DOI: 10.38146/BSZ.SPEC.2023.2.1

Special Challenges of Wildlife Forensics in Hungary

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Abstract

The causal relationship between human interference in both climate change and decrease in biodiversity is unquestionable. This fact supports the need to act effectively against those illegal activities affecting wildlife. Hungary is also involved in wildlife crimes, but there is a noticeable deficit in the processes of uncovering these actions, gathering proof and punishing those responsible. In this study the Authors examine what role forensics may play in the fight against wildlife crime.

Aim: Present the characteristics of wildlife crimes and outline the main features of wildlife forensics.

Methodology: The current national and international legal background and norms and guidelines for professional conduct are surveyed. The Authors also reviewed the most important relevant Hungarian and international scientific literature.

Findings: One of the most important and vital tasks of modern civilization is the preservation and protection of the environment – with an emphasis on life

on Earth. As part of this process there is a place for law enforcement to detect, punish and prevent further criminal activity connected with illegal activities involving wildlife. In Hungary the major barriers to effective punishment of those responsible for wildlife crimes are primarily: the lack of forensic technicians with sufficient specialized knowledge and practice; missing specialized standard operational protocols; insufficient knowledge of biology within law enforcement; insufficient funding of non-human genetic laboratories and the lack of adequate non-human (genetic) databases.
Value: For the first time in Hungary, the Authors outline the basic characteristics of wildlife forensics.

Keywords: wildlife crime, wildlife forensics, non-human forensic genetics

Introduction

The flora and the animal kingdom ensure the opportunity for a healthy human diet, provide aesthetic pleasure for humans and at the same time is an economically significant source of materials. Additionally, it has a significant influence on the culture of a given country or geographical region, which is most often due to the typical local endemic species. In recent decades, however, bio- and genetic diversity has sunk to risky levels in most places on Earth (Newbold, Hudson & Arnell, 2016). One of the reasons for this is that the environment necessary for human life has value not only from an abstract, philosophical, moral, aesthetic, ecological or genetic point of view, but also in that elements thereof are treasures that can easily be monetized. This situation is abused by many who desire to convert these values into cash – and a very significant amount of cash at that.

The term 'wildlife' is traditionally used to refer to the natural diversity of animals, plants and fungi. In general, local, domestic, and international organizations typically perform the majority of the work in connection with management and protection of wildlife, supported by the necessary legal background.

In the Hungarian legal system in the context of '*crimes against nature and the environment*' it is hard to uniformly define the characteristics of the term 'wildlife crimes' (or 'forest crimes').

This term, however, indisputably covers all the events that may occur in connection with the illegal exploitation of fauna and flora (Sziebig, 2018). Together with the illegal destruction of endangered species – capture, collection, hunting, fishing, harvesting, extermination, processing (e.g. for traditional medical

products such as tiger pastilles, bear gallbladder, etc), direct or indirect poisoning – international illegal trafficking causes the most significant damage to involved species (Smart, Cihlar & Budowle, 2021).

These, mainly organized illegal acts are – after the illegal arms and drug trades – one of the largest illegal businesses in the world (Beiglböck & Walzer, 2019; Gouda, Kerry, Das & Chauhan, 2020; Smart, Cihlar & Budowle, 2021).

These illegal activities are a threat, not only to biodiversity, but also to the food safety, biosecurity, economy and national security of the countries where they take place.

These risks, taking into account globalization, cannot be considered to be exclusively domestic risks.

Consequently, international cooperation against wildlife crimes supports not only preservation of natural resources, but also may contribute to the investigation and elimination of local and cross-border illegal networks (URL1).

The individuals and organizations involved along with their international networks can in many cases also be linked to money laundering and terrorism, which directly affects international security (Smart, Cihlar & Budowle, 2021).

In addition to changing the local biosphere, the unchecked, illegal shipping, the 'transfer' of various processed derivates and representatives of the animal kingdom (e.g. introduction of invasive species) also poses a danger – to biosecurity in a broader sense – to public- and animal health control as well as to food safety.[1]

Global epidemiological challenges arising from human interference in nature – which have often occurred in human history – also have an effect on the global economy. The effects of wildlife crime on the economy are not limited to recessions caused by pandemics, or the enormous costs of combating invasive species and new zoonoses.

It also has a direct effect on domestic economies by undermining legal animal trade, reducing the income from legal game hunting (due to the deterioration in the health of the local wild animal population), and also inhibits wildlife tourism and reduces associated incomes (Smart, Cihlar & Budowle, 2021).

The basic problem is that in so-called 'inner' phase of the criminal act, the conflict between positive and negative motifs does not fully manifest on either the procurer nor on the executor sides.

1 Widespread zoonoses such as HIV/chimpanzee, Ebola/fruit bat and H5N1/poultry, which are caused by the extinction of their intermediate hosts and/or inadequate physical distancing of evolutionarily separated species – an example of which is the consumption of local bushmeats. It should also be mentioned that the COVID–19 zoonotic backtrace has been the subject of scientific discussions.

Namely, the procurers are generally well-off people who live physically distant from the affected biological region, cannot see the consequences and for the most part don't consider the drastic effect of their orders on the biosphere.

In the case of the perpetrators of the crimes – individuals or criminal syndicates – the main deciding factor is not that they understand the damaging effects of their actions, but rather that in most cases they can be sure that there will be no legal ramifications for their criminal activity (Beiglböck & Walzer, 2019, Purtill, 2020).

From the point of view of globalization, it is especially frustrating and risky that in the less developed countries these crimes are often also aided by governmental corruption (URL2; URL3).

Hungary's concern

Although Hungary is not an exotic country, it has – similarly to other countries – significant natural values.

These natural values, often literally assets, although they do not in all cases receive national protection, may be of significant importance to our country and thus their protection is of national concern.

There is a large degree of latency in the legal or illegal trade of protected wild species, but we can state that Hungary does not currently have a featured role in this market.[2] Although the trade in endangered species is currently not considerable, exploitation affecting the wildlife population (e.g. poaching) is significant.

In Hungary there are both old and new challenges pertaining to the ancient tradition of hunting. Among these, maintaining the purity of the sport hunt has particular prominence. It should be noted, however, that the translocation of the routes for illegal trade can occur at any time, [3] so the degree of involvement of our country may increase overnight. This indicates that there is definitely sufficient justification for paying close attention to this problem.

Hungary is committed towards wildlife protection. This is evidenced by the Hungarian accession to the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), which regulates and coordinates the commercial market and trade of endangered species. Like all the members of the Visegrad Four – except for Poland – Hungary is not directly involved in the network of ICCWC (International Consortium on Combating Wildlife Crime)

2 This business is one of hundreds of millions of HUF yearly (Harnberger & Zsigmond, 2020).
3 Due to a more efficient official control as an increased risk factor.

(URL4). Numerous Hungarian laws ensure the protection of wild animals, e.g. Act XXVIII of 1998 on Animal Protection and Tolerance, Act CII of 2013 on Fisheries Management and Fish Protection, Act LV of 1996 on the Protection, Management and Hunting of Wildlife, and the Related Implementing Regulation, and also the Act C of 2012 on Criminal Code (CC) by ordering to punish crimes such as damage to environment (241. § of the CC), damage to nature (242-243. § of the CC), animal cruelty (244. § of the CC), poaching (245-246. § of the CC) and organization of prohibited animal fights (247. § of the CC).

In Hungary, investigating environmental crimes in more straightforward cases is the responsibility of city police departments. In more complicated cases, the county police headquarters are in charge and, in some exceptional cases, the water police headquarters carry out the investigation.[4] If the crime is considered as an organized crime or if it has an international nature as defined in the Palermo Convention (or in some other cases), the Rapid Response and Special Police Service has the authority to investigate.[5] This board also examines whether the environmental elements have been damaged to such an extent that their natural or previous state cannot be restored or if the damage affects three or more counties.

The investigation of nature damage also falls under the jurisdiction of the Rapid Response and Special Police Service if it is committed against a wild animal or plant species covered by Council of Europe Regulation 338/97/EC and threatens the survival of the population of the living organism.[6]

In individual cases, the National Chief of Police may also refer the investigation not otherwise belonging to the competence of the Rapid Response and Special Police Service, if it is necessary in order to promote more effective action against organized crime and corruption, or in view of the perpetrator of the crime or the circumstances of the crime.

According to publicly available criminal statistics, between the second half of 2018 and 3 March 2022 there were 25 cases against environmental degradation, 495 against damaging of natural environment or habitats, 14 cases concerning illegal fishing, 3 poaching cases and 120 cases of animal abuse registered, illegal animal fighting was not detected. These data cannot refer precisely to wildlife criminal acts.

It should be emphasized that in the case of crimes committed against wildlife, a higher degree of latency can be estimated. Additionally in the type of cases

4 Decree 25/2013. (VI. 24.) of the Ministry of Interior of Hungary, Annex 4., 3.1.–3.5.

5 Act CI of 2006 on the Proclamation of The United Nations Convention against Transnational Organized Crime. Adopted by General Assembly resolution 55/25 of 15 November 2000 in Palermo.

6 Decree 25/2013. (VI. 24.) of the Ministry of Interior of Hungary, Annex 2. 8.2.

of animal victims, it is often hard to clearly distinguish between ethically condemnable, legally prohibited and legally sanctioned human activities.

In Hungarian practice we have mainly encountered the following types of activities: unethical or illegal hunting, theft of harvested wild animals, illegal food trade in derivates from wild animals, misuse and cheating involving game trophies, trade of various ingredients of traditional so-called medicines (Zenke, Egyed, Pádár & Kovács, 2015; Zenke, Egyed & Pádár, 2017; Zorkóczky, Lehotzky, Pádár & Zenke, 2021; Zenke, Zorkóczy, Lehotzky, Ózsvári et al., 2022) as well as deliberate abuse of strictly protected animals (Zenke, Egyed, Kovács & Pádár, 2019) or poisoning of wild animals/bird of prey (Angyal, Farkasné & Halász, 2016; Deák, Juhász, Árvay & Horváth, 2020).

In many cases these crimes may extend beyond the borders of Hungary. Nowadays recent challenges involve the cross-border moving, migration and reintroduction and resettlement of formerly endemic predator species (e.g. wolf and bear) or identification of their biological hybrids (e.g. wolf, golden jackal and dogs) (Szives, Zorkóczy, Lehotzky, Somogyi et al., 2022).

When evaluating the economic damage caused to wild or bred prey populations it is more and more frequently necessary to distinguish between the actions of wild predators and poaching by dogs – either stray or owned. Traffic accidents caused by wild animals, deterioration in health of the domestic wild animal population (e.g. African swine flu), abuses related to its official control, and the detection and prevention of other illegal activities are also acute problems (Földi, 2021).

Factors affecting the fight against wildlife crime

Wildlife crimes are a highly diverse range of illegal activities. Due to this, various difficulties can be encountered during their detection, investigation and providing of evidence.

Related literature reveals the difficulty in evidentiary procedure with a wide range of cases such as that concerning the poisoning of an endangered species of vulture (Rendo, Iriondo, Manzano & Estonba, 2011), traditional 'medicines' (Byard, 2016; Jabin, Singh, Ghosh, Basu et al., 2019; Linacre, 2021), or the tracking of sauna wood materials obtained from illegal logging activities (He, Marco, Soares & Yin et al., 2019; Roman, Gangitano, Figueroa & Solano, 2020).

Part of the complication stems from the high diversity and number of affected fauna and flora. Making it even more complex is that the criminalization of

nature, wild fauna and flora can be approached from differing – anthropocentric, biocentric and ecocentric – aspects (Ege & Howe, 2020), which obviously has an effect on characteristics of the legal process (Ege & Howe, 2020).

Compared to crimes committed against humans, those committed against animals are usually of lower priority in the eyes of both society and the authorities (Smart, Cihlar & Budowle, 2021; Linacre, 2021). Also, legal regulation governing smuggling and requirements for import of wild animals or derivate products are peripherical in many countries (Gouda, Kerry, Das & Chauhan, 2020).

Although for several organizations the legal background stipulates obligations relating to nature, environmental and wildlife protection, the regulation often also contains contradictions. Due to the laborious and diffuse cooperation between involved entities, the low degree of efficiency of professional intervention, the lack of definition and development of competency as well as responsibility these organizations are often not able to effectively perform their functions. Insufficient biological knowledge in law enforcement agencies and legal departments as well as a lack of human and material resources contributes to perpetrators of wildlife crimes often going unpunished (Beiglböck & Walzer, 2019; Gouda, Kerry, Das & Chauhan, 2020).

The lack of success in decreasing ethically objectionable or criminal activities not only reduces the chances for prevention, but also causes non recoverable economic damage and contributes to the decline in quality of the given wildlife populations (Zorkóczky, Lehotzky, Pádár & Zenke, 2021).

Thus, the authors believe that the targeted and reasonable development, maintenance and support of wildlife forensic capacity should be provided for in Hungary similarly as in other countries (Smart, Cihlar & Budowle, 2021).

In addition, we suggest the development of a complex, special legal and professional background for wildlife crimes which effectively can aid in detection, investigation and verification. In this framework, the regulation should integrate valid international experiences as well as facilitating the special studies, trainings and continued education of selected units and officers from different authorities.

The adequate and transparent legal regulations of the process as well as solution of forensic and legal demands and requirements which are often different from the challenges of anthropocentric forensics provide for more efficient action against wildlife crimes. This can reduce the chance of those, frequently unbased, confrontative opinions of several public groups such as hunters, conservationists, farmers and trekkers and in addition guide their different expectations towards a common and cooperative solution.

Wildlife Forensics

Basic forensics questions

In contrast to most types of crimes, the most typical basic question in connection with wildlife crimes is that of whether a crime has even been committed rather than that of who did it (McFadden, 2020).

The first criteria for the effective application of the adequate legal act is the determination of the cause of death (Nishant, Vrijesh & Ajay, 2017) and the taxonomical identification of the individuals, remains or derivates of the incriminated species.

The death of representatives of wild fauna and flora can be caused by humans or by natural events. In the case of non-natural causes of death, those caused by legal activities (e.g. legal hunting, fishing, logging) or effects of the artificial environment (such as electrical wires, traffic, artificial objects) must be differentiated from those caused by illegal activities (e.g. illegal trapping, poaching, poisoning, trafficking).

For wild animals, the timeline of revealed ante mortem data and suitable examination of the related territory/environment by a forensic veterinarian specialist greatly supports the reasonable discussion and establishment of causal links based on tentative hypotheses (Garcês & Pires, 2020). The first step of forensic identification is, similarly to the analysis of drugs, microfibres or paints, the determination of significant 'group' characteristics which in this process equates to identifying the incriminated species (Burnham, Curtis, Trail, Kagan & Moore, 2015).

Accordingly, in wildlife forensics 'WHAT' instead of 'WHO' is the most frequent primary question (Moore & Frazier, 2019). The step of individualization ('WHO') may also arise. However, in connection with matching/exclusion in a given crime the question of 'WHERE? (FROM WHERE?)' is generally more often required. This answers the question of the biogeographical origin of the given species/remains, whether it is from a natural or unnatural (e.g. captive) habitat, from a region legally used for hunting/fishing/logging etc., or was perhaps involved in international trafficking. The demand for determination of sex, and number of incriminated species and individuals ('HOW MANY?') can arise in wildlife cases just as in human analogues. Additionally, at the start of the investigation it must be determined whether the relevant case data is already present in another case which can indicate that it fits the pattern of a 'SERIAL CRIME' (Nyitrai, 2021).

Crime scene investigation

As can be seen from the above, the range of crimes with which wildlife can be connected – both directly and indirectly – is extremely wide. Consequently, this also means that a high variety of locations can be involved.

Species from fauna and flora as well as a great variety of remains, derivates and processed products can be found in vastly different locations and environments (e.g. desert, forest, creek, ocean, etc.), involving extremely varying natural, artificial, open-air or isolated places (e.g. buildings, equipment, shipping or storage containers/rooms, cryostorage, boxes, internet sites, etc.) which can significantly affect and alter the discovering, selection, collection, preservation and storage of evidences (Cooper, Cooper & Budgen, 2009; Potter & Underkoffler, 2021).

In many cases, determining cause of death, or even detection of the animal connected with the crime can be problematic (Beiglböck & Walzer, 2019).

Since crimes may involve multiple, even physically separated locations and spaces within the affected species' natural or artificial habitat and environment, the question frequently arises as to whether the crime can be connected with more than one potential crime scene.

It is important to understand that wildlife and 'classic' crimes scenes may differ. This means that it may be difficult to recognize and detect that a given location is even in fact a crime scene.

Thus, in most cases, special professional skills are required to recognize these crime scenes as such (Parmalee, 2018; Beiglböck & Walzer, 2019).

Due to the differences inherent in illegal acts against wildlife, it is not obvious to everyone that they are even at a crime scene. While it is relatively easy to recognize the location of illegal logging, discovery of the remains or corpse of a wild animal does not necessarily mean that one has found a primary crime scene.

Tracking devices (Angyal, Farkasné & Halász, 2016; Váczi, 2020), acoustic (gunshot) detection systems (Kalmár et al., 2019; Sigmund & Hrabina, 2021), poison and cadaver detecting dogs can help us to define and localize the crime scenes especially in the case of protected species. At the same time, it is often necessary to extend the crime scene investigation by, for instance, reconstructing the path of wounded/shot animals, or tracking down shell casings.

If we chance upon a wounded animal or an animal's corpse or remains, or even just traces indicating that it has been at that location, then from a criminalistic point of view it is essential that we specify their roles in the crime. Of course, in most cases they are the subjects of the crime, but they may also play an active role (for example, poaching with dogs or hunter birds). They may also serve as 'silent witnesses' in wildlife crimes.

Of course, in these cases it is not a verbal 'testimony', but the examination of evidences and traces such as bites, scratches, hoofprints, hairs etc. that may be left on, or near them during the committing of the crime can lead closer to understanding what happened, and their importance can be as significant as that of a real testimony (Pádár, Kovács & Kozma, 2020).

During a crime scene investigation legal and professional regulations must be adhered to (Cooper, Cooper & Budgen, 2009; Gárdonyi, 2014; Gárdonyi, 2019; Parmalee, 2018; Beiglböck & Walzer, 2019).

Securing and protection of the crime scene is of primary importance in the case of wildlife crimes as well. Since, due to their nature, these are most often open-air 'living' crime scenes, it is even more critical to perform the crime scene investigation as soon as possible.

Delay in the crime scene investigation increases its exposure to not only weather, but also to biosphere related effects such as microbial, floral, faunal factors (predators, scavengers, herbivores or mushrooms). This negatively impacts the detection and sampling of evidences which in any case can frequently only be carried out in the midst of such situations that already challenge the sufficient and efficient crime scene investigation (Cooper, Cooper & Budgen, 2009).

Since there are typically few witnesses at wildlife crime scenes, the importance of the crime scene investigation is even more prominent (Parmalee, 2018).

Numerous factors can impede the immediate investigation (for example discovering the crime scene, lack of witnesses), and it is also not rare for criminals to deliberately alter the crime scene, mutilate, move or remove the impacted animal or its remains (Zenke, Egyed, Kovács & Pádár, 2019).

Of course, wildlife crimes are not always first detected by the relevant authorities, which means that both the order and timing with which the various officers or departments of different powers, scope and license are informed of the suspected crime also depends on the discovering witnesses (Angyal, Farkasné & Halász, 2016).

The steps taken by the person first to discover the crime scene (weighing the danger present, evaluation of health or other hazards, delineation of zones and boundaries, securing and protection of the scene, fixation and documentation of transient information that would otherwise no longer be available during the following investigation procedures) has a direct, primary effect on the success of the investigation and substantiation of the crime. In the best-case scenario, the suspicious circumstances or events are first detected by a ranger or gamekeeper with a degree of competence.

The gathering of crime scene data requires a specialized criminalistic way of thinking (Gárdonyi, 2014), since past events need to be deduced based on circumstances available in the present (Kovács & Nogel, 2017).

There is a real possibility that the crime scene has been altered, and this must be taken into consideration. At the 'live' crime scene of a wildlife crime, a vast number/amount of biological traces and remains are usually present before discovery of the crime event. This means that distinguishing between relevant and non-relevant trace/evidence/information can be of crucial importance.

There are several special requirements that arise for forensic officers and technicians working in the 'living', sometimes extreme locations of wildlife crimes. Although the investigation must begin immediately, it can rarely be planned for in advance, and the opportunities for a priori information are limited. It is also not enough to have a degree of legal/forensic skills, it is also essential to have ethological knowledge of the incriminated species for cognitive forensic reconstruction.

In addition to forensic technicians and officers with special training, it is recommended (and often necessary) that a crime scene investigation also involve other specialists such as veterinarians and biologists who have forensic proficiency.

Significant professional cooperation, even if not substituent in itself, can be provided by competent representatives of the affected local conservation or hunting organizations, or the owner of the given land (Cooper, Cooper & Budgen, 2009; Beiglböck & Walzer, 2019).

Although veterinarians with forensic experience play a role in animal crimes analogue to that of a human forensic medical examiner (e.g. determining the cause or time of wounds or death), the presence of the latter at the crime scene is very rare (Brownlie & Munro, 2016).

Methods

Although nowadays the palette of forensic methods available has grown significantly, the use of these in the case of wildlife crime is not self-evident.

Most of the forensic equipment and methods used in the examination process of investigation of crimes committed against humans can also be adequately applied in wildlife crimes (Cooper, Cooper, & Budgen, 2009; Beiglböck & Walzer, 2019; Gouda, Kerry, Das & Chauhan, 2020), although the effectiveness and success of some methods may be reduced due to the peculiarities involved (Moore & Frazier, 2019).

In general, one of the deficits – and perhaps the greatest – is that the applied methods are commonly much less rigorous than their analogue or homologue applications in human forensics.

The difficulty in standardizing examination procedures and compliance to quality management criteria (Smart, Cihlar & Budowle, 2021; Linacre, 2021) is not only due to the number of incriminated species and their biological diversity.

In some countries, the level of government financing of those research sites having professional competence that extends to wildlife crime forensic examinations does not allow for the implementation of very expensive quality management systems.

Those professionals who have over the years gathered and organized species related knowledge – not based on forensic criteria – and who are used in an ad hoc fashion by law enforcement have, on the whole, had to manage with a very low budget.

From a forensic viewpoint, an inadequate crime scene investigation, the incorrect management, storage and transport of gathered evidences, and in the case of animals the lack of necroscopy (or insufficiency thereof), the suitable availability of initial- and investigative support as well as the lack of witnesses and the uncertainty of their testimonies present the largest problems (Angyal, Farkasné & Halász, 2016; Beiglböck & Walzer, 2019).

Veterinary examinations

In the case of animals living in the wild, those examinations by veterinarians with forensic training and competence are, similarly to those by a forensic medical examiner (far earlier integrated in forensic practice), critical in the case of crimes resulting in the death of, or critical change in the health of animals (Brownlie & Munro, 2016; Beiglböck & Walzer, 2019).

Recognition of the signs, defects or damage to the corpse that indicate poisoning; differentiation between ante mortem and postmortem wounds; determination of the correlation concerning the formation of mortal injuries/wounds as well as the occasionally necessary carrying out of in-situ necroscopy are virtually indispensable for successful prosecution.

If the corpse or remains allow for it, determination of the impacted species can be done at the crime scene along with the estimation of the animal's age and time of death.

In the case of poaching, determining the pattern and distribution of livor mortis, hemorrhages and bruises may provide additional information concerning position changing, dragging or transferring of cadavers.

Although rarely – in the case of low power ammunition or weapons – the bullet may remain in the corpse, the relative stability of bullet wounds allows for sufficient ballistic reconstruction despite the decomposition process.

The necroscopy should be performed in autopsy rooms just as in the case of human victims.

Supplementing traditional anatomical, histological and toxicological examinations, the most effective non-invasive imaging technologies such as CT (computed tomography) and MR (magnetic resonance) have recently replaced traditional radiology.

In context of the recent epidemiological challenges, the analysis of the zoonosis and parasites connected with the necroscopy of invasive or illegally trafficked species is of particular importance.

However, in many cases the veterinarian/pathological examination is not really sufficient and the cause and circumstances of the animal's death can only be revealed by interpreting the summarized results of the entire investigation (Beiglböck & Walzer, 2019).

Identification, physical and anatomical characteristics

In order to answer the basic forensic question of 'WHAT' is this, the taxonomical characterization of the animal individual must be performed – i.e. the species must be identified.

In some cases, the species affected by the crime can be easily recognized on the basis of its physical appearance or (special) traits using general (graduate level) biological, taxonomical or anatomical knowledge.

From this point of view, the recognition can be more difficult for non-local/endemic, migratory species, subspecies, invasive, unusual, rare species, or related hybrids and variations.

Even for those with an amount of professional taxonomical knowledge, identifying partial, degraded remains or processed derivates presents a much greater challenge (Nishant, Vrijesh & Ajay, 2017).

Similar difficulties arise concerning those traces (e.g. hoof prints, scratch or rubbing marks) left by the given animal at the 'living' scene that may be modified or destroyed over time by environmental conditions.

In these challenging cases, those evidences (e.g. bones, trophies, hairs and other keratinous parts) which usually have morphologically distinguishing characteristics may be altered, including those incidents where these modifications are accelerated by human interference, with artificial manipulation and processes. Consequently, it is practically impossible to perform a successful morphological examination.

Combs made from whalebone, key rings from tiger claws, ivory chess pieces, fur- and leather fashion products, cosmetics or traditional 'medical/magical'

products – the forms of these items leave little chance for successful physical identification, even on the microscopic level.

In addition to considering the relatively simple, fast and inexpensive traits of classic morphological analysis it must be declared that the limits for standardization and lower resolution make it less acceptable for the criminal courts (Gouda, Kerry, Das & Chauhan, 2020; Nogel, 2020; Smart, Cihlar & Budowle, 2021).

The effective application of traditional trasology – the examination of footprints, hoof and paw prints, tire- and toolmarks – is often inhibited by the (weather) conditions at the open-air 'living' crime scene and trace contamination by multiple species/individuals. The TOD (Time of Death) can also be estimated using RNA stability and entomological analysis as well as by soil microbiome examination.

While isotope or trace element examinations, analysis of chemical composition with infrared techniques, or the combination thereof can provide information on the biogeographical origins, the 'omics'-technologies can provide information concerning the diversity of wildlife adapting to the urban environment.

Molecular examinations

Wildlife forensics and its methods currently focus on species identification, answering the question of 'WHAT', which is completed with the determination of biogeographical (population) origin and/or sex, and occasionally genealogical analysis.

In place of those less effective methods examining physical characteristics, today the more objective, standardized and validated molecular genetic methods have taken priority (Nishant, Vrijesh & Ajay, 2017; Gouda, Kerry, Das & Chauhan, 2020; Smart, Cihlar & Budowle, 2021).

Forensic genetic methods, like human forensic DNA analysis, can cover almost the entire range of biological remains potentially related to wildlife crimes. In addition, the analysis of minute amounts, or highly degraded samples (due to natural or artificial processes) is also possible (Pádár, Kovács, Nogel & Czebe et al., 2019; Pádár et al., 2020; Pádár, Kovács & Kozma, 2020; Nogel, 2022).

While the microscopic examination of hairs often found in connection with wildlife crimes requires well preserved hair structure (Nishant, Vrijesh & Ajay, 2017), even the DNA extracted from postmortem animal corpse long after the death can be successfully informative for identification (Pádár, Egyed, Kontadakis, Zöldág & Fekete, 2001).

In Hungary, non-human forensic genetics reaches back more than twenty years (Pádár, Angyal, Egyed & Füredi, 2001) and due to the nature of the country

has until recently focused primarily on game animals with trophy (Szabolcsi, Egyed, Zenke & Borsy, 2008; Szabolcsi, Egyed, Zenke & Pádár, 2014; Zenke, Zorkóczy, Lehotzky & Ózsvári, 2022).

Technological advances such as massive parallel sequencing can accelerate the amount and availability of genetic data, as well as providing more opportunities for examining bad quality, degraded or artificially processed evidence samples.

Non-human forensic genetics obviously also has its own limits due to the wide range of affected species and their mtDNA and nuDNA markers (Moore & Frazier, 2019; Smart, Cihlar & Budowle, 2021).

Although it can be stated that there is a significant amount of genetic data available for internationally endangered and protected species, there are also many species of endemic and national importance which have been relegated to the background during the scientific examination and data gathering.

In the case of crime related individuals from these species, the difficulty in obtaining species-specific genetic data and gathering information complicates the successful investigative and analytical process as much as the necessary steps for forensic validation (Zenke, Egyed, Kovács & Pádár, 2019).

In contrast to Homo sapiens, where with only one species the construction and synchronization of various genetic databases is relatively easy, the organization of the available sets of relevant data for representative wildlife species into a coherent, standardized, integrated forensic system has to date not been accomplished.

The opportunity for sampling, especially for endangered or protected species, can be in itself very complicated. This is further exacerbated by the genetic variance of species, as well as number of the examined traits and markers as well as the putative range of standardized analytical methods.

The necessary validation of certain forensic methods (e.g., allelic ladder construction) requires a representative population database of optimally two hundred individuals (Linacre, 2021).

The natural borders of habitats can limit the spread and wandering of species and may lead to the fixation of new genetic mutations, and in this way contribute to the development of distinct, local/regional genetic characteristics. This phenomenon stimulated the need for comparative genetic databases, of which, however, very few are available.

The concordance and combination of limited genetic data obtained from non-forensic institutional or museum comparative-collections – especially in the case of rare animals – with that of open source scientific (genetic), but not forensic, databases require careful attention and special caution since the applied methods for data gathering were generally not performed to meet forensic standards.

Based on the examination of existing databases, it can be concluded that the development of forensic databases operating in a quality control system is essential for the success of examinations (Gouda, Kerry, Das & Chauhan, 2020; Smart, Cihlar, & Budowle, 2021).

Summary

In the fight against wildlife crime, while preservation of the natural condition of human habitats is a critical factor, the economic significance also cannot be ignored.

It can be declared that in Hungary, the appropriate institutional network and system having biological, ecological and forensic knowledge has not yet been sufficiently established. In addition, the accumulated professional knowledge necessary to ensure effective action in the fight against wildlife crime has not yet been synthesized.

Basically, the key to prevention, investigation and prosecution is the involvement and cooperative work of competent professionals during the entire process.

Compared to traditional anthropocentric forensics, a slightly different approach and way of thinking is necessary in wildlife crime. Development of a modern forensic background, which requires significant investment, is also imperative (Moore & Frazier, 2019; Gouda, Kerry, Das & Chauhan, 2020).

In wildlife connected domestic forensic practice there are few standardized methods or adequate laboratories with suitable technical and personal background.

Most examinations, due to domestic characteristics (Nogel, 2022) are organized by university research institutes, are performed in circumstances that although of high quality, do not meet international forensic standards (Smart, Cihlar & Budowle, 2021; Linacre, 2021), are often based on ad-hoc forensic experience of affected research groups (Smart, Cihlar & Budowle, 2021; Linacre, 2021). Although the involvement of these cooperating groups seems to be reasonable – e.g., veterinarians, researchers with (bio)morphological, population biological, or wildlife biological backgrounds – their lack of experience in the field of forensics means that they do not have the necessary theoretical, practical or cognitive proficiency (Pádár, Kovács, Nogel & Czebe, 2020; Potter & Underkoffler, 2021).

Based on this assessment, the following appear to be vital in the near future

- specification of competencies and their boundaries;
- specialized training of crime scene investigators;

- expansion and enhancement of the contents of non-human forensic genetic databases;
- developments in laboratories for non-human (genetic) examinations towards meeting the requirements of professional compliance as well as those of forensic standards (accreditation).

In addition to genetic analysis, AI and computer-based modelling may provide further opportunities for examination of other related evidences (traces and remains) collected at the crime scene, as well as data and information gathered by involved veterinarians.

The goal is for the quality and effectiveness of the fight against wildlife crimes to be equal to that of any other type of crime. To reach this, additional legislative steps are required. In the development of these specialized regulations, it will be necessary to place the focus on the peculiarities of wildlife crime and their related crime scenes.

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Laws and Regulations

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Reference of the article according to APA regulation

Pádár, Zs., Nogel, M., Kovács, G., Gárdonyi, G. & Zenke, P. (2023). Special Challenges of Wildlife Forensics in Hungary. *Belügyi Szemle*, *71*(SI2), 7–28. https://doi.org/10.38146/BSZ.SPEC.2023.2.1