**UNIVERSITY OF VETERINARY MEDICINE BUDAPEST**

**Department of Pathology**

# Exploring the role of veterinary forensic pathology in combating animal cruelty and abuse


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Abstract

This thesis explores the role of veterinary forensic pathology in combating animal cruelty and abuse. It begins with an overview of veterinary forensic pathology, it's growth and relevance, emphasizing its importance in differentiating between various types of abuse and interpreting them. The evolution of this field is discussed, the historical foundations and current status, highlighting advancements and the need for standardized practices. Distinguishing forms of animal cruelty and abuse, including accidental and non-accidental injuries, blunt force and sharp force trauma, neglect, physical, and sexual abuse, and specific types of wounds, are examined. The thesis discusses post-mortem changes, highlighting the importance of separating these from ante-mortem injuries to avoid misinterpretations. The role of forensic pathology in crime scene assessment and evidence management is followed with the techniques and tools that are being used and emphasizing it with case studies and examples to illustrate practical applications.

Despite ongoing advancements, veterinary forensic pathology faces significant challenges. The lack of standardized procedures, limited training opportunities, and insufficient legal recognition hinder its potential for the necessary recognition and reduces the impact of forensic findings in court. This thesis argues for stronger legal support, interdisciplinary collaboration, and the establishment of dedicated training programs to enhance the effectiveness of veterinary forensic pathology, with the help of focusing on Germany's situation and future challenges and opportunities. By strengthening these aspects, veterinary forensics can play a more impactful role in promoting animal welfare and securing justice in cases of abuse.

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## I. Introduction

The choice to write about animal cruelty and abuse comes from my deep love for animals, a passion that has guided my life and studies. While it is a topic that causes me distress, particularly because I find it very disturbing to witness animals suffer, I believe that addressing these harsh realities is very important.

One of the most crucial aspects of animal cruelty is that animals cannot verbalize their pain and suffering. This makes it essential for veterinarians, caregivers, and owners to develop the necessary skills to identify abuse either through physical examination, inspection, clinical assessments, or forensic pathology. I find it both fascinating and challenging to realize the signs of cruelty in animals that cannot speak for themselves, mostly through injuries on their bodies, behavioral abnormalities, housing conditions, or forensic pathology.

My personal connection to this topic is because of the stray animals I grew up with every summer in Turkey. I was born and raised in Germany, where animal cruelty is not as widespread, and during my internships in veterinary clinics in Germany, I mostly saw that owners treat their pets very well and care for them like their own children. Germany also does not face significant issues with stray animals, which in contrast is not the case in Turkey. Seeing the conditions that street animals are being exposed to there, especially dogs, was heartbreaking for me and therefore inspired me to study veterinary medicine. These animals, many of whom are abandoned by owners who cannot or do not want to take care of them, face starvation, abuse, and neglect. It is tragic to witness how some of these animals develop extreme fear towards humans in the form of aggressive behavior or running away as a result of mistreatment, while others remain surprisingly friendly.

My thesis aims to explore these realities and give voice to animals that cannot speak for themselves. I will examine various forms of animal cruelty and abuse, including those that may not be immediately recognized. Eventually, the goal of this thesis is to raise awareness about the impact of abuse on animals and highlight the important role veterinarians play in identifying and combating cruelty in everyday practice and how forensic veterinary pathology plays a role in this field in court.

**a. Veterinary Forensics and importance of the topic**

Veterinary forensic medicine and pathology play important roles in cases of animal cruelty and abuse and are used in legal investigations to help courts understand the causes and significance of injuries or diseases in animals as well as to educate veterinarians and animal keepers about the protection and justice the animals deserve [1]. Unlike diagnostic necropsy, forensic necropsies involve careful evidence handling, adherence to standardized protocols, and comprehensive documentation to ensure legal reliability [2].

Veterinary forensics is quickly gaining recognition as a unique field of veterinary medicine, stimulated by growing awareness of animal cruelty and its link to violence against people. However, while forensic science is well integrated into human medicine, its application in veterinary cases is still catching up. Many veterinarians lack comprehensive training in veterinary forensic practice and may be uncertain about applying this field to legal cases. Nevertheless, research and publications are steadily expanding the knowledge base in veterinary forensics, including educational programs helping veterinarians with better and new tools and techniques to handle cases involving animals. However, to strengthen these investigations veterinarians will need to work with experts across various forensic disciplines [3].

The purpose of the examinations is to discover and look for injuries, abnormalities, or diseases and to interpret them so they can be used as a legal way to bring out the cause of death or the harm that it entails. The work of veterinarians in these cases includes reviewing medical histories, conducting scene investigations, performing pathology necropsies like post-mortem examination, documenting findings through photography and reports, and providing testimony in court as experts [1]. Investigations often involve different species, requiring pathologists to adapt their techniques and to consider anatomical and physiological differences [2]. The field plays a critical role in addressing not only domestic animal abuse but also wildlife crimes, which are often linked to environmental issues. Animals can serve as victims, witnesses, or even perpetrators in crime scene investigations, requiring veterinarians to interpret their findings within a broader medico-legal context [4].

The importance of these examinations is highlighted by their potential to illuminate wider societal issues, such as the connection between animal cruelty and interpersonal violence. Studies indicate that individuals who harm animals are at a higher risk of exhibiting violent

behavior towards humans, positioning forensic veterinary pathology as essential for both animal welfare and public safety [2].

The study “The Care of Pets within Child Abusing Families” explores the connection between child abuse and animal cruelty. It was conducted with families known for child abuse in New Jersey, where it was found that animal abuse often occurred in the same households where child abuse was present, with 88% of physically abusive households engaging in abusive treatment of pets [5].

Furthermore, cruelty to animals by children is frequently a predictor of future antisocial behavior, which may progress into violence against humans. This link has been documented in offenders, including prominent criminals such as Jeffrey Dahmer and Ted Bundy, who committed animal abuse as children [6].

Abusive adults will sometimes kill or damage pets in order to control or silence children, particularly in cases of sexual or ritual abuse. In rare cases, children damage pets in response to maltreatment, such as "dress rehearsals" for their own suicide. Veterinarians might encounter indicators of abuse in both animals and humans, as pets are commonly part of families experiencing domestic violence and this makes veterinarians potential first responders in identifying abusive environments [6].

**b. Types and indicators of Animal Abuse and Cruelty in Forensic Veterinary Pathology**

Forensic science is a multidisciplinary field combining skills such as scene investigation, forensic examination of dead animals and live animals, and analytical chemistry [7].

According to Munro et al., they describe in their book “Animal Abuse and Unlawful Killing, Forensic Veterinary Pathology” that it is recognizable that “*Veterinarians are aware (sometimes uneasily) that a further complication lies in the fact that the question of whether a situation or act involving an animal is judged ‘abusive’ also depends on the views that human society holds on particular groups of animal*s.” [8 page 13]

For instance, societal views on what is deemed acceptable for the care and slaughter of farm animals, the trapping and poisoning of vermin, and the use of laboratory animals in research often contrast sharply with the standards for pet animals. In essence, practices tolerated for one category of animals might be seen “abusive” for another [8].

In the context of companion animals, this confusion can be effectively minimized by adopting a classification system that the medical field has successfully developed for

identifying child abuse and can be applied to animal cases as well. This typology categorizes abuse into four main types including physical, sexual, emotional abuse, and neglect. It is possible that more than one type may occur. This approach is beneficial because it is straightforward, allows clear communication between veterinarians and other professionals like pediatricians, and helps standardize terminology, which is essential for conducting and comparing research in this challenging area [8].

For National Incident-Based Reporting System (NIBRS), the Federal Bureau of Investigation (FBI) categorizes animal cruelty into four distinct categories similar to those: (NCOVAA, 2017)

**A** Simple / Gross neglect: the failure of a person to provide for the needs of an animal (lack of food, water, shelter, grooming or veterinary care)

**I** intentional abuse or torture: the intentional act of harming an animal

**F** organized abuse: dog fighting and cockfighting; and

**S** animal sexual abuse [9]

Physical abuse, also known as non-accidental injury or battered pet syndrome, involves actions that cause bodily injury to the animal [8].

The term “Animal sexual abuse” is preferred over “bestiality” or “zoophilia” to highlight the harm done to the animal. It refers to using an animal for sexual gratification whereas injuries resulting from such an act can be severe depending on the type of act and the size of the animal [8].

Emotional abuse involves verbal harassment, threatening behavior, or failure to provide psychological comfort. Closely related to emotional abuse is neglect which describes the failure to provide basic necessities like food, water, shelter, and veterinary care for injury or illness, for instance abandoning an animal or allowing a collar to constrict as the animal grows [8].

The differentiation between blunt force trauma (BFT) and sharp force trauma (SFT) is notable. Briefly, an external agent applied to a body part is the most common mechanic of injury leading to damage to animal tissues. BFTs are due to non-sharp objects of force and have transmission of kinetic energy to the body that can result in abrasions, contusions, lacerations, or fractures. Tissues are subjected to different forces including compression,

tension, torsion, and associated injuries depend on factors like surface area of impact, magnitude, and duration of the force. In contrast, SFT causes specific wound patterns, and its main cause is sharp objects, especially knives. These injuries are difficult to diagnose correctly, which is especially important in cases of animal abuse, leading veterinary pathologists to identify if a wound was accidental or intentional [10].

## II. The evolution of veterinary forensic pathology

### a. Historical perspective

Forensic science has a long and distinguished history, especially in the field of human forensic medicine. It has evolved over centuries and as Forensic Science has developed it has now become a multidisciplinary field [11].

The development of it began in the mid 1700s, initially focused on equine medicine due to the influence of military and noble interests, which delayed the attention to other species. The first veterinary school was established in Lyon in 1761, and other institutions followed across Europe. Following developments in human pathology and encouragement for meat hygiene research in slaughterhouses, particularly in Germany. By the 19th century, veterinary pathology was taught in North America and Europe, and through the 20th century, pathology became more specialized with the establishment of organizations like the American College of Veterinary Pathologists (1949) and the European College of Veterinary Pathologists (1995), fostering standards and training across Europe [12].

### b. Development and current status

In the past, medical professionals played a very important part in forensic investigations, but today, it consists of a larger team of forensic specialists including forensic chemists, botanists, biologists, and others. This evolution reflects the maturation of forensic science as a discipline, whereas different subfields contributing to the overall understanding and investigation of crimes [11].

Veterinary forensic pathology, on the other hand, remains a much newer, less developed discipline, being still in its early stages, while human forensic medicine has seen continuous advancement since its early applications in China, Islamic medicine, and Europe. Reasons for this is partly due to the lack of formalized training, certification programs, consistent standards and institutional support and established medicolegal structures in veterinary medicine, unlike human forensic science, which is supported by accredited educational programs and professional organizations [11].

However, due to the increased awareness of animal welfare, forensic veterinary pathology has seen a significant rise in demand. Despite this, there are few standardized protocols for forensic reports in most countries. National organizations such as the European Society of Veterinary Pathology, have played a crucial role in promoting high standards. In recent years,

initiatives like the European College of Veterinary Pathologists (ECVP) were introduced to address the need for specialized qualifications, providing consistent standards for legal investigations involving animals. This progress is driven by public demand for better animal welfare enforcement, and forensic veterinary pathologists are increasingly recognized for their vital role in animal-related legal cases [12].

Since that growth in popularity, accredited programs at universities and colleges have been established in nations like the UK, ensuring that forensic practitioners receive standardized and independently assessed training. On the other hand, the lack of accreditation procedures in veterinary forensic pathology the field's growth and the acceptance of its practitioners as authorities in court are being hindered. Closing this gap is important for the field because veterinary forensic scientists will become more credible and knowledgeable with formal education and accreditation [1].

Additionally, human forensic medicine faces ongoing challenges in relation to scandals involving unreliable expert witnesses or the privatization of forensic services. These issues enable valuable lessons for veterinary forensic pathology [1].

By learning from these challenges, the veterinary field can build a more robust and reliable forensic framework, avoiding the pitfalls that have weakened public trust in human forensic medicine in some cases [1].

In conclusion, as veterinary forensic pathology continues to evolve, it must follow the example set by human forensic science by embracing interdisciplinary collaboration, formalizing training programs, and establishing accreditation standards. Only then can the field fully mature and contribute to the investigation of animal-related crimes with the same level of precision and authority as its human counterpart [1].

## III. Understanding animal cruelty and abuse

### a. Definitions and types of animal cruelty and abuse

Animal cruelty and abuse, much like the abuse of humans, can be classified into different types, with each having its distinct characteristics. As Munro et al. [8] discuss, there is significant confusion regarding the terminology in relation to animal abuse due to the fact that it includes a variety of situations, such as “cruelty”, “maltreatment”, and “ill-treatment”. Although these terms are often used, their applicability may become unclear as a result. The different societal views about the proper treatment of animal groups exacerbate this uncertainty [8].

As previously mentioned, practices accepted in livestock farming or scientific research might be considered cruel if applied to companion animals, which illustrates the social and cultural dimensions that complicate the definition of animal cruelty [8].

Types of injuries in case of animal cruelty can vary immensely, speaking of physical trauma to environmental injuries. Understanding these different types of harm is crucial for both legal cases and veterinary forensic pathology. In the following, there will be listed some of the most common injury types observed in cases of animal abuse in relation to the illustration (Figure 1) [1].

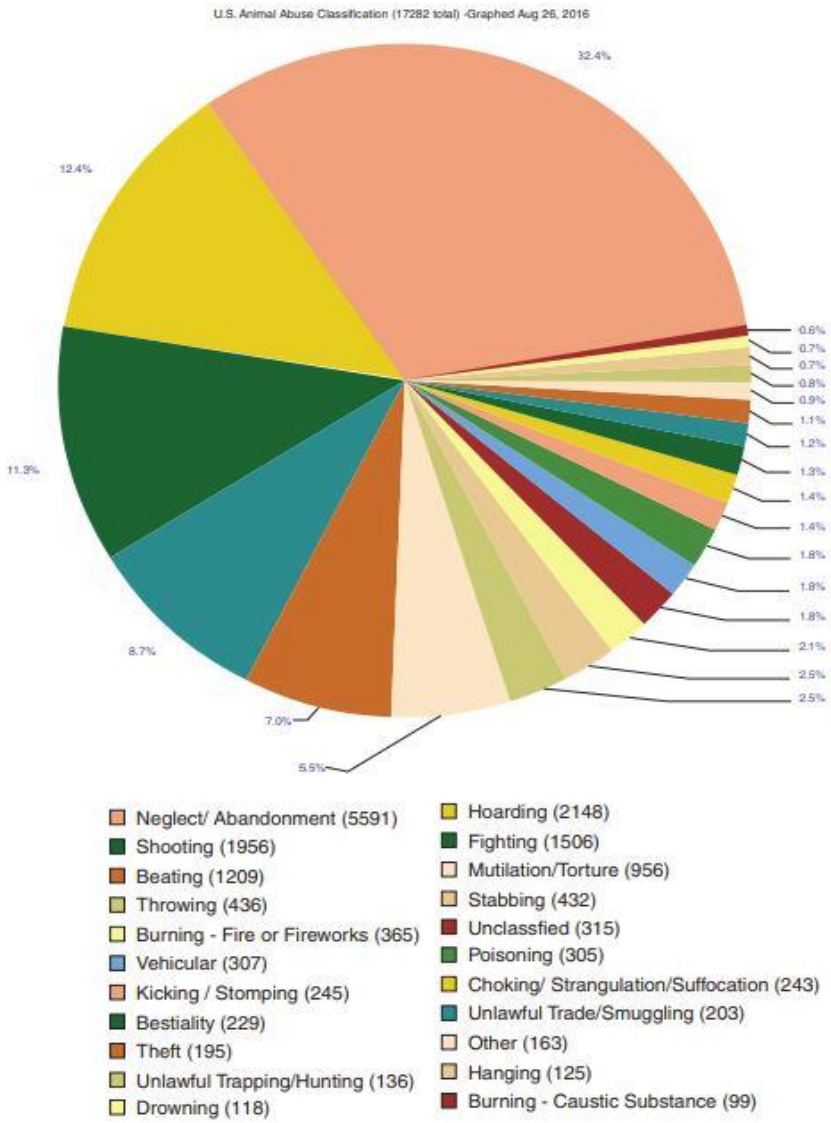


*Figure 1 [13]: US Animal Abuse Classification and AARDAS project*

**Neglect**

Neglect is frequently downplayed compared to other types of abuse but is actually a prevalent, common and harmful form of animal mistreatment. The general definition describes not providing an animal with its physical and mental requirements. Neglect can lead to harm to an animals' health and overall welfare and may even be considered a criminal offense, in some cases [1].

Neglect appears in different ways and can be categorized into different forms, such as husbandry-related neglect. This is the most common form, where basic needs such as food, water, shelter, or veterinary care like untreated injuries are not met. Economically-motivated neglect describes the cases resulting from cost-cutting methods or a lack of concern for the animal welfare, like in puppy mills. When animals are utilized for profit, such as racing

horses or fighting dogs, they frequently suffer for a long time because their needs are ignored. The failure to address obvious medical issues, such as embedded collars, untreated fractures, or visible tumors, result in prolonged and unnecessary suffering and are known as medical neglect. These cases often highlight apathy or complete lack of regular interaction with the animal. Last, but not least, a rare but concerning form of neglect, caregiver-fabricated illness, occurs when caregivers intentionally harm animals to seek attention or sympathy, where warning signs include animals presenting with unexplained symptoms that improve when separated from the owner or another abusing person [14].

The field of forensics is crucial for documenting and assessing instances of neglect in animals. While a basic physical examination can provide some indications of further diagnostic methods, like X rays, blood tests and urine analysis are required to gain a detailed understanding of the animals' health status. The effects of neglect may not be immediately obvious, but can be revealed over time through ongoing monitoring and testing [1].

The five freedoms of animal welfare [15]:

1) Freedom from hunger and thirst
2) Freedom from discomfort
3) Freedom from pain, injury or disease
4) Freedom to express normal behavior
5) Freedom from fear and distress

These freedoms serve as the foundation for assessing neglect and are most often violated when we are talking about neglect. The failure of providing the minimal standard of care offends the duty of the owner. Noticeable that also financial distress is not an excuse for an animal to suffer [1].

Legal definitions of neglect differ depending on the location. Nevertheless, in cases the standard of the "average person" is typically used to decide whether the pet owner should've been aware that their negligence would cause harm to the animal. Forensic veterinarians often approach the case with the questions whether the signs of neglect, such as malnutrition, untreated medical conditions or behavioral changes, were evident to the owner. Any obvious indicators help establish that the neglect was willful. For instance, these indicators can include foul odor from an infection or visible wound [1].

Furthermore, the environment in which the animal lives, also provides crucial evidence of neglect. Unsanitary conditions, unsafe housing, overcrowding, lack of basic resources such as clean drinking water, quality of feed, or providing cat litter can all be indicators. Over time these conditions have an effect on the animals' health, furthermore, provide a timeline of the neglect through evidences regarding the indicators like the presence of old feces, scavenging, or signs of contaminated drinking water like algae in water containers [1].

Neglect cases demand careful evaluation by both veterinary professionals and legal authorities. Without the proper investigation, the suffering of neglected animals may continue unimpaired [16].

**Hoarding**

As already mentioned, a form of neglect can include overcrowding, also called hoarding, representing the violation of the five freedoms. Hoarding, also known as the chronic form of neglect, is a form of animal cruelty that can be described as extreme neglect, where the owner collects a large number of animals, but is unable to meet their basic needs. This behavior is often linked to a mental health disorder, with the hoarder typically failing to recognize the suffering they are causing to the animals [16]. Furthermore, these conditions also pose significant health risks to humans, including zoonotic diseases and environmental hazards such as high ammonia levels [17].

Animals in hoarding situations experience physical effects, such as malnutrition, starvation, lack of medical care, and physical injuries, as well as psychological effects, such as chronic stress, anxiety, and developmental and/or social impairments [16].

As the hoarded animals often suffer from severe malnutrition due to insufficient and inappropriate feed, consequently in many cases there is competition between the animals to get the right amount of feed and water, leading to fights between animals, causing physical injuries such as bite wounds, scratches, infections, and overgrown nails that can become embedded in the skin. The lack of resources leads to underweight bodies, stunted growth, dehydration, starvation, and cannibalism (Figure 2 and 3) [16].

*Figure 2 [16]: Cannibalism in cat hoarding case in which the cats were suffering from starvation - page 226*

*Figure 3 [16]: Maternal cannibalism in response to stress in a hoarding environment - page 88*

*Figure 4 [16]: Cat hoarding case. Evidence of cats scratching at the window to get out - page 214*

Unfortunately, those animals also do not get the appropriate care they would necessitate. They frequently suffer from untreated medical conditions such as infections, parasitic infestations (fleas, ticks, intestinal worms, etc.) as well as from chronic diseases which the hoarding entails. Severe dental problems, eye infections, or skin diseases are very common in such environments [16].

Furthermore, the psychological impact also plays a crucial role in their development, especially in puppies and kittens. A lack of basic social skills and behavioral problems make rehabilitation difficult and may lead to behavioral issues, such as fear, aggression, or withdrawal [16].

Sadly, hoarding cases mostly result in broad anti-cruelty charges, overlooking the individual suffering of each animal, which reduces the severity of legal consequences [18].

**Dogfighting**

> "It's not the size of the dog in the fight, it's the size of the fight in the dog"
>
> - Mark Twain [6 page 243]

Dogfighting has its origins in mid-1800s England after bullbaiting was banned in 1886. Over time, bulldogs were bred for fighting, leading to the development of the pit bull terrier. Dogfighting is categorized into street fighting, hobby fighting, and professional fighting. Street fights are unplanned and without rules, often linked to gang activities. Hobby fights participate in organized fights a few times per year, while professionals make a full-time living from breeding, selling, and fighting dogs, often at national and international levels. [1]

In Germany, as well as in other countries, breeds such as Pit Bull Terriers, American Bulldogs, Staffordshire Bull Terriers, and Kangals are still abused for dogfighting [19]. However, it is important to know that these breeds are abused for dogfights and are not born as "fighting dogs". This confusion often leads to misinterpretation and false conclusions [20]. These dogs are specifically bred and trained using cruel methods to increase their aggression. Training includes the use of treadmills to enhance endurance, blood-soaked carpets are used as stimulants during fights, and in some cases, even kittens are allegedly used to provoke the dogs. Dogfighting in Germany is also linked to broader criminal activities, with these dogs often serving as weapons or status symbols for criminals, who exploit the animals only for financial gain and prestige [19].

Veterinarians may suspect dogfighting when animals present with multiple bite wounds, fractures, or dental injuries. Repeated veterinary visits for such injuries may indicate involvement in dogfighting [10]. Furthermore finding training equipment and medical supplies like sutures and intravenous fluids in suspicious settings can be a signal [1]. The housing of these fighting dogs is often in isolated conditions to increase aggression. In rural settings, they are chained, while in urban environments, they are often kept in crates, sometimes stacked in dark, cramped spaces. The lack of socialization and poor living conditions contribute to their aggressive behavior and represent an example of animal cruelty and abuse [1].

The wounds of spontaneous and organized dogfights can be differentiated based on different aspects, such as the form of the wounds. Forensic veterinarians are responsible for

documenting these injuries as well as any scaring, which can help identify whether a fight was organized or spontaneous. In addition, it is necessary to look for other features of abuse including fractures and/or infections. *Babesia gibsoni*, a common blood parasite found in fighting pit bulls that can be passed on through dog bites should also be investigated as part of necropsy [1].

**Cockfighting**

Cockfighting is a cruel practice, where roosters are forced to fight against each other, most often resulting in severe injuries or death. In these fighting, only male birds, specifically mature roosters, are involved. A mature rooster is referred to as a "cock" once it is two years old and has completed its first molt. Younger roosters also called the stags, may also be used in fighting events known as stag derbies. Female birds are not fought but are used for breeding purposes [1].

The preparation of the birds for such a fight is extensive and often involves a program called "the keep". This includes a strict diet and exercise program that may last two to four weeks. In this regimen the birds undergo various exercises like running, flying, and leg pulls to build muscle strength and balance. Sparring matches are also conducted to evaluate their fighting style and their fitness. Additionally, the roosters may be given dietary supplements and drugs, such as antibiotics and anabolic steroids during this period to enhance their performance [1].

Cockfighting involves physical alterations to the birds, such as removing their combs, wattles, and earlobes to prevent injuries and reduce their body weight, which gives them an advantage in the fight [1]. Furthermore, birds are sometimes trimmed off their feathers to prevent overheating during the fight [21]. In some extreme cases, their natural spurs are trimmed (Figure 4) to allow the attachment of weapons like gaffs (Figure 5) or knives (Figure 6) to their legs. These weapons increase the lethality of the fights making them even more dangerous [1].

The fights are brutal and often end in the death of one of the birds. These fights usually last not more than fifteen minutes, they end either with the death of one bird or a bird failing to continue attacking. Roosters who lose are often discarded or left to die from their injuries [21].

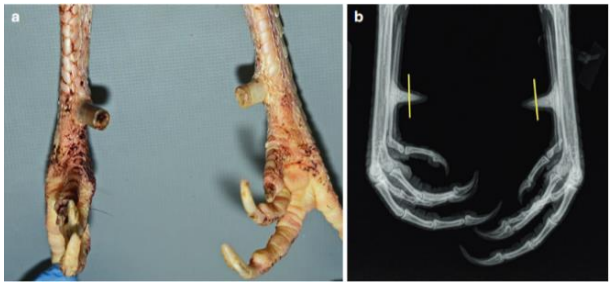


*Figure 4 [4 page 114]: Spurs cut short for the use with a gaff.*

*- Here: removed bone as well*

*Figure 5 [4 page 115]: Acrylic gaff*

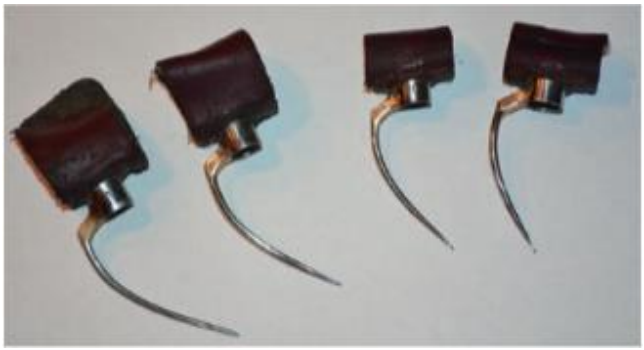

*Figure 6 [4 page 115]: Knives*

**Animal Sexual Abuse**

Animal Sexual Abuse (ASA) involves a range of abusive behaviors toward animals, including fondling, penetration (vaginal, anal, or oral), masturbation, and the use of foreign objects. While not all instances of ASA cause physical harm, the presence of unexplained injuries, particularly to genitalia, should always raise suspicion. ASA can also involve other trauma like blunt force, ligature marks, tail and ear injuries, or strangulation, which may be inflicted either as part of the abuse or during attempts to restrain the animal [22].

As mentioned in the introduction the terminology surrounding this subject is important. While most are familiar with the term "bestiality," which refers to sexual activity between a human and an animal, the term is problematic. Both "bestiality" and its synonym "zoophilia" focus primarily on the person involved, neglecting to address the harm suffered by the animal. A more appropriate and precise term is "animal sexual abuse" (ASA), which mirrors the terminology used in discussions of child sexual abuse and focuses on the abuse and harm inflicted on the victim [8].

Animal sexual abuse is distinguished by the focus on the animal's genitalia or the anus and rectum (or the cloaca in birds). Whether an animal is physically harmed depends on the type of sexual contact and the size of the animal. The injuries caused can range from mild to severe, and in some cases, may be fatal. Veterinarians have a vital role in identifying and managing injuries caused by animal abuse, although discussions should concentrate on the animal's suffering rather than the underlying motivations for the abuse [8].

ASA is not limited to a specific species or gender of animals, as well as the gender of the perpetrator. Both male and female animals of various species, including companion animals, farmed livestock, and birds, are subjected to sexual abuse by both men and women [8]. However, dogs are the most frequent due to accessibility and behavioral factors [23].

The examination of animals suspected of sexual abuse is crucial in establishing the nature of the injuries. Specialized kits are available for use in human cases, as well as in veterinary cases, and proper collection of forensic evidence is essential. In cases where male dogs are involved, identifying canine spermatozoa and distinguishing it from human spermatozoa can be a critical and helpful part of the investigation. Even though ASA is seen as a taboo topic [23], veterinarians must remain aware that sexual abuse exists, recognize the injuries associated with it, and include ASA in the differential diagnosis of lesions affecting the genitalia, anus, and rectum of animals [8].

When it comes to semen found at these scenes, it is important that animal and human sperm can be differentiated so the origin of this evidence can be accurately identified, particularly when dog sexual abuse cases are investigated. The Kernechtrot-pico indigo-carmine stain, also known as Christmas tree stain, produces a unique staining pattern in dog sperm, where in the sperm head, a colorless band can be observed between the acrosomal and postacrosomal regions, a feature not present in human sperm. This band could serve as a marker for canine sperm in forensic examinations. The samples from eight dogs were analyzed, confirming the presence of the colorless band in each [24]. This feature provides a forensic tool for cases where dog semen must be identified to differentiate it from human sperm and contributes to animal abuse investigations [24].

Besides morphology, biochemical tests are very important for distinguishing between human and animal semen. Acid phosphatase, found in large quantities in human semen, is a marker that persists for up to 24 hours in the vaginal tract and hence is often used in forensic analyses. Since P30 is a glycoprotein that originates from human prostate and is present in semen whether it contains sperm or not, it provides an excellent marker for human semen. In contrast, canine semen does not result positive to test for either acid phosphatase or P30, which essentially makes these biochemical markers very specific in evaluating doubt when committed human sexual activity is suspected [16].

In some sexual abuse cases, there is no sperm present due to a variety of reasons such as lack of ejaculation, condom use, aspermia from vasectomy, degradation of sperm over time, or the natural drainage of semen. In those cases, forensic experts are still able to detect male DNA from epithelial cells or lysed sperm, but interpretation therefore can be challenging since the victim's DNA may hide that of the perpetrator. Y-chromosome short tandem repeats (Y-STR) analysis is a central tool to resolve these types of mixed profiles. Forensic tools such as the Sperm Hy-Liter test allow specific detection of human sperm heads without cross-reacting with animal sperm such as that of dogs, cats, and other species. The Rapid Stain Identification Semen (RSID) test that detects human semenogelin, also does not cross-react with animal seminal fluid or other bodily fluids such as blood or saliva. This positive molecular identification is particularly important when dealing with instances of sexual abuse of animals by humans and when human as well as animal sperm may be present in the samples. A correct differentiation is essential to correctly indicating the responsible person and researching animal abuse [16].

**b. Types of wounds and injuries**

In forensic pathology, the analysis of wounds and injuries is very important to determine the cause and harm that was done to the animal. Here the identification and interpretation can provide evidence in cases where animal cruelty and abuse are suspected. Wounds are caused by external forces and may affect either skin, deeper tissue or both. In forensic veterinary medicine, injuries are categorized into different types based on the nature of the force and the tissues affected [8].

Distinguishing between accidental and non-accidental injuries (NAI) is a critical aspect of investigations into animal trauma. Non-accidental injuries are intentionally inflicted traumas that often result from abuse or neglect. These injuries are characterized by specific patterns that separate them from accidental harm. Radiographic evidence in NAI cases often reveals multiple fractures across different body regions or fractures at varying stages of healing, indicating repeated abuse over time. Transverse fractures are noticeably more common in NAI cases, typically caused by blunt force trauma, such as beating or kicking. The delayed presentation of injuries is another hallmark of NAI. Animals subjected to abuse often show advanced fracture healing, such as callus formation, suggesting that medical care was postponed or completely ignored [25].

In contrast, accidental injuries arise from unintentional events, such as road traffic accidents, falls, or dog attacks. These injuries are often localized to a specific body region and typically present as spiral fractures rather than the transverse fractures common in NAI. Pelvic fractures are a frequent finding in accidental trauma, reflecting the high-impact forces of road accidents. Unlike NAI, accidental injuries are usually treated immediately, and radiographs often show recent trauma without evidence of long-term neglect or healing [25].

Differentiating accidental from non-accidental injuries remains difficult without comprehensive medical records or detailed anamnesis. However, forensic necropsy techniques, including careful analysis of lesions and toxicological testing, play a crucial role in identifying malicious intent [26].

This distinction is vital in legal proceedings, where accurate identification of NAI can lead to the prosecution of perpetrators and the protection of vulnerable animals [25]. In a documented case, a cat was presented in the clinic with skull fractures and abdominal hemorrhages, where radiographic imaging revealed healed rib fractures, as an indication of prior abuse. The ability to distinguish these as non-accidental injuries led to the conviction

of the perpetrator under animal cruelty statutes, as the evidence was clear that the owner's claim of accidental injury from a fall was not possible [26].

Distinguishing between blunt force trauma and sharp force trauma is essential to understand the nature and cause of injuries. They differ in their mechanism and forensic implications.

Blunt force trauma occurs when a blunt surface collides with an animal's body, or when a blunt object strikes the animal. There must be movement involved either from the object, the animal, or both. This motion and the resulting impact are necessary for the trauma to occur [27]. Abrasions occur when the skin is scraped against a rough surface, while bruises form due to bleeding beneath the skin, often influenced by tissue density and proximity to bones. Lacerations, caused by stretching or crushing forces, are irregular tears in the skin that are frequently accompanied by bruising or abrasions. Blunt force injuries are common in accidents, such as falls or vehicular collisions, but can also indicate deliberate acts of violence, such as beating or kicking [28]. Abdominal injuries may not always show external bruising, but severe internal damage, such as ruptures of the liver or spleen can occur. The lack of visible signs makes internal examination crucial in identifying trauma to these organs with the help of radiographic diagnostics. In young animals, the flexibility of their rib cages may result in internal bruising without external signs, making it important to carefully reflect the skin during an examination. [8].

In contrast, sharp force trauma involves injuries caused by cutting or stabbing with sharp object and is primarily categorized as incised wounds and stab wounds [8].

Incised wounds, also known as cuts, occur when sharp objects like knives, broken glass, or other objects are drawn across the skin. These wounds tend to be long and shallow, with clean edges and profuse bleeding, but not as deep. In veterinary cases, knives of various types, such as hunting knives or box cutters, are commonly used to inflict these injuries. In most cases, it is not possible to provide information about the weapon used, but they often bleed heavily due to the clean-cut [8].

Stab wounds, or puncture wounds, are penetrating injuries caused by thrusting sharp objects like knives, swords, or even scissors into the body. These can result in severe internal bleeding and damage to organs, such as lungs or heart [8] and the depth of a stab wound is usually greater than the surface wound and can be misleading depending on the dynamics of the incident (Figure 7). Perforating wounds, which pass through the body, are also a type of stab wound. The angle, direction, and depth of the stab wound can sometimes offer clues

about the circumstances in which the injury was inflicted [8]. These injuries typically suggest intentional acts of violence, though accidental sharp force trauma can also occur [28].

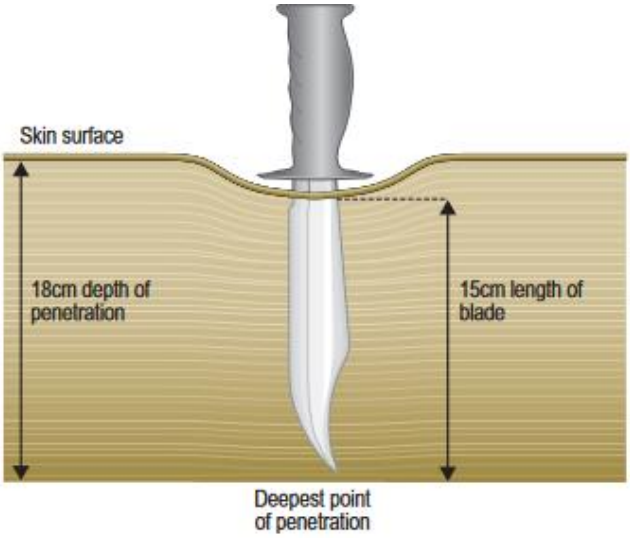


*Figure 7 [14 page 45]: a forceful stab to the body may depress the wall allowing deeper organs to be injured, thereby creating a misleading impression of the blade length*

In case of gunshot wounds in animals, the injuries are highly complex and influenced by the firearm type, and projectile designs, such as velocity, energy transfer, and the anatomical characteristics of the affected animal. Veterinarians often rely on human medical literature to understand gunshot wounds, yet the dynamics are different between humans and animals. For instance, military munition is designed for human targets with consideration for survival, while hunting munition, used in animals, aims for a quick, lethal impact [29].

Gunshot wounds typically have distinct entry and exit points, with the entry wounds often being smaller and more defined due to the projectile's impact. Exit wounds, if present, are usually larger and more irregular because of tissue disruption as the projectile exits [29]. Wound channels are straight paths created by the projectile as it passes through the body, often resulting in significant damage to tissues, bones, and internal structures [30]. When a bullet impacts bone, it can lead to fragmentation, creating secondary projectiles from shattered bone pieces, this can result in a complication of the wound, causing multiple tissue injuries around the bullet's path and increasing the risk of infection. Furthermore, gunshot wounds are highly prone to contamination because the projectile carries bacteria and debris into the body [29].

In cases of illegal shootings or animal abuse, veterinarians are called upon to assess gunshot wounds for legal purposes, which highlights the importance of understanding ballistics, wound characteristics, and interpretation of the findings accordingly in forensic cases [29].

In organized dogfighting, distinguishable wound patterns are observed. The study by the Cummings School of Veterinary Medicine at Tufts University [31] examined injuries in dogs involved in both spontaneous and organized dogfights, focusing on differences in the extent, distribution, frequency, and location of injuries. Dogs from organized fights showed a high prevalence of wounds concentrated on the thoracic limbs, dorsal and lateral aspect of the head, the muzzle and oral mucosa as well as the dorsal and ventral part of the neck and chest. These injuries mostly include deep puncture wounds, avulsions of skin and tissue, and sometimes fractures with damage most commonly found around the oral cavity. This is because dogs in organized fights are specifically bred for this purpose and trained to be more aggressive, attacking continuously despite being injured themselves [31].

In contrast, spontaneous dogfights resulted in superficial, less severe, and more isolated injuries, often located on the pinnae, neck, and front legs. Unlike organized fights, spontaneous fights typically involve fewer wounds, with dogs more likely to stop fighting after initial injuries and the absence of multiple wounds in different healing stages (Figure 8). This distinction in wound patterns makes forensic veterinarians able to identify whether a dog has been involved in organized dogfighting, with evidence-based injury patterns indicating more frequent and severe trauma in these cases [31].

Additionally, bite wounds can frequently carry bacteria like *Staphylococcus intermedius* and *Escherichia coli*. This contamination can provide forensic insights, as the type and source of bacteria help identify the wound's origin and whether abuse or neglect is involved [32].

*Figure 8 [4 page 104]: Each white mark on the dog's face represents a bite wound injury. Annotation: bite wound scars are easier to see on dark-coated dogs*

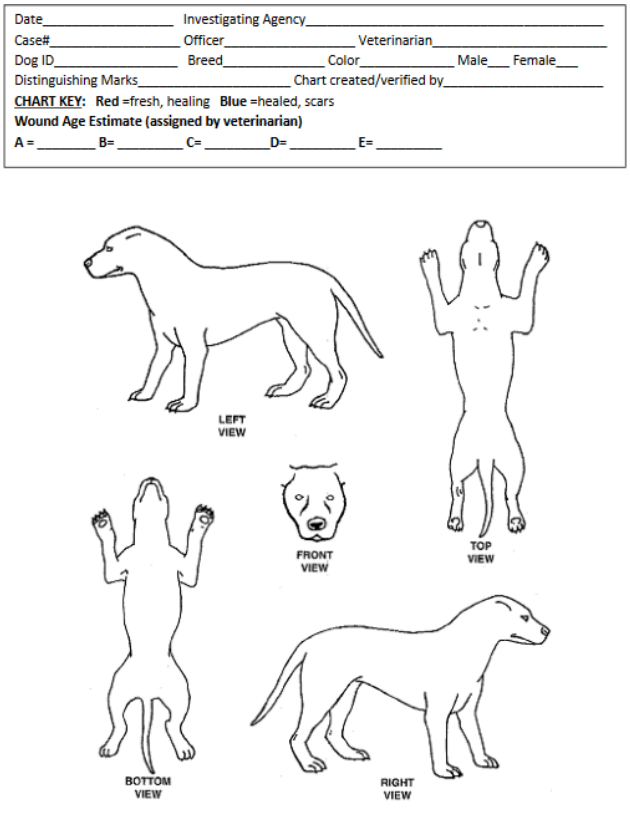


*Figure 9 [23]: Dog fighting and injury chart*

The previous figure shows a form used by veterinarians to document cases of dog fighting injuries comprehensively (Figure 9). It includes details such as the animal's identification,

name, breed, color, sex, the responsible veterinarian, case number, investigation agency, and the incident date. The veterinarian marks affected body regions as the pictured figure, using red ink to indicate fresh wounds that are in the healing process and blue ink for scars from previous injuries that have already healed. This visual documentation provides a clear and structured record of the dog's injuries.

Last, but not least, these wound analyses and interpretations help veterinarians with essential information on what may have happened to the animal. Furthermore, wounds or injuries as well as the cause of death also are differentiated in literature in categories in areas to distinguish between thermal trauma, firearm wounds, asphyxia, drowning, physical trauma, poisoning, and bite injuries [8].

**c. Post-mortem identification**

**i. Post-mortem changes and post-mortem interval**

In post-mortem examinations, understanding the natural changes that occur after death is very important. These physicochemical processes begin immediately or shortly after death, independent of the cause of death, and follow a specific order. However, the progress of these changes is significantly influenced by endogenous and environmental factors, such as high temperatures, humidity, thick coat or fat layer, and fever or bacteremia before death accelerate the process [33]. Therefore, pathologists and veterinarians need to be experienced in these natural post-mortem changes to distinguish them from potential signs of animal cruelty or abuse and to avoid misinterpretations. Additionally, the recognition and interpretation of these changes are crucial for estimating the post-mortem interval (PMI), which is a key factor in many forensic investigations. PMI estimation can support or exclude suspects and provide a timeframe for events in suspected animal cruelty cases. However, there are limitations due to species-specific differences and the variability in methods, which makes it more challenging in comparison to human PMI [1].

Typical post-mortem changes include [33]:

| | |
|---|---|
| Algor mortis | cooling of the body, which depends on various internal and external factors |

| | |
|---|---|
| Pallor mortis | pale discoloration caused by blood settling in lower body parts, though this Is often challenging to detect in animals due to hair or pigmentation |
| Exsiccatio postmortalis | desiccation due to evaporation, visible on the skin and mucous membranes |
| Mummification | complete tissue dehydration under dry heat or air, which inhibits bacterial decomposition |
| Rigor mortis | muscle stiffening in skeletal, cardiac, and smooth muscle, influenced by factors like temperature, pre-death activity, or diseases |
| Cruor mortis | post-mortem clotting, which produced dark red, smooth clots not attached to the vessel walls |
| Imbibition | discoloration from hemoglobin or bile, spreading through surrounding tissue |
| Autolysis | self-digestion as cellular enzyme breaks down tissues, leading to softening |
| Putrefaction | breakdown of tissues into gases, liquids, and salts, accelerated by warm temperatures |
| Adipocere | post-mortem wax, formed through saponification under certain conditions |

Post-mortem changes provide veterinarians and forensic experts about possible causes of death if the correct interpretation is given. As shortly mentioned in the previous chapter “Types of wounds and injuries”, literature highlights various possibilities of wounds, injuries, and also potential causes of death. These include thermal trauma, firearm wounds, asphyxia, drowning, trauma by physical agents, and poisoning [8].

Thermal injuries in animals can result from various causes including direct contact with flames, hot surfaces, liquids as well as radiant heat, electricity, microwaves, hyperthermia, and hypothermia. Direct and radiant heat injuries are generally localized, whereas hyper- and hypothermia may cause more widespread lesions. The shape of lesions can be a critical factor in identifying burns. As Munro and Munro describe in their book Animal Abuse and

Unlawful Killing: Forensic Veterinary Pathology *"Biologically abnormal patterns such as straight or angular borders, drip configurations or unusual symmetry' may increase the index of suspicion of a burn.* [8] [page 48]" For instance, cigarette burns have a characteristic size and shape in cases of companion animals, being roughly circular, non-progressive lesions on the forehead, forelegs or paws [8].

In the forensic evaluation of thermal injuries, the key questions include the cause, timing, and circumstances of the injury, along with differential diagnoses [8]. Furthermore, in the chapter "Case studies and examples," there will be some specific instances of these types of incidents.

Thermal burns caused by high temperatures are typically categorized by severity. The listed degrees of burn are influenced by various factors including temperature, duration, quality of substance, extension of burn, and the age of the animal [8].

| | | |
|---|---|---|
| first-degree | superficial, affects only the epidermis [34] | pain +++[16] |
| second-degree | partial thickness, involve epidermis and part of dermis [34] | pain ++ [16] |
| third-degree | full-thickness, affecting all skin layers, bones, muscles, and tendons [34] | pain - [16] |

Thermal injuries can be the result of heated veterinary pads, electrocution, lighting strikes, scalds from hot liquids, and injuries from microwave radiation. Their effect can either be external, which affects the skin, or internal, affecting the trachea and/or esophagus. In cases of transportation and handling the burnt cadaver to the laboratory it is important to handle the body with caution to minimize the risk of accidental contamination by burnt material in the respiratory tract of the animal [8].

As explained in the previous paragraph, bones, muscles, tendons, etc., can also be affected by thermal injuries like fire burns, not only the skin. In case of examination of fire victims, it is therefore essential to document the scene carefully and establish the context within the fire. To differentiate fractures from traumatic injuries or extreme heat, radiographic imaging is used. Bones exposed to extreme heat tend to change color, often appearing grayish-white.

Additionally, the structure of burned bones may become brittle and have a fine, network-like pattern of superficial fractures, visible on radiographs. These kind of fractures disintegrate easily, which is another indicator they resulted from heat rather than physical trauma [16].

Therefore, in deceased victims, determining whether an animal was alive at the onset of fire is critical. In general, bodies showing minimal external injuries most probably died from smoke inhalation rather than burns. Post-mortem heat exposure can cause blisters with erythematous rims and searing, but these features do not indicate ante-mortem injuries. For instance, heat-induced blisters result from dermal capillary contraction, moving blood to the blister rim. Heat also causes muscle splits parallel to muscle fibers, whereas splits perpendicular to the fibers indicate ante-mortem trauma [8].

Severe burns can lead to tissue swelling and blood accumulation as well as in ante-mortem injuries, particularly in the check cavity. In case of hemorrhages encrusted on the chest lining, it likely indicates injuries of ante-mortem trauma. On the other hand, fire can also cause blood to collect in the chest. On gross examination, it is typically impossible to distinguish between ante-mortem and post-mortem burns. If the animal survived long enough to produce an inflammatory reaction, microscopic evidence might exist. Nevertheless, this does not prove the burns were post-mortem [16].

**Firearm injuries**

Firearm injuries in animals, often involve three primary types of weapons: air-powered guns, shotguns, and rifles. Each weapon has its characteristics resulting in unique injury patterns. Air-powered guns typically fire single pellets causing limited damage due to lower energy whereas shotguns discharge multiple pellets simultaneously, leading to a scattering effect that leads to a pattern of small wounds. However, rifles fire bullets at high velocity, which can lead to more significant and deeper injuries [8].

Gunshot injuries in animals may be mistaken for other types of wounds, such as puncture, bite, or laceration wounds [8]. Nevertheless, differentiating between entry and exit wounds is vital. Entry wounds typically have clean margins and gunshot residue, while exit wounds are jagged and irregular [35].

For animals with unexplained injuries, it is essential to perform radiographic imaging to identify signs of gunshot wounds, including fractures, pneumothorax, hemothorax, peritonitis, or signs of lead poisoning if a projectile is retained especially in a joint [16]. Additionally, it helps locate pellets, bullet fragments, and the bullet's trajectory through the

body. High-velocity bullets often fragment upon impact, creating a “lead snowstorm [8] [page 56]” effect visible on radiographs. On the contrary low-velocity bullets break into larger, more identifiable fragments [8].

Kinetic energy plays a key role in assessing tissue damage, while radiographs help distinguish exit wounds induced by fracture from those caused by a bullet. This differentiation is crucial for veterinarians and forensic experts when determining if an injury resulted from firearms [8]. Therefore, it is advantageous to be familiar with different weapons and munition types to evaluate injuries [35].

**Asphyxia and Drowning**

Asphyxia is a condition where oxygen intake or carbon dioxide elimination is disrupted, which leads to death by cerebral hypoxia and cardiac arrest [8]. This can include suffocation, strangulation, and mechanical asphyxia. In forensic investigations, understanding the mechanism of oxygen deprivation is critical for identifying the cause of death, as asphyxia often does not leave specific lesions [36].

Asphyxiation can occur through various methods and can be classified into suffocation, strangulation, mechanical asphyxia, and drowning. Suffocation involves smothering, and choking whereas strangulation involves hanging, ligature strangulation, or manual strangulation. Mechanical asphyxia is known as the “restriction of respiratory movements, either by the position of the body or by external chest compression [page 170]” [16].

Lesions like petechiae, pulmonary edema, and congestion are common but nonspecific, whereas ligature marks, foreign objects, or environmental context are essential evidence. Differentiating asphyxia from post-mortem changes or unrelated injuries is crucial [36].

> “Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid. Outcomes are classified as death, morbidity, and no morbidity [37].”

The forensic investigation of drowning involved analyzing the circumstances of the death, evaluating post-mortem findings, and determining whether submersion occurred ante- or post-mortem [36].

The process of drowning involves laryngospasm, water aspiration, pulmonary edema, and progressive hypoxia leading to death, whereas behavioral responses include struggling, convulsions, and gasping before unconsciousness. Macroscopic post-mortem signs can

include distended lungs that fail to collapse, often with pulmonary edema and congestion, which are not exclusive to drowning. In contrast, froth in the airway, trachea, and nasal passage indicates ante-mortem activity. Presence of water or foreign material in the stomach and respiratory tract. Microscopic signs on the other hand consist of flooding of alveoli with fluid, intra-alveolar hemorrhages, and over-distended alveoli. Evidence of aspirated foreign material, such as plant debris, can support drowning as the cause [38].

The diatom test is a method that is being used to support the diagnosis of drowning, involving the detection of diatoms, which are microscopic unicellular algae found in water and in the tissue of the deceased animal. During drowning, water containing diatoms can enter the lungs, penetrate the alveolar-capillary barrier, and circulate through the bloodstream to other organs. Detecting these diatoms with a light microscope in internal organs, such as the liver, and kidney, can indicate ante-mortem inhalation or aspiration of water, indicating drowning as the cause of death [39]. X-ra

Post-mortem changes can be altered through the environment. Water slows down putrefaction compared to land and bodies may sink initially and resurface due to putrefactive gases. Cold water can stop decomposition completely, leading to preservation and aquatic scavengers and mechanical trauma from the environment can obscure lesions [38].

Drowning often leaves a wet coat, although in intentional cases perpetrators may try to dry it, and both asphyxia and drowning can result in bruising from attempted escape or restraint [16].

*Figure 10 [16] [page 171]: Soil in Trachea indicating live burial*

In case of live burial, multiple forms of asphyxia can contribute to the death of the animal. As visible in the previous figure (Figure 10), the pressure from soil or burial material depending on its depth and weight can compress the chest and lead to asphyxia. The animal may inhale or ingest soil, which may be found in the upper and/or lower airways. These

cases indicate active respiratory effort or soil ingestion. Additionally, the animal might have broken nails with soil embedded in them, and other signs of struggle or evidence could be found in the grave [16].

**Heat stroke**

Heatstroke is a life-threatening condition characterized by an imbalance between heat production and dissipation, leading to severe hyperthermia, systemic inflammation, and multi-organ dysfunction. It can be classified into two different types, classic and exertional heatstroke. The classic heatstroke is caused by environmental heat exposure, whereas exertional heatstroke is triggered by physical activity in hot or humid conditions. In animals, especially dogs, heatstroke is mostly observed during summer months and often arises from situations such as keeping in overheated cars or intense exercise without proper acclimatization [40].

Damages depending on the temperature can be [41]:

Temperatures over 41°C: induce nervous system damage

Temperatures over 41.5°C: can cause cellular apoptosis

Temperatures over 42.8°C: alter cellular enzyme activity and cell membrane stability

The longer the exposure to this hyperthermia, the worse the outcome, which can include irreversible neuronal death and brain damage [41].

This risk particularly is evident in situations like being left inside a car on a hot day. As the temperature within vehicles rises, the dog pants to cool itself, leading to moisture buildup in the air, which increases the relative humidity. Since dogs release most of their body heat through radiation and conduction, the effectiveness of panting decreases through the humidity in the air of the vehicle preventing proper evaporation. This cycle causes the dog’s temperature to rise further, making it restless and generating more muscle heat and in conclusion causing even more stress on its heat regulation system. The time it takes for heat stroke to develop is dependent on temperature, humidity, ventilation, and the dog's individual resilience, ranging from less than an hour in extreme conditions to a few hours in milder cases [8].

Heatstroke initiates a cascade of pathological processes, including direct cytotoxicity from heat and activation of the acute phase response. The condition shares similarities with sepsis,

as it involves systemic inflammatory responses mediated by cytokines and chemokines. Endothelial cell activation, coagulation abnormalities, and fibrinolysis lead to microvascular thrombosis, hypoxia, and tissue damage. Multi-organ dysfunction, including renal failure, encephalopathy, and disseminated intravascular coagulation, often follows. Heat shock proteins (HSPs), produced in response to thermal stress, play a protective role by stabilizing proteins and mitigating oxidative damage. However, genetic factors and a lack of acclimatization may impair an animal's ability to produce adequate HSPs, increasing susceptibility to heatstroke [42].

In cases of neglect, post-mortem findings reveal distinct changes in various body systems and manifest through physical and environmental indicators, often compounded by entomological findings. A study conducted by Lutz L. et al. [43] analyzed 6 autopsied cases of neglect, revealed that the majority involved elderly individuals receiving care in domestic environments. Key forensic indicators included pressure sores, malnutrition (Figure 11), dehydration, and contamination by excrement. Results show that in 40% of the cases, insect manifestations, primarily by the house fly *Musca domestica,* were evident [43].

The infestation of fly larvae, known as Myiasis, often indicate prolonged exposure to unhygienic conditions, which is a hallmark sign of neglect. The duration and progression of myiasis can help forensic experts determine the extent of neglect and approximate timelines of victim suffering. Arthropod activity, particularly from flies and beetles, often begins ante-mortem in neglected individuals, leaving distinctive patterns that forensic entomologists can analyze to correlate with neglect timelines. The presence of maggot masses, their development stages, and the associated necrotic tissue provide crucial data on the length and severity of neglect. Forensic examinations integrate these findings with post-mortem changes like decomposition stages and tissue breakdown to form comprehensive legal arguments in cases of animal and human neglect [44].

Neglect-related post-mortem changes often present as advanced physical deterioration, including decubitus ulcers and inflammatory skin lesions [43]. A loss of subcutaneous fat occurs, leading to dehydration and wrinkling of the skin. A dull, fragile coat indicates protein deficiency, while certain vitamin and mineral deficiencies, like zinc, cause specific skin changes such as parakeratosis in pigs [8]. Such findings are frequently coupled with poor hygiene, characterized by soiling and severe environmental uncleanliness. Forensic examination must distinguish between neglect-induced injuries and other post-mortem

changes while considering the caregivers' psychological state and systemic failures in care delivery [43].

Muscle atrophy begins quickly (Figure 12), especially in monogastric animals within 24 hours of starvation. The back and thigh muscles are initially affected, with atrophy extending to all muscle groups. In cases of severe malnutrition or prolonged suffering, rigor mortis may not develop typically due to depleted glycogen reserves in the muscles. Blunt force trauma or other violent acts, the onset of rigor mortis can be affected by muscle damage, trauma, or bleeding, potentially causing irregularities in how rigor mortis sets or resolves. Additionally, rigor mortis could be delayed in severely stressed or starved animals, as their bodies are already depleted of energy [8].

The stomachs of malnourished animals often contain fibrous material, which may give the false impression of adequate feeding. Additionally, in dogs and cats, the stomach may contain non-food items like plastic. These animals often have a less pronounced odor post-mortem compared to well-nourished animals [8].

All organs shrink during emaciation, particularly the liver, spleen, pancreas, thymus, and salivary glands. In young animals, the lymph nodes may appear enlarged and swollen. Radiographs of young animals may show growth arrest lines in the long bones [8].

Thin animals may also suffer from underlying diseases such as advanced neoplasia, parasitism, or Johne’s disease, which should be evaluated for their contribution to poor conditions [8].

*Figure 11 [8] [page 18]: Bull Mastiff - Neglected and starved to the point of death over a 5-month period*

*Figure 12 [8] [page 18]: Same Bull Mastiff – profound loss of muscle, deformity of the rib cage*

**ii. Misleading interpretation**

In forensic investigations of animal cruelty, the right and appropriate interpretation of post-mortem changes is crucial. These findings help clarify the cause and manner of death, assess signs of abuse, and confirm whether the animal suffered before death. If post-mortem changes are misinterpreted, critical signs of cruelty might be overlooked or misidentified, potentially leading to an incorrect conclusion regarding the events leading to death and therefore misleading the court and other people [8]. Mostly these misinterpretations happen due to environmental or pathological factors that mimic ante-mortem injuries [44].

A well-structured post-mortem report is important to differentiate between injuries occurring before death and changes occurring after death. For instance, injuries may appear externally as bruising or fractures, while internal findings can uncover hidden trauma, chronic malnutrition, or other indicators of any kind of long-term abuse. Thorough proper documentation and clear categorization of these findings facilitate proper comprehension of the situation [8].

Additionally, forensic necropsy reports serve as a basis for legal evidence in cases of animal cruelty. Therefore, they must present objective, detailed accounts, as courts rely on these interpretations to assess the possibility and extent of abuse [8]. Errors in determining wound age, bruise age, drowning status, time since death, and other factors can easily lead to misleading interpretations [45].

It can be difficult to accurately determine if a wound occurred ante- or post-mortem. The presence or absence of certain cellular reactions around wounds can mislead, as post-mortem injuries may still show minor cellular infiltration, complicating the distinction. Moreover,

the timeline for wound healing differs among animal species, making extrapolation from human data unreliable. For instance, wound formation differs even between closely related species such as dogs and cats, which heal at differing rates [45]. A dead body undergoing autolysis can easily lose hair and skin upon handling, which must be distinguished from ante-mortem wounds. Bodies buried in shallow graves can also be punctured by search tools used to locate them [7].

The University Hospital of Schleswig-Holstein in Kiel, Germany, found out that counting mast cells at the wound margin can help differentiate between ante-mortem and post-mortem wounds [7]. In living tissue, when damage occurs, white blood cells, including mast cells, gather in the affected area to promote healing. Mast cells release enzymes to aid in tissue repair, but after releasing these enzymes, they lose the ability to produce chlor-acetate esterase, making them undetectable under certain stains. This results in fewer or no visible mast cells at wound edges in ante-mortem injuries, while undamaged areas contain more mast cells. In post-mortem wounds, there is no enzyme release, leading to a uniform distribution of mast cells across the wound, indicating the wound was inflicted after death [7].

Estimating the age of bruises is complex due to species-specific differences in bruise development and healing. Bruise color and consistency change over time, but this timeline is variable and can be affected by environmental factors and the animal's condition. Misinterpretation here can lead to errors in establishing when an injury occurred, which is critical in abuse cases [45]. In a case study involving a dog euthanized after sustaining a dog bite, it was examined how bruising might mislead forensic conclusions about a wound age. Immediately after euthanasia, the animal´s bruising was documented photographically. The autopsy done later revealed color changes in the skin and bruises becoming apparent, which may be interpreted as ante-mortem injuries. This case highlights how bruising is unreliable for determining wound age post-mortem [7].

In case of drowning, determining if an animal was alive when submerged is complicated by the absence of definitive drowning markers. Drowning signs are largely non-specific, and histopathological changes observed in lungs post-drowning lack the diagnostic certainty required in court. Moreover, diatom testing can yield misleading results due to contamination or false positives from post-mortem submersion, making conclusions unreliable without supporting evidence [45].

Key factors contributing to misleading post-mortem findings in neglect-related cases, for example, include skin lesions such as pressure sores and breakdown caused by prolonged immobility can appear similar to traumatic wounds. Also, parasitic activity, which can occur both before and after death, may resemble advanced decomposition or tissue damage unrelated to neglect. For instance, maggot activity can alter wound edges or create openings in the skin, further complicating the differentiation between injuries caused by neglect and those resulting from external trauma. To overcome these challenges, forensic experts must integrate environmental, pathological, and entomological evidence to differentiate neglect-related changes from other post-mortem artifacts, accurately reconstructing the circumstances of death. [44].

Eventually, post-mortem interval estimation methods like temperature-based measurements or rigor mortis can vary widely across species. Environmental factors such as temperature and humidity further impact decay rates, adding unpredictability to estimations. Entomological evidence is useful and requires species-specific knowledge. For forensic veterinary pathologists, the use of these methods without cross-verification can mislead investigations [45].

Given these challenges, caution and species-specific expertise are critical to avoid misleading interpretations. Pathologists must recognize the limits of available methods and use multidisciplinary approaches to improve accuracy, especially in cases of suspected abuse, where precise timing and injury interpretation can affect legal outcomes significantly [45].

## IV. Role of veterinary forensic pathology in identifying animal cruelty

### a. Crime scene Assessment and evidence management

A forensic necropsy often does not begin on the examination table, rather, it starts at the crime scene itself. Unfortunately, veterinarians tasked with performing forensic necropsies are rarely able to attend the initial crime scene investigation [1]. A crime scene is not necessarily the location where a crime occurred, it rather is defined as the place where evidence may be found and serves as a marker for the court whether a crime has occurred or not [7].

The initial examination of the scene provides essential context for interpreting necropsy findings, including the condition of the animal, environmental factors, and situational evidence like temperature or the presence of bodily fluids [46].

Beyond recognizing the value of crime scene evidence, forensic veterinarians and pathologists must be experienced in identifying, collecting, and preserving forensic evidence. This does not necessarily mean that veterinarians need to be experts across multiple forensic fields. In practice, most veterinary forensic cases benefit from a multidisciplinary approach involving specialists such as toxicologists, entomologists, and osteologists. A fundamental principle in forensic science is acknowledging one's limitations and being aware of consulting other forensic professionals [1].

The process of determining the cause of death and presence of abuse, neglect, or any other intentional harm requires detailed documentation of all findings, both positive and negative, which may indicate signs of cruelty. Gathering background information, such as any history of prior injuries, signs of malnutrition, and medical interventions, is essential to distinguish between accidental and intentional harm [16]. A structured approach to evidence management ensures its integrity and admissibility in court. This includes photographing the scene, documenting each animal's condition and environment, and collecting trace evidence such as fibers, foreign hair, or biological samples. Bodies must be handled minimally to preserve trace evidence, and packaging must follow strict protocols to avoid contamination. Tools like forensic rulers and photography ensure accurate documentation of injuries and lesions [46].

In cases where euthanasia was administered, it is important to document the method, as any signs resulting from it should not be mistaken for abuse-related injuries. Medical devices

and evidence of prior wounds should remain in place for examination to avoid misinterpretation as abuse [16].

Freezing and thawing practices must be carefully managed to preserve any indicators of abuse, such as hemorrhages, signs of neglect, such as reduced bone marrow fat, or signs of poisoning, which are often present in cases of malicious intent. This careful approach ensures that the evidence gathered can be used effectively to support findings of animal cruelty [16].

When possible, a scene examination can reveal crucial indicators of abuse, such as signs of struggling, restraint, or attempted escape. Observing multiple deceased animals can help determine whether the deaths occurred simultaneously or over time, a consideration especially relevant in cases of suspected neglect involving multiple animals [8].

Three primary types of crime scenes are recognized:

1. The incident, death, and discovery all occur in one location
2. The incident and death occur in one place, but the animal moves to another location before dying
3. The incident and death occur in one place, but the body is later transported elsewhere [8]

In cases of neglect and starvation, the main objective of a forensic necropsy is to document the condition of the animal's body and determine whether any concurrent diseases are present. These cases often display signs of poor care, such as unkempt or dirty coats, overgrown nails or hooves, dental issues, poor body condition, and evidence of external or internal parasites [47].

When severe matting is present, the hair coat should be shaved off in large and intact sections, kept as evidence, and weighed, as it might contribute significantly to the carcass weight. If external parasites are found they need to be identified and documented, and the skin should be examined for ulcers or dermatitis, especially around the perineum. Overgrown hooves should be cut open for laminitis inspection, and paw pads checked for ingrown nails. Dental issues like missing, fractured, or worn teeth should be recorded using dental charts. Even when parasites are not visible, feces or intestinal samples should be submitted for further analysis [47].

A key observation in neglect cases is the animal’s body condition, which reflects the level of muscle and fat. Severe cases result in emaciation, marked by the loss of subcutaneous and

internal fat, and muscle wasting. The term *negative energy balance* is used to describe a state where the energy expended by the body surpasses caloric intake. Negative energy balance can result from external factors like insufficient nutrition or internal ones, such as increased metabolic needs or diseases. If no disease is found during necropsy to explain severe weight loss, the cause of death is considered starvation. However, necropsy findings alone cannot establish external causes like intentional food deprivation [47].

To ensure accuracy, veterinarians should use a recognized body condition scoring system and provide detailed photographic documentation. Internal examination should note the level of fat reserves in key areas like the omentum, kidneys, heart lining, and bone marrow, as these are the last reserves to deplete. The digestive tract should be thoroughly examined, photographed, and potentially preserved for further testing. The content, quality, and type of ingested material should be recorded [47].

Finally, estimating the animal's ideal body weight and comparing it to the actual weight should be included in the report. Although it is difficult to determine the exact duration of undernutrition, conclusions should be drawn based on experience and available data, clearly stating if the caloric intake was adequate to maintain health and if disease explains the observed condition [47].

**b. Techniques and tools**

Veterinary forensic pathology makes use of several advanced techniques to accurately assess animal cruelty cases. The necropsy is fundamental and must be conducted with utmost precision since it can only be performed once. A thorough necropsy involves an external examination to document physical traits, such as species and visible injuries, followed by an internal examination of body cavities and organs to determine cause of death [48].

Modern imaging technologies, like CT (computed tomography) and MRI (magnetic resonance imaging), can greatly enhance these assessments, providing non-invasive insight that supplements the traditional necropsy, even though they cannot replace it completely [48].

Traditional radiography, or X-Ray imaging, has been used for a very long time to detect internal injuries, such as bone fractures, embedded objects, and trauma. For instance, in cases of shooting, this method is basic but very decisive. CT scans provide a more advanced alternative, offering a 2D and 3D reconstruction that allows pathologists to identify subtle injuries and track the cause of internal injuries, such as fractures and foreign objects.

Furthermore, combining CT with angiography allows visualization of the vascular system, which can be especially helpful in assessing cases involving circulatory trauma [48].

Forensic pathologists can additionally contribute to the understanding of animals deaths by leveraging their expertise in identifying causes and mechanisms of lethal injuries. In cases of CT scanning, they investigate and clarify the cause of injuries in animals. Furthermore, forensic pathologists are experienced in identifying whether injuries occurs ante-mortem or post-mortem, which is crucial in these kind of cases. By analyzing patterns of inflicted trauma, forensic pathologists can help in cases of suspected animal abuse, as they are skilled in differentiating between accidental and non-accidental injuries. They bring techniques from human forensic pathology, such as microbiological or toxicological analyses, which are valuable in confirming causes of death [49].

Another imaging technique combining CT, MRI, photogrammetry, and laser scanning called the virtual autopsy (virtopsy) has emerged as a non-invasive forensic tool. Originally designed for human forensics, virtopsy is also finding application in veterinary forensics, particularly to capture comprehensive external and internal data without disturbing the body. In some cases, photogrammetry paired with laser scanner provides detailed 3D color models of external injuries, making it possible for investigators to link these injuries with specific objects or trauma types and helping in crime scene reconstruction [48].

Despite its value, post-mortem imaging has limitations. It may not capture important diagnostic details like tissue color or consistency, which are accessible through physical necropsy. Moreover, specific soft tissue injuries, such as certain cardiac or ischemic lesions, are difficult to detect through imaging alone. Nevertheless, post-mortem imaging provides crucial advantages, allowing non-invasive sample collection for histological or toxicological analysis, minimizing infection risk, and preserving evidence digitally for repeated review and consultation [48].

Video recording can provide invaluable, real-time insights into potential crimes involving animals and/or their behavior. Recordings may come from sources like CCTV systems, law enforcement devices, ATM cameras, dash cameras or personal video cameras of mobile phones. These videos undergo thorough analysis to confirm authenticity, enhance clarity, and assess suitability for expert testimony. In cases of suspected animal cruelty, veterinarians might be called upon to evaluate these videos within the context of a forensic investigation, even though it is less frequent in animal related cases. The importance of such video

evidences consists in the unique perspective on animal behavior and the context of their treatment, offering an opportunity to observe potential physical and emotional suffering. The five freedoms offer a checklist for veterinarians to systematically assess welfare videos and are used as a framework when evaluating video footage [22].

Using a structures approach is essential to ensure a clear, comprehensive assessment. There are five steps including the reviewing of the video and pay good attention to it, examining animal characteristics for evaluating physical, behavioral signs such as body condition, posture, vocalization and mentation. Third step is the identifying of abnormalities, such as poor health, fear, injuries, inadequate shelter, and any deficiency in the five freedoms. Formulate an expert opinion serves as the fourth step, in which observations are being summarized in a report or court testimony. Last, but not least presenting findings and the clear communication of these findings, providing context from other investigative data [22].

In conclusion, videos are powerful tools in animal cruelty cases, revealing conditions and events that may otherwise remain unseen. Through methodical examination and expert analysis, veterinarians provide insight into the welfare of animals in these recordings, often playing a crucial role in bringing justice in cases of abuse and neglect [22].

Bloodstain Pattern Analysis (BSPA) is a forensic method that relies on scientific principles from physics, biology, and chemistry to analyze bloodstains at a crime scene. Although it incorporates scientific principles, there is an element of interpretation involved, making it both a scientific and evaluative discipline. BSPA helps investigators reconstruct events by examining the size, shape, distribution, and position of bloodstains. Forensic experts can often use these patterns to infer details such as the nature of the attack, the movements of the victim, the number of blows, and the positions of individuals involved [22].

BSPA uses several categories to classify bloodstains, such as passive stains (Figure 13) (influenced only by gravity, such as drips and pools), spatter patterns (Figure 14) (resulting from forceful events like a gunshot or beating), and altered stains (Figure 15) (where blood patterns have changed due to external factors, such as drying or contact with surfaces). Each type can reveal specific aspects of the incident [22].

One essential part of BSPA is determining the area of convergence, or the point in two dimensions where bloodshed originated, by tracing the path of individual droplets back to their source. When analyzed in three dimensions, the area of origin gives a clearer picture of the height and position of the blood source. While BSPA can’t always provide exact

conclusions, it is a valuable tool for disproving or supporting witness statements by comparing bloodstain evidence with accounts of the event [22].

The complexity of BSPA and the potential for contamination at crime scenes make it critical that trained experts document and collect bloodstain evidence carefully. When limitations arise due to overlapping patterns or altered stains, the most responsible course is to avoid forming unsupported conclusions. In forensic cases, BSPA serves as a supplementary method, guiding investigators toward the most plausible sequence of events based on blood evidence [22].

*Figure 13 [22] [page 86]: Drip pattern that creates small round spatter around parent stain*

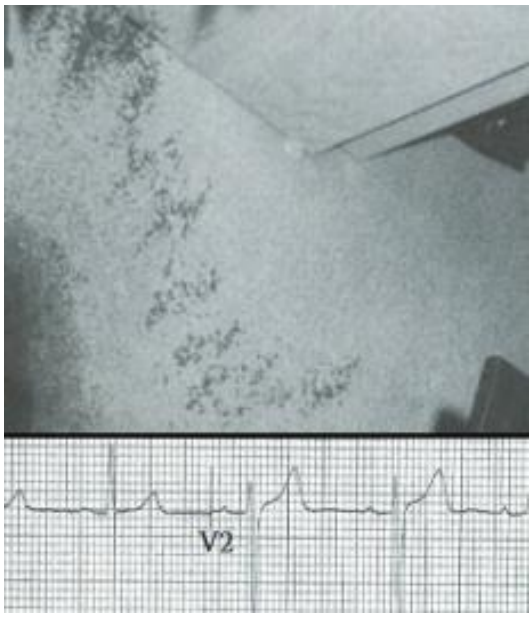


*Figure 14 [22] [page 92]: Arterial "spraying" with comparison to the contraction cycles of the heart. If an artery is crushed or completely injured, the ends may retract under the skin, subcutaneous fat, and muscles, which eventually result in the spraying pattern.*

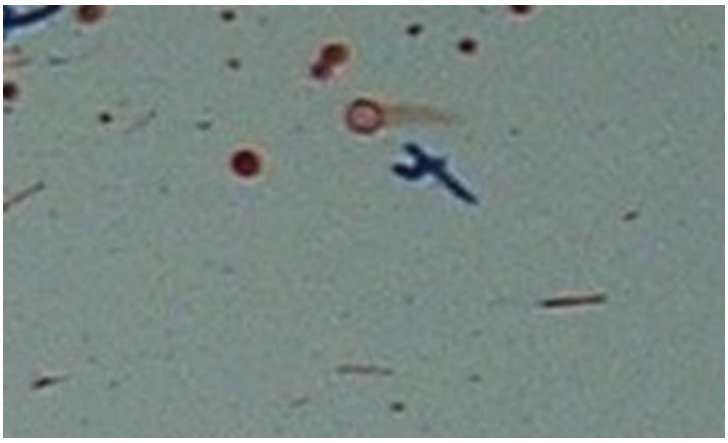

*Figure 15 [22] [page 95]: Bloodstain wiped through after 4 minutes, leaving peripheral rim intact*

In forensic investigations, the presence of insects, particularly flies and beetles, can be helpful in determining the time of death or the period of neglect in both humans and animals. When flies colonize wounds or bodily openings in living organisms, it is referred to as myiasis, a condition often associated with neglect. The development rate of these insects is temperature-dependent; warmer temperatures speed up their growth, while cooler conditions slow it down. Forensic entomologists can estimate the duration of neglect by examining the growth stages of these insects at the time they were collected [50].

In cases of animal cruelty or neglect, forensic entomology can provide essential evidence. Adult flies often deposit their eggs in wounds or bodily openings, including areas soiled by bodily fluids. During investigations, it is crucial to collect and preserve maggots from various body areas separately, such as wounds, to observe any variations in developmental stages, which can help to suggest the time and location of insect colonization [50].

An example of this application can be visible in Figure 16, a two year old French bulldog, that allegedly had been alive and well the day before its death. The veterinary pathologist reported numerous fly maggots on the dog´s body, nits in the fur, and the beginning of skeletonization at the right upper jaw, as well as other post-mortem changes like no subcutaneous fat, no fat deposits, no intestinal mesentery, and empty stomach. The veterinary authorities collected fly maggots from the body and analyzed to estimate the minimum period of colonization. By examining the maggots and using temperature data, forensic experts could approximate the development timeline of specific fly species, which in turn

helped provide insights into the timing of the dog's death and the potential period of neglect [50].

In conclusion, the forensic entomology analysis indicated that the dog could not have been alive and healthy on the evening as it was said by the owner, as the state of decomposition was advanced, with the brain severely decomposed or missing (Figure 17). Based on entomological evidence, the dog had been colonized by cadaver flies two days before the latest, with the possibility of earlier colonization if it had been kept in cooler conditions than the 30°C outdoor temperature [50].

This case highlights the importance for veterinarians and forensic pathologists to preserve and document insect evidence carefully. Proper preservation of maggots and other entomological traces is crucial, especially in complex cases where more precise data is needed for reliable conclusions [50].

*Figure 16 [50] [page 388]: French bulldog - condition of emaciated dog´s body on delivery to the mortician*

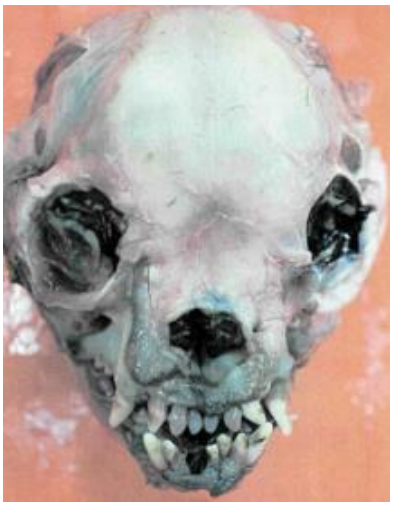

*Figure 17 [50] [page 389]: The eyes and brain of the dog are missing because of the feeding activity of fly maggots and advanced decomposition*

Furthermore, animal hair is now a valuable type of trace evidence due to its durability and potential to survive in degraded environments. It can provide information on species origin and, sometimes, individual identification. Furthermore, it can indicate contact with suspects or victims, offering insight into the crime scene dynamics and potentially revealing drug use or hair damage from heat or decomposition. The proper evidence handling follows the three R´s – Recognition, Recording, and Recovery. Recognizing evidential hairs requires systematic searches in areas likely affected during a crime, such as wound in animal fighting cases. Precise documentation and proper recovery techniques are critical to maintaining evidential value, as incorrect handling can render hair evidence so it cannot be used in court. While it is useful, hair analysis is subjective and prone to misinterpretation. Awareness of these limitations allow investigators to accurately assess the reliability of hair evidence, avoiding overstated conclusions [7].

In forensic pathology, accurately estimating the time of injury is a critical aspect of reconstructing events and understanding trauma. An approach involves analyzing the spatial distribution and behavior of neutrophils, which respond rapidly to tissue damage, showing distinct patterns of migration and concentration in the hours following injury. This technique uses advanced histological and immunohistochemical methods to provide detailed insights into the timing and progression of injuries. Neutrophil activity peaks within the first 24 hours of injury, with their proportion, migration distance, and spatial distribution serving as reliable markers for determining the age of contusions [51].

In a controlled study [51], these parameters were analyzed using digital pathology systems that quantified neutrophil migration patterns near blood vessels in injured skeletal muscle. The findings revealed that neutrophils exhibit distinct migration behaviors during the acute phase of injury, transitioning from localized clustering to wider distribution over time. Such precision enables forensic pathologists to estimate the timing of injuries with remarkable accuracy, especially within the critical early hours post-trauma in veterinary and human forensic cases [51].

**c. Case studies and examples**

**Neglect**

A 6.5-year-old cross-bred bull terrier, previously subjected to abuse by its owner (who had a history of physical abuse against the dog), was seized after reports of further mistreatment. Upon examination at the veterinary clinic, the dog exhibited multiple deep, scabbed wounds on the head, bruising around the muzzle, and broken canine teeth. Bruising was also observed in the neck and left armpit, with subcutaneous emphysema extending from the neck and chest to cover the rib cage. X-Rays revealed multiple rib fractures and signs of bone degeneration in the femur and spine. Despite efforts to manage the condition, the dog's health continued to decline, leading to a decision for euthanasia.

Post-mortem findings revealed multiple myeloma, which had caused 14 rib fractures of varying ages, spinal collapse with spinal cord compression, and tumor masses in the femur and small intestine. Although there was no definitive evidence linking the rib fractures to physical abuse, it was recognized that early diagnosis and appropriate treatment could have managed this progressive disease and alleviated the dog’s suffering. Consequently, the owner was convicted of animal cruelty for failing to provide necessary veterinary care.

Additionally, the healing wounds on the dog’s head were likely caused by burns, possibly originating from a cigarette. However, despite ruling out other conditions such as autoimmune diseases, parasitic infections, and fungal infections through histopathological examination, the evidence was insufficient to support an additional charge of cruelty [8].

**Animal Sexual Abuse**

Law enforcement became involved in this case after discovering disturbing photographs during a routine screening of digital images submitted for development. The images showed a person inserting a mallet handle into the vagina of a dog, along with photos showing human male genitalia in contact with a dog's vulva.

Following the acquisition of a search warrant, authorities took two female Labrador Retrievers, aged approximately 3 to 5 years, from the suspect´s residence. Both dogs displayed significant evidence of vaginal trauma, with visible linear lesions extending over 10 cm into the vaginal area.

In court, law enforcement established the identity of the dog's owner as the individual shown in the photographs. The prosecution’s approach focused primarily on demonstrating the

extent of the torture, pain, and suffering of the animals rather than searching the explicit details of the abuse itself. Eventually, a felony conviction was secured [10].

**Thermal injuries**

In an act of intimidation by a criminal gang involved in serious crimes, a bull terrier belonging to a member of a rival was abducted. The dog was secured to a railing by its chain collar, cut and stabbed with a knife, and then set on fire.

The findings of the necropsy include the dog´s skin exhibited a parchment-like texture over much of the body with the most severe charring affecting the head, shoulders, and the front of the chest. The subcutaneous muscles of the head and shoulders appeared tawny and partially cooked. The impression of the chain was deeply embedded in the burned skin of the neck (Figure 18). Furthermore, there were extensive lacerations and splits in the skin over the front of the chest, left shoulder, and the front surface of the left foreleg between the elbow and wrist. The frontal bone and the left zygomatic arch were fractured. A significant amount of blood had accumulated in the frontal sinuses, and there was fragmentation and loss of teeth in the left upper jaw. Lastly, in the respiratory tract, findings included blood pooling in the larynx and upper trachea, blood-stained froth in the upper trachea, moderate amounts of blood and mucus in the lower trachea and main bronchi, severe congestion and flooding of the lungs, and numerous inhaled carbon particles in the air sacs of the lungs (Figure 19).

The blood found in the frontal sinuses suggested that the skull fractures occurred before death. The presence of blood, froth, and carbon particles throughout the respiratory tract clearly indicated that the dog was alive while exposed to the fire.

The splitting of skin in burned bodies should be considered carefully, as heat can cause splits in the skin, particularly over extensor surfaces and joints, which may resemble ante-mortem injuries. This phenomenon, observed in human burn victims, could also apply to animals. Such splits must be distinguished from true wounds, which can be challenging when there is significant heat damage. Examining deeper tissues may provide definitive evidence of injuries inflicted before death [8].

*Figure 18 [8] [page 50]: Burnt skin retained a deep impression of the chain around the neck*

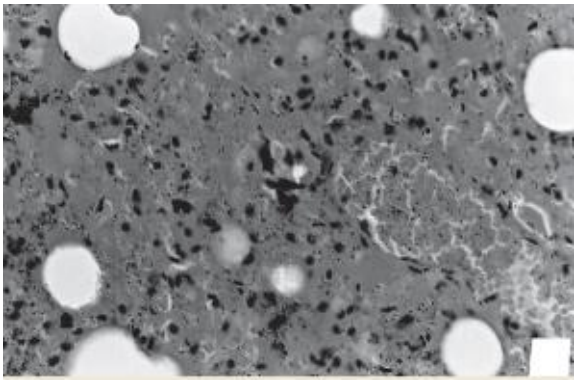

*Figure 19 [8] [page 50]: Inhaled carbon particles visible in congested lung*

**Firearm injuries**

A pine marten was discovered in a domestic freezer, exhibiting two primary areas of injury. Findings in the chest included significant blood staining on both sides of the chest. An eight-millimeter hole was found near the sternum on the lower right side, while a larger, irregular bigger hole was observed in the left chest wall between ribs four and five (Figure 20). Massive bleeding had filled both sides of the thorax, and extensive damage was noted in the middle sections of the lungs. Furthermore, head injuries were observed with an elliptical hole on the top of the head with hair pulled into it. The surrounding skin was bruised. A hole penetrated the skull, accompanied by an irregular fracture in the cranium. The left side of the skull showed multiple fractures, and a large hole was located at the angle of the mandible on the left side. Most of the brain was destroyed, and fragments of a bullet were found in the head, jaw, and in the skin near the jaw. There was no significant bleeding along the path of this bullet from the top of the head to the left side of the head.

The investigation concluded that the pine marten had initially been killed by a rifle shot to the chest. A second shot was fired at the head shortly after death, likely to ensure that the animal was deceased [8].

*Figure 20 [8] [page 64]: Pine marten wounded in the chest by a bullet - metal probe indicated the track of the bullet*

**Asphyxia**

Firefighters responded to an apartment fire, primarily concentrated in the bedroom. After extinguishing the blaze, they searched the remaining areas of the apartment. In the kitchen, they discovered "Taffy," a middle-aged female dog, lying deceased in her bed.

Due to the suspicious circumstances surrounding the fire, which raised concerns of arson, the police requested a post-mortem examination of Taffy to determine if smoke inhalation was the cause of death.

The findings of this case reveal that Taffy was in good physical health, showing signs of proper care with no evidence of natural illness. However, a single subcutaneous bruise was observed on the back of her neck. Her lungs, trachea, larynx, eyes, and subcutaneous tissues were heavily congested, yet there was no evidence of smoke inhalation.

The findings suggested that Taffy had not died from smoke inhalation but from asphyxiation caused by a ligature around her neck.

Upon questioning, the owner’s boyfriend confessed to hanging Taffy using the cord from a dressing gown, suspending her from the loft hatch before setting the apartment on fire [8].

In the following case, a man brought a severely injured 5-month-old Dachshund puppy to a veterinary emergency hospital, claiming the injuries occurred from a fall during bathing. Upon examination, the veterinarian identified serious injuries inconsistent with an accidental fall. The puppy suffered fractures to multiple ribs (Figure 21), extensive lung contusions, a hemothorax, a hemoabdomen, and liver lacerations, all indicative of blunt force trauma. Due to the severity and nature of the injuries, Humane Law Enforcement was notified to investigate suspected animal cruelty. Sadly, the puppy succumbed to its injuries the next day, and a necropsy revealed the full extent of trauma. The injuries, clearly unrelated to a simple fall, led to a conviction of aggravated felony animal cruelty for the perpetrator [21].

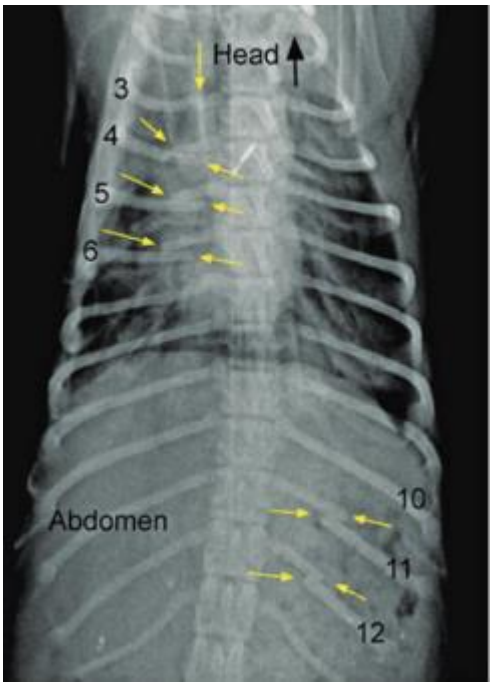


*Figure 21 [21] [page 385]: Chest X-Ray reveals six rib fractures in puppy*

## V. Addressing Animal Cruelty: Legal Frameworks, Forensic Advances, and Future Directions

### a. Role of forensic pathology in court: A focus on Germany

The "Reform des Tierschutzkriminalstrafrechts zur effektiven Bekämpfung von Tierquälerei", analyzes the shortcomings in the legal system concerning animal welfare and proposes reforms to strengthen the enforcement of animal cruelty laws in Germany. It highlights the enforcement deficit, showing that current enforcement of animal protection laws is inadequate, with only a fraction of reported cases leading to convictions. Many cases are either dismissed or inadequately punished, often resulting in minor fines instead of substantial penalties [52].

The report advocated for moving animal cruelty laws from the Animal Protection Act (Tierschutzgesetz - TierSchG) to the Criminal Code (Strafgesetzbuch) to give these offenses greater legal weight and visibility. This shift aims to ensure that animal cruelty is treated as a severe criminal offense, not just a regulatory matter, which would encourage stronger prevention and more consistent prosecution. The proposal also suggests increasing penalties for repeat offenders and those involved in industrial-scale animal cruelty, reflecting the seriousness of these actions [52].

The "§17 Tierschutzgesetz" (Animal Protection Act) stipulates that:

> Anyone who:
>
> 1. Kills a vertebrate animal without reasonable cause, or
> 2. Inflicts upon a vertebrate animal
>    a. Significant pain or suffering out of cruelty, or
>    b. Prolonged or repeated significant pain or suffering,
>
> Shall be punished with imprisonment of up to three years or a fine [53].

A research highlights while there is a comprehensive legal framework, enforcement of animal cruelty laws often falls short, with a high rate of case dismissals and lenient penalties. The study utilized data from German criminal statistics (SVS) between 2002 and 2028 and case files from the prosecutor's office in Gießen for 2016 and 2018 to analyze the outcomes of animal cruelty cases. A significant percentage of cases are dismissed, and fines are commonly imposed rather than prison sentences, even in severe cases. Furthermore, the study found that when prison sentences are issued, they are frequently suspended [54].

**b. Advancing Animal Welfare in Germany**

Germany's proposed amendment to the Animal Welfare Act aims to modernize animal protection laws and address enforcement gaps. It introduces a ban on year-round tethering of animals, regulates painful practices like tail docking and dehorning, and mandates video surveillance in slaughterhouses to ensure compliance. Stricter penalties, including higher fines and longer prison sentences, reflect the seriousness of animal welfare violations. The law also strengthens oversight of online animal trade and prohibits the sale or display of animals with hereditary defects resulting from unethical breeding. Additionally, the creation of a Federal Animal Welfare Commissioner aims to enhance coordination between governmental levels and prioritize animal welfare nationwide. These measures represent a significant step toward ensuring the ethical treatment of animals and aligning regulations with modern standards [55].

However, in October, animal welfare and rights organizations called for significant revisions to the proposed reform of Germany's Animal Welfare Act. While the draft includes some improvements, it falls short of addressing key issues and continues to permit many forms of animal cruelty. Among the critical demands are a total ban on tethering, the cessation of animal transport to high-risk countries, and prohibiting the use of wild animals in circuses. The organizations also advocate for a positive list of permissible pets and a knowledge certification for pet owners to prevent improper care. The draft neglects meaningful reforms for animals used in experiments. Instead, a parallel regulation would legalize the killing of millions of "surplus" laboratory animals. Severe testing procedures remain permissible, and the approval process for experiments is insufficient to ensure adequate animal protection. Additionally, the use of the hormone PMSG, obtained from the blood of pregnant mares under highly cruel conditions, was highlighted as an overlooked issue. About 30% of mares subjected to these procedures die due to stress and malnutrition, while the hormone is used in pig farming to increase litter sizes, often leading to suffering for both sows and piglets. The organizations demand a complete ban on the production, import, and use of PMSG [56].

**c. Future challenges and opportunities**

Veterinary forensic pathology is developing as a distinct discipline, emphasizing its importance in legal investigations of animal cruelty. Forensic necropsies differ significantly from routine diagnostic exams due to their focus on legal credibility and evidence preservation. Despite the need for specialized skills, most veterinary pathologists report insufficient training in forensic methodologies, creating challenges in addressing animal cruelty cases effectively [57].

Nevertheless, the field has seen growth over the past decade, as public interest in holding offenders accountable for animal-related crimes remains strong [47] as well as the recognition of the link between animal cruelty and crimes against humans, such as domestic violence and child abuse. Veterinary forensics now encompasses international associations, a peer-reviewed journal, and numerous studies, consultancies, and training opportunities for professionals across various fields. This development underscores the increasing importance of veterinary forensics in both animal welfare and public safety [58].

Over the last 75 years, veterinary pathology has evolved significantly, becoming increasingly sophisticated, and veterinary forensic pathology is now on the brink of further advancements. The field is benefiting from new approaches, such as revisiting older assumptions and exploring molecular techniques, which promise to enhance diagnostic accuracy and forensic rigor [47].

In 2015, the University of Florida College of Veterinary Medicine introduced the first master's program in veterinary forensic sciences. This 16-month, entirely online program offers hands-on learning opportunities at forensic diagnostic centers. In 2023, Florida International University launched a similar master's degree in veterinary forensic science investigation, also spanning 16 months, and delivered online. These programs equip professionals with the skills to investigate animal-related crimes, including crime scene analysis, necropsies, examination of live victims, evidence documentation, and expert witness testimony [58].

In the future, veterinary pathologists could play a more integrated role in investigations, from scene inspection to necropsy, to additional testing and court appearances. This comprehensive approach enables a thorough understanding and accurate interpretation of lesions. Currently, scene investigation and necropsy are often conducted by forensic veterinarians, with veterinary pathologists joining later for necropsy or histopathology.

Although this separation limits effectiveness, it can be somewhat eased by sharing detailed reports and photographs with pathologists [47].

Strong partnerships between forensic veterinarians and veterinary pathologists provide crucial advantages. For example, forensic veterinarians, familiar with the environments from which these cases arise, can alert pathologists to potential hazards, such as chemical contaminants from drug labs or trauma patterns in animals used in illegal rodeos. Merging this field-specific expertise with pathologists' diagnostic skills generates superior forensic outcomes [47].

While there are no established standards or universally consistent practices in veterinary forensic pathology due to limited legal precedent, growing experience, and collaborative guidelines are building a foundation for best practices. The field may still be in its early stages, but veterinary pathologists equipped with an understanding of judicial requirements and a willingness to adjust their practices to meet forensic demands can provide valuable insights in court. Although forensic cases can be demanding, they offer significant personal and professional rewards by contributing to community service and advancing animal welfare [47].

One key area of development is the integration of forensic entomology, which utilizes arthropod evidence to establish timelines of neglect or abuse. This technique relies on the analysis of insect colonization patterns, species succession, and environmental factors, such as temperature, to provide detailed insights into the circumstances surrounding an animal's death or neglect [59]. Furthermore, it requires integrating advanced techniques such as molecular diagnostics, imaging, and interdisciplinary collaboration to ensure reliable evidence collection and legal credibility Despite its potential, challenges include a lack of formal training, certification, and dedicated resources, underscoring the need for further development in education and research to strengthen its application in legal contexts [60].

## VI. Discussion

Veterinary forensic pathology is developing rapidly, yet it still faces limitations that hinder its full effectiveness in combating animal cruelty. Although demand for veterinary forensic services has risen with increasing public awareness of animal welfare, the field lacks the standardized training, protocols, and medicolegal support found in human forensic sciences. This gap often restricts veterinary pathologists from fully contributing to legal cases.

In human medicine, forensic pathology plays a critical role in the legal system. It is highly advanced and widely used in court cases to determine what happened to a person and, as a consequence, to ensure that perpetrators are held accountable through appropriate legal judgments. In most cases, thorough forensic investigations provide clear evidence that leads to accurate legal outcomes. In contrast, such comprehensive forensic support for animals is not really available, which frequently results in insufficient evidence to determine what happened to an animal. Consequently, perpetrators may avoid appropriate punishment. This limitation is further exacerbated by the lack of robust laws specifically designed to protect animal rights, leading to inconsistent or inadequate legal consequences.

Furthermore, even when veterinary forensic investigations do identify cruelty, legal outcomes often fall short. In Germany, for instance, animal cruelty offenses under the Tierschutzgesetz (Animal Protection Act) frequently result in minor penalties, with many cases being dismissed or resolved with fines rather than prison sentences or the prohibition of keeping an animal in the future. This inadequacy points to a systemic issue where the gravity of animal abuse is not appropriately recognized within the legal framework, limiting the deterrent effect of current laws. The proposal to elevate animal cruelty laws to the Criminal Code could address these gaps by enforcing stronger penalties, particularly for repeat and severe offenders.

Proposals to elevate animal cruelty laws to the Criminal Code could address these shortcomings. Stronger legal penalties, especially for severe or repeat offenders, would not only reflect the serious nature of animal abuse but also serve as a more effective deterrent. Implementing such measures would align the legal response to animal cruelty more closely with the standards applied to human cases, ensuring greater justice and protection for animals.

## VII. Summary

This thesis introduces veterinary forensic pathology, emphasizing its crucial role in investigating animal cruelty and abuse. It explains the need for veterinarians to interpret injuries and gather evidence in cases where animals cannot communicate their suffering. The significance of veterinary forensics in legal contexts is also underscored, aiming to bridge gaps in justice for animals.

Veterinary forensics has a rich history but remains underdeveloped compared to human forensics. Starting from early animal pathology for food safety, the field has grown to include specialized forensic pathology focused on legal investigations. Recent advancements, though limited, highlight increasing awareness and the establishment of educational programs, but challenges persist, particularly in standardizing practices across countries.

The document defines various types of animal cruelty, including physical abuse, neglect, and organized fighting, each having distinct forensic indicators. It discusses how societal and cultural norms influence the perception of abuse and the importance of identifying specific injury patterns in animals subjected to different types of cruelty. Furthermore, analyzing post-mortem changes is essential to differentiate between ante-mortem and post-mortem injuries accurately. Factors such as post-mortem changes, bacterial activity, and external or internal conditions are reviewed, demonstrating how these processes can impact forensic examinations and influence case outcomes.

Discussing crime scene assessment, and evidence management together with the application of forensic tools and techniques are being demonstrated, including necropsy, imaging, sample collection, Blood pattern analysis, and the identification with the help of flies. Case studies illustrate the practical application and demonstrate the outcome of such cases in real-world settings.

While veterinary forensic pathology is progressing, it faces challenges like limited training, inadequate legal support, and low conviction rates for animal cruelty. The need for specialized prosecution units and stronger laws to support forensic findings is emphasized, along with recommendations for improving interdisciplinary collaboration and training for veterinarians.

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