CRIME FORENSICS

The growing wealth of genomic data on an expanding array of species [94] is providing an increasing number of marker systems and innovative tools for forensic investigations, all at decreasing costs. These endeavors are of utmost importance in advancing DNA forensics in animal casework and deepening our understanding of the physiology and care of animals involved in illegal wildlife trade (IWT). For instance, in 2016, the sequencing of the genomes of Chinese and Malayan pangolins [95] unveiled the absence of the IFNE (Interferon epsilon) gene, which contributes to mucosal immunity in these animals. Additionally, there was a reduced number of heat shock protein gene family members, indicating these animals' susceptibility to stress-induced immunosuppression. This knowledge sheds light on the challenges of maintaining pangolins in captivity and their vulnerability to stress and infection during trafficking [96]. It equips veterinarians, rehabilitation centers, and enforcement authorities with the insight needed for treatment and rehabilitation of live specimens [95,97]. This example underscores the pressing need to expand our knowledge of species across various fields, including ecology, behavior, veterinary care, reproduction, and, most importantly, genetics. This will enable us to comprehend and mitigate the impact of poaching through enhanced forensic tools and conservation strategies.

While humans share DNA markers across all populations, and differences in allele frequency estimates between population groups can be accommodated, animal species exhibit significant disparities in their STR typing systems. Developing, validating, and standardizing these systems for a multitude of species is a substantial challenge. Standardized STR testing systems are invaluable for supporting investigations and prosecutions related to IWT. However, many highly trafficked species have limited populations distributed across small ranges. Establishing these testing systems, including test validation, laboratories adhering to rigorous forensic procedures, the necessary skills and expertise, sharing control materials, and training personnel for testing, is a costly and complex endeavor. The primary responsibility for species protection lies with the authorities in the areas where these species are found. Prosecutions related to animal poaching predominantly take place within these areas. Therefore, significant efforts should be made to enhance the availability of forensic tools and skills to support prosecutions and establish database systems within these regions, either on a national or regional level.

“While the idea of a global, standardized system for species-specific ranges is commendable, it may be more feasible to improve systems that notify range countries or regions in which a collaborative data and technology center operates for one or several species. This could involve streamlining the process of sending test samples to these centers and establishing a centralized reporting platform that directly informs all relevant authorities of the testing results and any matches found in the databases. A platform like CITES may facilitate the efficient movement of samples to these centers and provide a reporting platform that connects various relevant organizations” [103].

8. CONCLUSION

The prosecution of IWT crimes can be enhanced through legislative measures, including the implementation of comprehensive animal protection laws, the imposition of stricter penalties, the training of the judiciary, and the establishment of dedicated environmental courts. Achieving this goal necessitates unwavering political commitment from all countries involved in IWT. It requires the recognition of the serious threat that poaching and IWT pose, not only to biodiversity and the future of our planet but also to the moral fabric of society, which is eroded by rampant criminal activities. Global-scale interdisciplinary collaboration remains one of the most effective means of surmounting the intricate scientific and legal challenges presented by IWT.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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