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# Editorial: Diagnostic tools and research applications to combat wildlife trade issues

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Editorial on the Research Topic
Diagnostic tools and research applications to combat wildlife trade issues

## Introduction

Illegal and unsustainable wildlife trade (IUWT) poses a significant threat to global biodiversity and ecosystems, highlighting the need for innovative solutions (Cardoso et al., 2021; Fukushima et al., 2021; Hughes, 2021). A plethora of taxa are poached worldwide for various uses, including traditional medicine, ornaments, food, fashion, and exotic pets. This wide diversity of taxa are regulated by a complex mix of policies at international and local levels, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), depending on their use, form, and jurisdiction. Therefore, the complex and diverse questions related to the IUWT require a broad range of diagnostic tools, with ongoing innovation needed as new species and trade scenarios emerge.

The development and application of diagnostic tools in wildlife trade research and enforcement play a crucial role in addressing the multifaceted challenges associated with IUWT, and are essential for understanding trade patterns, enforcing laws, and preventing ecological erosion caused by wildlife poaching. Many of these tools are used for research and intelligence, and their insights can guide law enforcement, inform conservation strategies, and influence policy (e.g., Andersson et al., 2021; Hatten et al., 2023, 2024). For a diagnostic tool to serve as forensic evidence in court, it must be validated, and be conducted by a qualified forensic analyst in a laboratory which is set up to forensic standards (e.g., Ewart et al., 2018, 2021; Webster et al., 2024; Frankham et al., 2025). These factors differentiate forensic tests from research, but forensic test validation and development is often underpinned by prior IUWT research projects involving assay development and the generation of reference data. As such, advances in IUWT research and technology have expanded opportunities to combat wildlife trade through multiple aspects, including conservation, policy, investigations, and forensic science.

This Research Topic of Frontiers in Ecology and Evolution, entitled "*Diagnostic Tools and Research Applications to Combat Wildlife Trade Issues*" showcases a range of emerging tools, research, and case studies highlighting the complex and multidisciplinary nature often required

to tackle wildlife crime. It can be divided into two parts: traditional forensic methods used in complex casework questions, and the development of emerging diagnostic research tools. The eight articles presented in this Research Topic, from multiple countries, explore diverse questions and crimes, and offer potential solutions and interventions for IUWT.

# Diagnostic tools and applications in IUWT

## Traditional methods applied to complex cases

Wildlife trade issues involve a multitude of species that are subject to poaching and trafficking, and enforcement may require information on a variety of investigative questions. Addressing these complexities often demands multidisciplinary approaches, integrating technologies and scientific methods such as molecular, chemical, morphological, and entomological techniques to support efforts. A key approach applied in wildlife diagnostic research and forensic casework is the use of genetic analyses to identify the species of an unknown biological item (Ogden et al., 2009). In their articles, Bar-Gal and Frazier and Bauman highlight cases in Israel and the United States, respectively, where multiple genetic techniques assist law enforcement in wildlife crimes. While many of their techniques are already established, their work emphasizes the importance of decision-making, combining methods to address simple and complex cases, and maintaining local reference databases tailored to specific species or issues. Another traditional forensic method is the use of entomology, in which insects serve as biological indicators to estimate post-mortem intervals (Bansode et al., 2025). In this Research Topic, Feugang Youmessi identifies arthropod species colonising rat cadavers (*Rattus norvegicus*) to estimate time since death, and demonstrates a high arthropod diversity that could aid wildlife crime investigations in Cameroon and across the Central African region. Although not new to forensic science (Anderson, 1999; Watson and Carlton, 2005), wildlife forensic entomology remains underutilised due to the complexity of carcass species involved and limited knowledge in this area (Tomberlin and Sanford, 2011; Anderson and Byrd, 2019).

## Emerging research and applications

Beyond traditional genetic and morphological methods, emerging technologies such as stable isotope analysis (SIA) and X-ray fluorescence (XRF) offer powerful tools for tracing the origins and species of wildlife products. Hill et al. found that SIA can identify recent captive rainbow lorikeet (*Trichoglossus moluccanus*) escapees in wild populations, especially those with small isotopic niches. Invasive species, often resulting from wildlife trade, pose significant threats to native ecosystems (Cardoso et al., 2021), and their study highlights SIA's potential for managing and enforcing measures against such spill-over effects.

While identifying origin is important in some cases, species identification is the most common application of wildlife forensics (Ogden and Mailley, 2016). However, challenges arise when morphologically-similar products come from different species with varying CITES regulations. Santos et al. highlight a multi-element SIA approach to distinguish between regulated elephant ivory and unregulated mammoth ivory traded across Asia and Siberia. This cost-effective method enables fast and accurate species identification, enabling ivory to be effectively triaged and processed. Similarly, Brandis et al. found that portable XRF (pXRF) could potentially be used as a rapid and cost-effective tool to accurately identify species and provenance (captive or wild) of traded Australian Tiliqua skinks. These articles also highlight limitations of using SIA and pXRF for investigations and management, such as dependence on tissue type, reference databases, and elements analysed. As a result, they are not yet feasible for wildlife forensic casework due to challenges in validation and database development. However, such methods can enhance investigations when combined with other methods like DNA analysis or multi-isotope analysis, and provide additional information—such as dietary, water source, and habitat data—that DNA alone cannot offer (Prigge et al., 2024).

The integration of emerging technologies like artificial intelligence (AI) and open-source platforms significantly advances wildlife enforcement and investigations against poaching and illegal trade. As criminal activities evolve, so must our solutions (Stolzenberg and D'Alessio, 2025; U.S. Department of the Treasury, 2024). Lynam et al. review various global conservation technologies, highlighting how open-source tools are used to combat poaching. In particular, AI, especially facial-recognition, has revolutionised individual identification. Hau et al. describe a facial-recognition system combining morphometrics and AI to monitor species like the endangered humphead wrasse (*Cheilinus undulatus*), which is traded through enforcement gaps in Hong Kong into the seafood market. Such approaches enhance conservation efforts by enabling more efficient tracking of illegally sourced wildlife at both individual and species levels (Petso et al., 2022).

# Conclusion

Addressing wildlife trade issues requires a diverse, interdisciplinary approach that combines scientific research and applied diagnostic tools. Developing and applying diagnostic methods to detect, identify, and track illegal activities is crucial for mitigating threats to endangered species and combating wildlife crime. While many tools are initially developed for research, they have the potential to be adapted for forensic use through validation and the generation of appropriate reference data. Ensuring these tools generate the relevant information and are also cost-effective is essential for law enforcement, and collaboration between scientists and enforcement agencies is vital for knowledge exchange and effective implementation (Hatten et al., 2020). Through innovation, capacity building, and cooperation across sectors,

these tools can better help protect biodiversity, combat wildlife crime, and promote sustainable resource management.

## Author contributions

CH: Writing – review & editing, Project administration, Conceptualization, Writing – original draft, Visualization. KE: Writing – review & editing, Writing – original draft, Conceptualization. AN: Writing – review & editing, Writing – original draft. AA: Writing – original draft, Conceptualization, Writing – review & editing. JM: Writing – original draft, Supervision, Writing – review & editing, Conceptualization.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

## Publisher's note



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