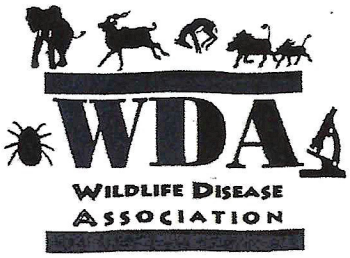


Africa & Middle East Section

Second Annual Meeting, 6 & 7 November 2003

Onderstepoort, South Africa

(hosted by the Wildlife Group of the South African Veterinary Association)

Wildlife Forensic Pathology

Dr Richard K. Stroud

US Fish & Wildlife Service

Wildlife Law Enforcement and Forensics in the United States

Richard K. Stroud DVM MS
Veterinary Medical Examiner

US Fish and Wildlife Service
National Wildlife Forensics Lab
1490 E. Main St, Ashland, Oregon

Wildlife is considered a valuable asset in the economy of the United States. Over 82 million US residents hunted, fished or watched wildlife in the United States in 2001. They spent an estimated $108 billion dollars (US) on recreation activities involving fish and wildlife resources. Wildlife is relatively abundant in the United States. Estimates of major big game animals in the United States are 20 million white tailed deer, 2 to 3 million mule deer and black tailed deer and 1 million elk. In addition, millions of waterfowl and other game birds may be hunted. Millions of acres of public land provide ample opportunity to almost any citizen who wishes to legally hunt or fish. Unlike Europe and other countries of the world, fish and game animals belong to the people, not the land owner in the United States. Protecting these assets from illegal activities that harm wildlife and fisheries, even on private land, by people who would selfishly use and abuse these resources is the job of the wildlife law enforcement officers that work under various governmental agencies.

Wildlife resources were not always as abundant in the United States. At the turn of the century, most formerly abundant populations were reduced to a mere fraction of the original numbers by commercial market hunting, habitat destruction, and unrestricted subsistence hunting. Wildlife or "game"laws were instituted and enforced and federal and state game refuges established in the early years of the twentieth century. Private sportsman's organizations such as Ducks Unlimited and the Rocky Mountain Elk Foundation has purchased millions of acers of critical habitat which they managed to provide replacement of habitat lost to development. As populations rebounded and opportunity to hunt and fish increased, the need for enforcement of laws to protect certain wildlife species and regulate the harvest of other species became more evident. Wildlife law enforcement in the early days consisted primarily of field officers playing a cat and mouse game with commercial poachers and hunters violating local game and fish laws. Today, enforcement of protective laws is far more complex.

Wildlife law enforcement is an essential aspect of wildlife management. The scope of modern law enforcement activities associated with the protection of fish and wildlife resources has developed significantly in the last several decades. Illegal killing of protected species may now include a wide variety of activities other than "poaching"that may effect animal populations. Examples include oil spills, unprotected power lines, improper pesticide use or disposal of toxic waste material as well as illegal commercial taking of protected species. Laws have also been established to protect habitat critical to the survival of endangered species. The United States is also committed to the protection of endangered wildlife world wide. Commercial markets involving international trade in illegal wildlife or wildlife parts has developed which is second only to the drug trade in dollar value. This has resulted in the

need for a more scientifically sophisticated approach to criminal investigation of crimes against wildlife and fisheries resources. For this purpose, the forensic support capability of the National Wildlife Forensic Laboratory has been established.

Laws to protect and manage wildlife resources in the United States may originate from the federal or state or a combination of both governmental entities. Federal laws tend to protect migratory bird species, threatened and endangered species, species of special significance, and marine mammals. Federal wildlife officers and wildlife inspectors investigate illegal importation of wildlife products from foreign sources under the international CITES treaty obligations. Federal laws also facilitate the investigation of wildlife crimes where local state jurisdictions have been crossed

In recent years, losses of wildlife due to environmental contamination such as toxic spills or illegal dumping have been investigated by federal wildlife officers in conjunction with state officers. Damages to the environment along with "replacement values" of documented wildlife losses have been charged to the responsible party. This has resulted in multimillion dollar settlements which have been used to restore or protect essential wildlife habitat. Industries that formerly accounted for untold numbers of wildlife deaths due to illegal dumping of industrial toxic materials have found it necessary to change processes and clean up sites of pollution. These actions, along with the more traditional role of investigating "poachers" and other illegal hunting activity, have changed significantly the image of the wildlife enforcement officer in the United States.

State wildlife enforcement officers work closely with federal officers in protecting local non migratory wildlife populations. Law enforcement officers in the field that enforce fish and wildlife protection laws number approximately 8000 throughout the United States. Canada has another 1500 to 2000 such officers. While the majority of these are state officers, the number includes about 200 federal Fish and Wildlife Special Agents and 100 Wildlife Inspectors stationed at various ports throughout the United States.

The need for scientific analysis of evidence taken by wildlife officers during wildlife crime investigations has been recognized for a long time. Unfortunately, until 1989, wildlife officers had to rely on human forensic laboratories to process evidence items. Of course, this resulted in low priority for wildlife cases and often, inability to met the special needs posed by wildlife officers who had samples that were not of human origin. Proper forensic handling of evidence became even more important when officers pursued crimes involving wildlife encountered major commercial smuggling rings run by the Russian Mafia or other criminal enterprises and environmental crimes perpetrated by large industrial corporations.
Prior to the opening of the United States Fish and Wildlife Service, Wildlife Forensics Laboratory in Ashland, Oregon in 1989, wildlife "forensics" work in the United States was scattered in various wildlife disease labs, university laboratories, local human crime laboratories or was just not done! This was neither efficient or effective for the officer in the field. Problems with proper forensic handling and processing of evidence were further complicated by a lack of developed protocols and comparative standards for analysis of wildlife related evidence. The concept of having a forensic capability for just wildlife cases was conceived by Ken Goddard, a former human crime laboratory director. The concept was supported by the officers in the field and was finally funded and the laboratory built in 1989. The case load for all of the various divisions of the laboratory currently is between 600 and 700 cases per years and includes thousands of individual evidence items processed by about 30 staff members.

Criminal investigation of a wildlife related crime may start in the field at the crime scene or may be the result of information gathered by the investigating officer from informants, from other agencies, reported by a concerned citizen or developed in a variety of other ways. Internet sales of wildlife and wildlife products for example has been very prolific source in recent years of leads to activity related to commercialization of wildlife and wildlife products. The need for a forensic scientist to verify the species identity of confiscated products using DNA and/or morphological characteristics, extract computer records from the suspect's own computer, develop finger prints linking the suspect to the illegal object, work-up undercover voice or video recordings, and finally prepare exhibits for court presentation may all be part of a single evidence processing request.

Forensic laboratories must provide a multi disciplinary approach to the analysis of evidence gathered in a criminal investigation. The US Fish and Wildlife Service Wildlife Forensic Laboratory provides this multifaceted capability to Special Agents and the Wildlife Inspectors of the Fish and Wildlife Service, the primary federal agency in the United States that is responsible for the administration of the laws governing endangered species, migratory birds, CITES permitted importation and exportation of protected wildlife, marine mammals, bald eagles, and the interstate transportation of illegally taken game animals. In addition, the laboratory does wildlife related casework for other federal agencies, state game and fish agencies and even foreign governments. The laboratory does not do case work for private individuals or agencies. Some state fish and game agencies have limited forensic capabilities for processing wildlife related evidence. Usually this involves a capability to identify local animals through DNA, hair identification, bone and skull identification, some necropsy capability, and occasionally chemical analysis of suspected poisoning cases. Other wildlife case work may be done in cooperating human related crime labs, universities with veterinary research or diagnostic laboratories or in private consulting laboratories. Fees are often charged for these services to the game and fish agencies.

Forensic Capabilities at the US Fish and Wildlife Forensic Lab

Capabilities at the National Wildlife Forensic laboratory are very diverse and are continually increasing in scope and precision. The major areas of expertise of the laboratory include morphology, pathology, DNA/protein identification, chemistry, firearms, finger printing, and technical support which includes computer seizures and audio/video enhancement. A special evidence handling section tracks the location and possession of each evidence item submitted to the laboratory for analysis. In addition to examination of evidence, scientists at the laboratory must build reference collections for comparative use as controls or known specimens, do research to validate new protocols, provide training to field agents and inspectors and finally to prepare for and testify in court when subpoenaed.

Morphology

Morphology is the study of anatomical relationships or "forms". Expertise in mammalogy, ornithology and herpetology is available in the Morphology Section. This section of the laboratory is particularly important in the enforcement of import regulations under CITES Treaty obligations. One has no problem with the identification of a whole intact animal such

as an elephant which has a trunk, large ears, an essentially hairless thick skin, large trunk-like feet and weighs several tons. However, a leather wallet made from elephant skin or a carved elephant ivory chess piece is a little more challenging. The microscopic hair follicular patterns and structures in processed leather are used to identify elephant skin whereas dentine patterns known as "Schreger angles" are measured and compared to standards to differentiate African elephant ivory form other ivory sources. Feathers and fur used to decorate various tourist souvenirs or real cultural artifacts may require microscopic identification to ascertain their species of origin. Hair or feather identification may also be useful in the identification of stomach content of poisoned wildlife. The trade in reptile and amphibian parts and products such as boots, purses or other items must also be identified using microscopic skin and scale detail. Obtaining and preparing a large collection of bird, mammal, reptilian and miscellaneous animal related material for use as comparative reference material has been a major task for the morphology section. Without this comparative material, world taxonomic literature, and experience with wildlife trade items, the morphology section would not be the effective unit it is today in combating the trade in illegal wildlife products.

Pathology

The Pathology Section consists of two veterinary pathologists who examine carcasses of primarily birds and mammals that are submitted frozen from field investigations. Like the medical examiner in human forensics, the objective is usually to determine a cause of death. While animals killed by poachers using guns and traps are usually easily recognized, animals killed by poisoning and industrial toxicant present a challenge to the veterinary pathologist. Other sections in the laboratory evaluate the trace evidence such as stomach contents, bullets and other material taken from the carcass in order to assist the necropsy examination. The standard necropsy examination includes complete radiographs of the evidence, visual or gross necropsy examination, and on occasion, microscopic examination. Photographs are taken to document visual and microscopic findings.

Genetics/Protein

The ability to identify and/or individualize samples of blood or tissue to a species or individual animal level through the application of DNA technology is well recognized as an essential tool in criminal investigation. Unlike human crime labs, the Genetics Section of the Wildlife Forensic Laboratory has the challenge of identifying tissues from a large variety of species, some of which are endangered. Statistically significant data bases of reference tissues or DNA reference samples must be available for comparison. For example, the development of protocols for the identification of multiple species of endangered sturgeon in mixed batches of caviar smuggled from the United States, Russia or Iran has been significant tool for the prosecution of smuggling commercial quantities of caviar by the Russian Mafia and a contribution to the preservation of these ancient species around the world. Currently, the bush meat trade in the United States is a high priority for the genetics team to develop capabilities to identify meat from various protected species such as great apes illegally included in this trade. The ability to match samples of blood and tissue from a field crime scene to animal parts in possession of the suspect is an essential tool in pursuing individuals for illegally taking big game animals. The laboratory maintains an extensive tissue reference collection for use as controls in case work. Development of specific protocols for a large variety of species or families of animals requires imagination and ingenuity.

Criminalistics

Criminalistics includes multiple analytical forensic capabilities. Firearms and bullet comparison is essential to match bullets from carcasses and guns from the suspect. Finger prints, document examination, tool marks, x-ray fluorescence and infrared spectroscopic light and scanning electron microscopy examinations are all done on submitted evidence to bring out hidden features which connect the suspect to the evidence. Analytical chemistry capability using high performance liquid chromatography (HPLC) and both GC and LC mass spectrophotometers is available for the detection for pesticides and other poisons in stomach content as well as composition examinations of a large variety of suspect material from Chinese medicines to plastic "ivory".

Technical Support

The illegal commercial wildlife trade is often "big business" and has a trail of business transactions which are frequently kept on a computer. Forensic computer seizures and analysis of hard drive data done by the laboratory personnel may provide the evidence needed to persecute individuals in the illegal wildlife trade. In addition, analysis of undercover or remote surveillance audio and video tapes may provide evidence needed to pursue a suspect in a wildlife crime. Exhibits necessary for professional appearing presentations in the court room are also prepared in this section from photographs taken both in the field and in the laboratory during evidence analysis.

The Role of the Veterinarian

The role of the medical examiner is well established in human criminal investigation. The medical examiner is the translator of information from the deceased that gives clues to what has happened. Likewise, the veterinary pathologist may participate in the solving of crimes against animals. Veterinary pathologists are trained to diagnose the cause of death and disease in domestic animals and wildlife. This training and experience has a natural transition to assisting in wildlife law enforcement activities. In addition, more animal abuse cases are being brought to the courts which also require a forensic evaluation by a veterinary pathologist. Developing specific skills for forensic evaluation protocols, evidence handling and court presentation is easily done. Becoming recognized as an additional resource by individuals in the law enforcement community may require some personal contact and voluntary participation.

The development of a full service forensic capability for wildlife in a region or country requires significant resources dedicated to the conservation of wildlife resources. Convincing the law enforcement establishment of the need for such specialized capability for wildlife is dependant on the resources available and the political pressures from groups concerned with wildlife conservation.

Forensic Pathology For The Wildlife Veterinarian

Richard K. Stroud DVM MS
Veterinary Medical Examiner

US Fish and Wildlife Service
Division of Law Enforcement
National Fish and Wildlife Forensic Laboratory
1490 E. Main St., Ashland, Oregon, USA

Enforcement of protective wildlife laws is an essential aspect of wildlife management. Without law enforcement, few regulations which are designed for wildlife management objectives would be implemented or effective. The slaughter of wildlife populations for human profit has gone on in the past and in many parts of the world continues unabated today. The international trade in wildlife products from illegally poached animals is a multi billion dollar/year enterprise. The wildlife veterinarian has an essential role in the investigation and prosecution of illegal wildlife harvest. Indeed, far more animals are lost to illegal killing than are lost to disease. To be an effective part of the law enforcement team, the wildlife veterinarian may need to become familiar with certain aspects of criminal investigation. The purpose of this seminar is to give an overview of the techniques for forensic investigation of illegally killed wildlife so that he/she can more effectively participate in the criminal prosecution of those who would destroy our wildlife resources for their own personal gain without regard for the management objectives.

The wildlife veterinarian is uniquely qualified to participate in wildlife law enforcement. As a veterinary pathologist or "veterinary medical examiner" he/she may have the duty of determining if death of an animal is due to natural or criminal activity. The medical examiner is a well recognized part of the investigational team for human death investigations. The veterinarian, trained in pathology and other biological sciences, can fulfill a key role on the forensic team. Recognizing lesions of forensic importance and interpretation of those lesions along with proper protection, handling, and presentation of the evidence is essential to forensic investigation of wildlife criminal activity. Forensic science actually involves a multi disciplinary scientific approach to explaining evidentiary observations pertaining to a criminal or suspected criminal activity.

The recognition of a potential forensic case is highly variable depending on the field circumstances. Illegal poisonings and gunshot deaths may be encountered while investigating natural mortality. Wildlife enforcement officers may submit suspected illegal take cases for work-up to veterinary diagnostic labs. Environmental contamination from industrial sources may be the cause of wildlife deaths which the state may seek legal liability and restitution. The earlier the potential for a legal case is recognized, the better the pathologist can process the case in a manner consistent with the local law enforcement needs.

Forensic wildlife cases by their nature are rarely the fresh well preserved carcasses typically seen in veterinary diagnostic laboratories. Carcasses may be submitted that consist of bones, dried skin and hair, partially scavenged carcasses, maggot filled carcasses, and relatively intact frozen whole carcasses. As a forensic wildlife pathologist, determining a diagnosis is

only one objective. He/she must also attempt to derive as much information as possible regardless of the stage of decomposition of the carcass because this is the only evidence that may be available. Gunshot wounds are relatively easy to evaluate in decomposed carcasses, poisoning on the other hand is not.

Taking part in legal cases obligates the wildlife pathologist to certain responsibilities. No longer is the carcass or evidence item processed in a manner that permits just a quick diagnosis. A more thorough examination to rule out other possible causes of death or contributing factors must be undertaken where the carcass condition permits. Evidence documentation, transfer, and preservation become major concerns. Collaboration with law enforcement investigators and/or forensic scientists of other disciplines is essential. And finally, when the case is complete, the desire and ability to stand in front of a court room and be questioned by a hostile opposing attorney concerning the work you did and the conclusions you made based on your observations. It is not enough to develop a simple diagnosis in a legal case, the pathologist must be prepared to educate the court and defend his conclusions concerning the events which lead to the death of the animal. This must be done in a completely objective manner. The forensic pathologist is a seeker of truth, not an advocate for the prosecution or the defense. Only through the wildlife pathologist can the animal victim of the crime speak and tell their side of the story.

Objectives of a Forensic Pathological Evaluation

The most obvious objective for a pathological evaluation of a carcass of an animal is to determine the cause of death which for most pathologists means providing a diagnosis. As we know, multiple diagnosis may be applied to any pathology report depending on the level of investigation which is directly related to the post mortem condition of the carcass. In legal circles, we refer to the **cause**, **manner,** and **mechanism** of death and we may also list **contributory** and **incidental** findings. The medical examiner is expected to determine a "**cause**" of death meaning the disease, injury or abnormality what alone or in combination is responsible for initiating the sequence of functional disturbances that ends in death. This is different than the "**mechanism**" of death which infers more of the physiological consequence of the injury or disease. The "**manner**" of death relates more to the circumstances around the factors that initiated the cause of death with special reference to the social relationship and personal causation. As the investigating pathologist and an "**expert**" witness, you may be asked to explain your opinion on the above designations for the case at hand.

Other objectives which must be considered in a forensic evaluation include the recovery of trace evidence, a reconstruction and documentation of the sequence of events where possible, and an estimation of the time of death. Trace evidence may include bullets or bullet fragments, tissue or organ samples, stomach and crop contents, carrion feeding insects, hair, etc. Proper procedures to document the association of the trace evidence items with the original carcass and appropriate preservation and packaging of the trace evidence are also the responsibility of the pathologist. A chain of custody must be established for each trace evidence item removed from the original carcass. Photo documentation of the items recovered to demonstrate the origin of the sample or item is an effective way to establish the connection between the carcass and the new trace evidence sample.

For example, a bullet might be photographed in situ with a pointer demonstrating a wound path prior to removing the bullet. Skin samples around a suspected bullet wounds which are removed to demonstrate lead residue or duration of wound should be photographed before

and after removal to establish the relationship of the "trace" evidence or sub item to the original sample. Radiographs (x-rays) are an excellent way to document the presence of bullets, bullet fragments and pellets. However, field radiographs of large animals are rarely practical. Metal detectors may be used to demonstrate and recover bullets from carcasses in the field.

Time of Death

Time since death is a common request made of the wildlife pathologist by the investigating officer. In human homicide cases, this of course is very important to establish in order to include or exclude suspects. While various methods have been used extensively in human homicide investigations, there is currently no single accurate marker of the time of death according to the Handbook of Forensic Pathology, 1990. Body temperature, rigor mortis, vitreous humor potassium levels, eye changes, electrical stimulus conductivity, entomology and taphonomy (weathering of the bone) studies have all been used to establish approximate time of death. The investigator must recognize that all these methods have inherent exceptions and inaccuracies. Making time of death estimations must consider many variables, especially when the interval of time increases from the death of the animal to the necropsy examination. In addition, the wildlife pathologist must consider species differences, predator and scavenger damage as well as habitat differences which may enhance rapid decomposition. A carcass may appear to be in an advanced stage of decomposition on anterior end of the carcass and a well preserved state on the posterior end because of the effect of maggot invasion and scavenger bird damage to gunshot wound in the thorax. Carcasses that have been immersed in cold water or that have been buried in dry soil may appear relatively well preserved because of the lack of oxygen to promote the bacterial decomposition process. Time of death in carcasses submitted to the lab frozen are of course another impossible request to fulfill because of the high variability in freezing techniques used by submitters. In summary, time of death is very difficult to determine even under the best circumstances and the pathologist should be very careful in defining any narrow ranges of time of death. Field experience is a definite advantage in investigating and judging time of death of animals in the field.

Evidence Handling

Proper handling of evidence requires that a continuous record be maintained from the time the evidence is collected until its presentation in court. This is referred to as the chain of custody and includes the dates of transfer, the persons who transfer the evidence, and the location of storage. The evidence should be stored in a separate locked facility with access limited to those involved in the examination. Packages are sealed with "evidence tape" which is tamper proof and initialed and dated by the person who last opened and examined the evidence item. Evidence may be shipped by "common carrier" without representatives having to sign the chain of custody as long as the package is sealed properly. However, if evidence is transferred within a facility or organization, it is best to directly transfer the evidence between the persons who actually will be doing the analysis. This practice shortens the chain of custody and lessens the chance of some secretary or lab tech being subpoenaed into court to testify that they handled the evidence.

When collecting material such as tissues or stomach content for chemical analysis which involves destructive methods, always collect sufficient material to accommodate any

duplicate testing requested by the opposing side. Proper preservation of the evidence is also essential. For example, bullets or bullet fragments should be washed and dried and put in a porous paper envelope. Bullets in plastic bottles or bags tend to corrode if they are not thoroughly dried, thus obscuring the fine detail of the barrel impressions and making it difficult for a firearms examiner to match to a suspect gun. Samples containing suspected organophosphate and carbamate pesticides should be processed as soon as possible to prevent further loss due to degradation of the chemical. Insects from the carcass, if they are to be used to establish a time of death, should be preserved in alcohol for study by an entomologist according to established protocols. Additional samples of immature insect larva must be cultivated to mature forms for identification of species so must be collected in proper media for growth and pupation.

All trace evidence samples removed from a carcass should be analyzed in a manner that continues to preserve the chain of custody and uses established, court acceptable protocols. The analysis provided by other forensic scientists may provide the pathologist with key information on which he bases his evaluation. However, the final evaluation or examination report is only as defensible as the weakest link in the chain of events which includes the chain of custody, the protocol used for analysis, the qualifications of the analysts, and the general quality control of the procedures used. It is always an advantage to use certified laboratories which employ qualified experienced forensic scientists who operate using established protocols. Always inform the analyst that the samples presented are part of a forensic investigation and that appropriate care be taken to preserve the chain of custody and the integrity of the sample. Also inform him that he may have to testify in a court of law regarding his results and methods of analysis.

Preparing for Courtroom Testimony

The ultimate purpose of doing a forensic case is to provide unbiased factual information to the legal establishment. This also includes providing investigative information to the wildlife enforcement officer which will enhance his ability to apprehend the person or persons responsible and finally providing supportive information to a judge or jury to determine guilt or innocence. The importance of proper documentation of what you did and what you saw is second only to what was concluded in your examination. Photo documentation of the evidence you received in its original condition is necessary to establish that what you examined was indeed the same evidence submitted from the field. Crime scene photographs taken by the investigating officer may be important to establish certain relationships that are helpful to the pathologist. If the necropsy examination is done in the field at the scene, the pathologist must be sure that adequate photo documentation is done to reconstruct the scene and findings in a courtroom.

Radiographs may be taken to document trauma lesions and gunshot wounds where they are practical to take. Photographs of all lesions and significant findings are routinely taken so that in a future courtroom, they are available for visual aids to substantiate what you observed and recorded in the pathology examination report. Anticipate what would be beneficial in explaining what was discovered if you were explaining to a jury your findings and take photographs that "tell the story". The old adage that a picture is worth a 1000 words is especially true in forensic pathology. Digital photographs have certain advantages over 35 mm film prints. However, original photo file discs must be "locked" to assure a copy of

unalterable pictures is available in the permanent record of the case. Trace evidence items derived from the original carcass should be photographed in situ to document their origin. All evidence introduced in court must be "sponsored". This means that any item such as a bullet must have verification as to who collected it, where was it found and indeed, is this the exact same bullet that you removed from the carcass submitted as evidence. Having photographs and radiographs showing the evidence in situ where you found it gives a judge or jury a better understanding of the origin of the evidence.

Notes or dictation taken during the necropsy examination from which the examination report is written are part of the permanent record of the case which may be "discoverable" by the opposing side in a trial situation. Therefore, notes should be complete and should be checked against the final report for consistency. Negative findings should be recorded to indicate that the observation or evaluation was made and not just overlooked. Examination reports should be written in a format that can be understood and used by the enforcement officer and the court, including the jury. Observations and conclusions should be clearly listed and explained in an order which reflects their importance to the question being asked. The report should reflect a standard necropsy examination protocol as much as the evidence will permit. This will help assure the jury that a complete study was done according to professional standards and that nothing was missed. Where decomposition or scavenger damage masks meaningful pathological evaluation, record this observation in your notes. The pathologist is only obligated to record and evaluate lesions which are in adequate condition. Obviously, certain lesions such as gunshot wounds may have a far better chance of retaining their pathological identity than lesions due to poisoning. Therefore, be as complete as possible with the pathological evaluation considering the state of decomposition and/or degree of scavenger damage.

Examination reports and/or any information from the examination should only be released to the submitter or his legal representative to maintain confidentiality. Any further distribution of information regarding the case is the responsibility of the submitter unless the court orders differently. The defense has the right to review all materials pertaining to the case under a "discovery order". This includes the original evidence, notes and tapes made during the necropsy examination, x-rays and photographs, phone logs, etc. This is done through a request from the court. The pathologist should always review all materials that make up the case file for accuracy and consistency prior to sending out a final report to guard against embarrassing questions derived from the defense's review of the whole file including your field notes, telephone logs, etc. which may arise during your testimony that might destroy credibility.

In the courtroom, you may be asked to be a "witness of fact" or an "expert witness". A witness of fact may only answer questions related to what was personally seen or experienced. An expert witness may offer an opinion or interpretation based on his training, knowledge or experience. A veterinarian is formally trained in the basics of animal anatomy and pathology. Additional formal or informal training in wildlife biology, forensic pathology, toxicology, etc. is always helpful. The defense attorney may question the experience a pathologist has in both general and specific terms relative to the case. It is a good idea for a wildlife pathologist to keep a "life list" of all the necropsy or other examinations conducted by species and type of death. This may be useful when questioned by the opposing attorney about your specific experience relative to the case in question. Publications and presentations are also important in establishing that your are a qualified expert recognized by your peers and that you can give accurate professional evaluation of the

evidence presented. The attorney for the side that you represent has the responsibility to present you as fully qualified to be an expert witness in the case in question. The attorney for the opposing side has the obligation to point out your lack of specific qualifications to testify. The judge will either accept you as an expert witness or disqualify you. You may still testify as a witness of fact.

When court testimony is required, discuss what you can and can not testify to with the attorney who has called you. You may assist in developing the questions that he may ask you to bring out the technical points that will be the basis of your testimony. Anticipate what the other side may ask based on their perception of the facts and be prepared to give explanations as to why that explanation is not plausible or is different from your observations. Portray a professional appearance, answer questions with confidence but not arrogance, don't let the opposing attorney "rattle you" with his questions which seek to discredit your training, integrity, or competence - that is what he is paid to do. Let the jury or judge decide if you are a credible witness who is qualified to testify as to the meaning of the evidence presented and examined. Use professional quality photos or exhibits to portray what you found in your examination and what it might mean.

Rely on the professional attorney to guide you through the testimony process. The type and order of questions presented to you while you are in the witness box (stand) is determined by court protocol and an overall "game plan" of the attorney to enhance the maximum effect of evidence presentation. Once you have been asked questions by the attorney that has called you (called "direct" testimony), you are now open for questioning by the opposing side ("cross examination"). If additional points or explanations are required, the original attorney may ask additional questions ("redirect"testimony) and the opposing attorney may then ask for additional questions ("recross") and so on until the witness has completed the testimony and is excused by the judge.

Many texts are available to guide the scientist in the art of courtroom expert testimony. Review of one or more of the listed texts prior to testimony is essential for the inexperienced. (See listed texts in useful references list)

Pathology of Significance in Forensic Wildlife Investigations

Poaching of wildlife with guns is normally considered as a law enforcement question that requires a "forensic" examination of the evidence. However, depending on the status of wildlife and environmental protection regulations in any given country, forensic cases may be developed that include intentional and accidental poisoning, industrial pollution, electrocutions, trauma from traps and snares, illegal fishing methods, and many other potential wildlife mortality factors. In the United States, most illegal killing of wildlife includes either gunshot, poisoning, and certain types of trauma including electrocution of birds. The following sections will discuss the lesions and investigative priorities for these types of forensic necropsy investigations.

Gunshot

The science of ballistics is the study of the factors affecting the travel of a projectile to the target. However, wound ballistics is the study of the pathological effect of a projectile passing through a body. Wound ballistics is a pathological question that a veterinary pathologist with a background in animal anatomy and physiology is best suited to evaluate. Basic knowledge

of guns and ammunition is essential to evaluate gunshot wounds in forensic cases. Recognizing the presence of a gunshot wound in an animal carcass is relatively easy as long as scavenger damage has not distorted it's characteristics. Open wounds may be the first avenue of entrance into a carcass for scavengers and necrophagus insects. Forensic investigation of the carcass requires that the pathologist attempt to answer certain questions including: type of weapon used, number of times shot, trajectory of the wound path, lethality or incapacitation caused by the wound, and duration of the wound. In addition, recovery and proper preservation of the projectile for evaluation by the firearms examiner is a part of the pathologist's responsibility.

Firearms used to kill wildlife are of three basic types in their ability to cause gunshot wounds: high velocity, low velocity and multi projectile (shotgun). High velocity includes most center-fire rifles and a few specialized pistols which have the ability to propel a bullet at speeds from 2000 ft/sec to 4000 ft/sec. The dynamatics of tissue damage is relative to the velocity of a projectile, the size (mass) of the projectile, the construction of the projectile, and the elasticity of tissues impacted. A small semi-jacketed bullet traveling at a high speed will do more damage to liver tissue than a large solid lead bullet traveling at low speed through lung tissue because of the factors involved in releasing the potential kinetic energy of the bullet.

Center-fire rifles are most commonly used for big game animals and for shooting at long distances. Bullets fired from center-fire rifles travel at high velocity and generally are built with a lead core surrounded by a copper jacket. If the jacket completely covers the lead core, the bullet is typically a military or "ball" round and was not designed for hunting. Bullets designed for hunting are "semi-jacketed" meaning that the point of the bullet is not covered with copper plating but has exposed lead, plastic inserts or hard metallic inserts which initiate the process of bullet expansion or "mushrooming" to impose maximum impact damage to the animal.

Bullet wounds from such bullets traveling at high speed are typically small at the entrance hole with rapidly expanding tissue tearing and destruction as the kinetic energy is released into the tissue from the expanding disintegrating projectile. Fragments from the bullet and sometimes bone fragments radiate from the bullet wound path as the bullet travels through the carcass causing additional hemorrhage and tissue tearing. Tissue rapidly expands and then collapses along the projectile's path. If the carcass is relatively small, the bullet may pass completely through leaving a large avulsive type exit wound which is much larger than the entrance wound.

Large animals shot with center-fire rifle bullets may not have exit wounds. The bullet may travel through the carcass until the tough skin on the opposite side is reached. The energy of the bullet may be reduced enough to "bounce" from the tough skin and " deflect" along the subcutaneous tissue plane ending up some distance from the original wound track. Fully jacketed or military type bullets may also travel at a high velocity but tend to penetrate a carcass leaving only a relatively narrow wound channel without the radiating massive tissue tearing of a mushrooming semi jacketed bullet.

The radiographs of wounds from high velocity center-fire rifles may demonstrate a "snowstorm" of radio dense pinpoint to small irregular fragments from the fragmenting semi-jacketed bullet. Certain types of bullets, such as Barnes solid copper bullets, although they may mushroom, do not fragment and do not leave the typical "snowstorm" effect of semi-

jacketed lead core hunting bullets. Military fully jacketed bullets also do not leave the snowstorm effect in the tissue.

The radiograph may also demonstrate a separation of the lead bullet core from the copper bullet jacket which has a lesser radio density. The bullet jacket is the important part of the bullet to recover because only the bullet jacket has distinct rifling markings usable by a firearms examiner to match the bullet to a suspect gun.

Low velocity firearms include most pistols, shotgun slugs, black powder firearms, pellet or air rifles and .22 caliber rimfire rifles and pistols all of which have bullet velocities of 2000 ft/sec or less. Wounds from these firearms tend to be more like puncture wounds without the radiating tissue tearing produced by high velocity bullets. The bullet crushes tissue as it proceeds along the wound track. Bones may be broken and organs penetrated. Bullets from these firearms tend to be solid projectiles made of lead or copper alloy. They may flatten or mushroom or even break apart when they encounter bone along the wound track. However, the snowstorm effect seen in high velocity bullet wounds does not occur because the lower velocity does not result in the radial expansion of tissue or cause the bullet to fragment in the same manner. Some fragments of the bullet or slug may be present but these tend to be larger and are generally associated with collision with bone along the wound track. Lead shotgun slugs may exit a carcass the size of a deer in several large pieces leaving irregular jagged edged holes in the skin. Wounds to solid bony structures such as the skull will have more radio dense fragments, even with low velocity bullets.

The .22 caliber rimfire cartridge is the most common cartridge in the world. Wounds from bullets from these cartridges tend to be puncture type wounds no larger than 1 cm diameter which may travel some distance through the carcass. Where bone is encountered, very fine particles of lead may be present and observed in radiographs along with the deformed bullet.

Defining a wound track (wound trajectory) may be important to establish the number of times an animal has been shot and from which direction. Establishing the possible trajectory is often important in establishing guilt in an illegal shooting case. So called "self defense" cases where an animal is killed while allegedly attacking the shooter may be verified by establishing a bullet wound trajectory. Entrance wounds have certain unique characteristics such as smooth regular sides with the presence of an "abrasion ring". Exit wounds are typically larger than an entrance wound and have irregular torn margins with tissue strands exiting the wound. Wounds in the skin may be dissected and radiographed. Because of bullet mushrooming and fragmentation, exit wounds typically have more radio dense material from the fragmented bullet embedded in the tissue surrounding the actual bullet hole.

Recovery of bullets or bullet fragments can be difficult from the carcass of a large animal. Following a wound track carefully in the dissection process is helpful. Using a wooden dowel painted white is often helpful in tracing the wound track. Photographs of the white dowel may be taken to demonstrate the trajectory. Radiographs of the carcass or suspected parts are the preferred manner of precisely locating bullets or large bullet fragments. Metal detectors may also be useful especially in field situations. However, the metal detector may have a limited depth of penetration, especially in fat. I have found them to be ineffective in a large carcass. Dissected carcass parts, no more than 6 to 8 inches thick, may be scanned with a metal detector to recover bullets.

As the bullet travels down the barrel of a firearm, it picks up individualizing rifling markings

on the outside surface which is in contact with the barrel. This produces an individual "fingerprint" of the barrel because each barrel has lands and grooves along with microscopic imperfections that produce a unique, identifiable imprint on the bullet. A firearms examiner may have the ability to match the bullet back to an individual firearm barrel by examination of the recovered bullet and comparing it with test fired bullets from the suspect gun. The recovery and proper care of the bullet from the carcass is the responsibility of the pathologist. Bullets should not be handled with forceps or any other tool which would leave scratches or otherwise damage the surface. They should be washed and excess tissue fragments carefully removed and finally thoroughly dried prior to placing them a container such as a small paper envelope which is not airtight. Bullets placed in plastic bags or airtight containers while still wet may corrode and destroy the fine detail needed by the firearms examiner. For high velocity bullets, the copper outer covering or jacket is important for bullet identification. Occasionally the inner lead core of the bullet will separate from the jacket along the wound track. The jacket is not as radio dense as the lead core and may be more difficult to visualize in a radiograph. Small jacket fragments or the lead core of a bullet are not valuable as evidence. Shotgun pellets, shotgun slugs covered with plastic (known as sabots) and slugs fired through unrifled barrels do not have individualizing characteristics valuable to a firearms examiner.

Assessing the lethality of a wound or a least the ability to incapacitate the animal is another important aspect of the pathological examination. If the wound is immediately incapacitating such as a spinal shot, this information is important to the field investigation of the crime scene to locate either a bullet or a casing in the local environment. Animals that are "heart shot" may travel several hundred yards. Being able to narrow the area of search of the crime scene by estimating the animal movement after being shot and prior to death is important to the field investigator.

The duration of a wound is best verified by visual or histopathological examination for evidence of tissue reaction. This may be important information where the defendant claims that someone else previously shot the animal.

Animals killed with shotgun pellets usually have multiple wounds. An x-ray of the carcass may give some indication of the number of pellets present and even the composition of the pellets. Non toxic shot regulations for waterfowl hunting have been instituted in the United States and Canada. These regulations require the use of steel, tungsten or bismuth shot pellets that are not toxic when ingested as are lead or copper coated lead pellets. In forensic cases involving illegal use of lead shot, the pathologist must not only recover a sample of the pellets used and have them tested for composition but he must also document that the wounds caused by the illegal shot are lethal or incapacitating.

Likewise, the use of firearms to kill large game animals during seasons reserved for archery hunting, the pathologist must evaluate the wound for the presence of lead or copper from a bullet along with the character of the wound in submitted carcasses or tissues to discern differences between a wound caused by a cutting edge of an arrow and the wound caused by a bullet or shotgun slug. Radiographs of the wound tissue are essential in identifying the presence of bullet particles. Usually the exit side of the wound is more productive because the bullet has mushroomed and/or fragmented and will therefore leave more lead or copper residue. The wound must also be shown by the pathologist to be fresh and that it was lethal or incapacitating.

Information relating to firearms and bullet wounds is abundant in the medical literature (see useful references listed). Almost all of it however is relevant to human homicide investigations, military, or police weapon capability. Because of the wide variety of guns used in hunting, both legally and illegally, and the variety of animal species encountered by the wildlife veterinary pathologist, it is difficult to make solid predications as to specific types of wound characteristics indicating specific firearm or ammunition types. Knowledge of local hunting customs and availability of weapons and ammunition is valuable. Consultation with the local wildlife law enforcement officer is also essential prior to writing reports or making statements relative to the potential weapon used to illegally kill wildlife.

Trauma Wounds of Forensic Importance

In human forensic pathology, differentiation of trauma wounds in violent death is a major concern. Trauma wounds are also important to the veterinary pathologist to document because the pattern of the wounds often tell a story of what has happened to the animal. Several types of trauma injuries are encountered in forensic investigations. These include patterned injury, blunt force injury, and sharp force injury. In addition, predator and scavenger injury must be considered and differentiated from possible injury related to illegal activities. Electrical contact injury is also an important injury for large birds of prey which has forensic implications.

Patterned Injury

The pattern of the lesion or series of lesions may give important clues as to what has happened to cause the death of an animal. Because of the hair or feather covering of wildlife, skinning of the entire carcass is essential to locate and evaluate trauma injury. Individual lesions may be incised, crushing or tearing lesions. They may be classified as lacerations, abrasions or puncture wounds. They may have a unique or characteristic distribution on the carcass which would give important clues to their cause. Premortem trauma must be differentiated from postmortem scavenger damage. The forensic pathologist must evaluate all the characteristics and the distribution of the trauma lesions to define the events and the possible cause. These observations then must be documented with photographs and descriptions in the report.

For example, domestic animals or wildlife killed by predators may have a specific pattern of lesions that indicates a feline predator as opposed to a pack of canine predators. Clean deep sharp angled punctures in the neck or throat are suggestive of large predatory cats. Multiple crushing, tearing, puncture wounds to the abdomen and flanks along with crushing wounds to the neck and trachea is suggestive of canids such as a wolf or pack of dogs. The pattern of attack may be unique to the local large predators. Local biologists are a good source for information of how local predators attack. Hemorrhage associated with bite wounds suggest pre mortem predator attack. Measurement of puncture wounds from canine teeth may suggest the size of the predator. Swabs for DNA analysis of saliva around wounds may also be valuable for defining the attacking animal. No hemorrhage suggests that the carcass has been scavenged and that some other cause of death other than the predator is present.

Livestock losses due to protected predatory or scavenger wildlife species may be compensated by the government. Therefore, a thorough crime scene investigation along with the forensic necropsy may be required to verify the assumption of true predation and collect the compensation or insurance. In cases of human death from suspected wildlife, the

veterinary pathologist may also participate in the autopsy of the human victim and do the necropsy of the suspect animal if caught and killed.

Trap and snare lesions are crushing type wounds in specific locations. Skinning of the neck or foot may be required to document underlying changes caused by crushing of the tissues. External abrasions or contusions may not be evident, especially in heavily feathered or haired animals. Strangulation is the cause of death in illegal snare cases. Crushing of the trachea or larynx with hemorrhage along the laryngeal cartilages is often observed along with congested lungs in strangled animals. Trap and snare imprints are recognizable as alternate congested and ischemic imprints in the skin which will be retained even after the death of the animal.

Vehicular trauma is characterized by multiple large contusions or abrasions often called "road rash" along with various bone fractures, especially crushed ribs. External lesions may or may not be evident. Not all vehicle strikes are found in close proximity to a road. Animals may travel some distance from a road after being hit before they succumb to internal hemorrhage, pneumothorax or other trauma induced complications. These may be mistaken for illegally killed animals especially if open wounds are evident or scavenger damage has occurred. Likewise, collisions with stationary objects such as power lines, buildings, and radio towers is a major cause of death in protected birds. Pathology associated with collisions may be evident as fractured wings, sternal bones, and cervical vertebra. Sometimes all that is evident is hemorrhage at the base of the heart where the heart has torn away from the supporting tissue and ruptured the aorta or other major vessels. Where large numbers of birds are killed in this manner, the installation of diversionary technologies has substantially decreased the mortality. However, legal pressure, backed up by forensic investigations, may be necessary to force the owners to invest in the installation of diversionary or protective devices.

Electrocution

Electrocution, while not classically considered as trauma, is a major cause of death for large birds of prey. Usually there is a history of the carcass being found near a high voltage electrical power source such as a transmission line. However, we have found delayed electrical contact deaths some distance from such sources. Electrical contact lesions may be very extensive to small lesions only 1 or 2 mm in diameter. They are characterized by burned, curled or melted feather filaments, cauterized skin, subcutaneous pocketing of the tissue along tendons and bones and "cooked" muscle tissue. Hemopericardium, presumably caused by violent contraction of the heart and rupture of the atrium or cardiac vessels is a surprisingly frequent finding in electrocuted eagles. Because of the large numbers of eagles documented as having been electrocuted in the United States, electric power companies are being forced to install protective devices on power poles in critical eagle habitats. Because of the cost, this action is taken reluctantly after forensic documentation of the cause of death of protected birds and citation of the company owning the power poles.

Poisoning of Wildlife

Intentional poisoning of wildlife is wide spread in the United States and constitutes a major area of forensic investigation. In addition of wildlife protection laws, pesticide use and environmental contamination regulations are violated by these practices. Most intentional poisoning is done by livestock owners in an effort to eliminate perceived predators. While poisoning of undesirable species is appropriate in many cases, the consequences of uncontrolled use of poisons can be disastrous to protected species and other non target

species. Forensic investigation of wildlife poisoning may discern intentional illegal poisoning from accidental legal poisoning. In the United States, control of undesirable wildlife is primarily done by governmental agencies using very specifically targeted methods. Therefore, most predator or other wildlife poisoning is illegal. Pesticides used legally for agricultural purposes may kill wildlife on occasion. However, when careless use or improper disposal results in wildlife death, liability under a variety of laws may be assessed.

The objectives of a forensic examination of a suspected poisoning case is to identify and quantify the presence of a toxic substance, determine the source of the toxic material, and to determine if the victim is the primary target or if it was a secondary perhaps accidental poisoning. The determination of fault, i.e. was the poisoning accidental or the result of negligence or malice is up to the court to decide.

The pathological examination must eliminate other causes of death, establish the presence of a toxic substance in significant quantities, and document a possible route or source of exposure. Most acutely poisoned wildlife have ingested some toxic substance and will have crop or stomach content present that contains the toxic material. If multiple food sources are evident, the pathologist must separate the different food items and have them analyzed individually. Usually the last items consumed are the ones containing the poison. Items present in the crops of birds may be suspect because pesticides are easily absorbed through the mucosal lining of the crop. The presence of recently ingested parts of other animals may indicate that a secondary poisoning has taken place. The target bird or animal has been incapacitated by the effects of the poison put out for them and therefore become easy prey for other species such as scavengers or birds of prey. When the stomach or gizzard is digested releasing the toxic contents contained in the prey species, the predator species is acutely poisoned. The identification of this scenario has legal implications and should be documented.

Food items should be identified. This may require DNA/Protein identification of meat samples, hair, bone or feather identification of stomach content, or other methods to define the type of bait or prey species that was consumed which was the carrier for the poison. Many times grains are impregnated with strychnine, avitrol, or carbamate and organophosphate pesticides and placed in the environment. Seed identification can be done by local agronomists. Insects containing high levels of pesticide may also be found in insectivorous birds which indicates that local spray programs may be the source.

When no food items are present in the anterior digestive track, the pathologist must consider drinking water as a possible source along with cutaneous exposure. Collection of exposed skin from the feet or mucosal lining from the crop or stomach may yield positive analytical results for the offending toxic chemical. Depending on the suspected poison, tissue samples such as liver, kidney or brain may also be collected for analysis. However, in poisoning cases involving organophosphate and carbamate pesticides, 1080, and others, identification of the offending specific chemical in tissue samples may not be possible due to the metabolism of the original molecular structure. Brain cholinesterase inhibition has classically been used to indicate pesticide poisoning by carbamate and organophosphate pesticides. However, this analysis only provides a quantitative measurement of effect, and it does not identify the pesticide responsible which is essential for a forensic case. We have found that brain cholinesterase is not a reliable method to document pesticide poisoning because of a number of problems with postmortem degradation and difficulty in obtaining accurate controls in

most forensic cases.

Samples collected for analysis in a potential forensic case should be collected in duplicate. Most chemical extraction and analysis protocols are destructive to the evidence sample. The defense in a legal case has the right to have the sample analyzed by a second laboratory. Analysis must be done by "standard protocols" which are accepted within the discipline. Otherwise, a special trial or hearing may be requested to "try the methodology used" to determine if the science used is acceptable to the court. The protocols and quality control procedures used at the laboratory to do the chemical analysis may be challenged. Therefore, it is a good practice to use a laboratory that is experienced in doing forensic casework. Warn the analyst that this is a forensic case so that appropriate handling of the evidence is done and appropriate protocols and controls are used and that the analyst may have to testify in a court proceeding.

In the United States, 82% of the poisoning cases investigated by the US Fish and Wildlife Service Special Agents involved organophosphate and carbamate pesticides which inhibit cholinesterase. Of those, carbofuran is the most often encountered pesticide in wildlife poisonings accounting for over 30 % of all cases. Carbofuran was detected in 37% of the poisoned eagles. Famphur (Warbex used as a cattle grub pour on systemic pesticide), aldicarb and fenthion are also commonly encountered in poisoned eagles. These restricted use agricultural pesticides are illegally applied to carcasses and baits in an effort to poison predators and scavengers. Such practices may kill protected and endangered species directly when they feed on the bait or indirectly when they feed on other animals that have feed on the baits (secondary poisoning).

Other poisoning events occur as the result of improper use and disposal of agricultural pesticides. Waterfowl are frequently the victims of Diazinon poisoning when they feed on lawns where grass has been treated with this pesticide and not properly watered after application. Water contamination may also occur with runoff from treated fields or improper disposal of containers. Poisoning of carrion feeding species, especially eagles, directly related to veterinary practice involves the improper disposal of domestic animal carcasses euthanized with sodium pentobarbital. Strychnine treated grain available for controlling rodents within their burrows is frequently found in birds that eat the grain directly or feed on rodents that are convulsing above ground. Avicides, such as Avitrol, Starlacide and Fenthion used to control undesirable birds such as European Starlings, Rock Doves and English Sparrows frequently cause the poisoning of birds of prey that feed on the dead or debilitated birds. These are secondary poisonings and have different legal connotation than illegal use of carbofuran on a baited carcass.

Other Forensic Wildlife Cases

Laws protecting wildlife may include provision for liability for losses through industrial toxic waste spills, oil spills, obstructing structures, and attractive nuisances that kill wildlife. In the United States, provisions are written into many wildlife protection laws that provide for "strict liability" for killing wildlife as well as habitat destruction that results in losses of animals. The wildlife pathologist may be asked to participate in forensic cases that document mortalities of wildlife that are due to cooperate negligence. Wildlife mortality due to oil spills, oil tank entrapment, cattle carbohydrate (molasses) supplement entrapment, power pole electrocution, stationary towers in flyways, and cyanide leach mining operations are only a few of the examples of wildlife mortality cases which require documentation of the cause of

death using a forensic format. Such cases may be a greater challenge for the wildlife forensic pathologist than the usual poaching or poisoning case because large companies have the resources to challenge the findings and conclusions of the pathologist and other forensic scientists that are involved in the case. In such cases, the pathologist may become a member of a team that documents the environmental impacts of the activity being cited for liability. Most of the time, the objective is to get the company to do something to stop or decrease the mortality. However, to bring them to the point of changing something that would cost thousands of dollars, may require extensive litigation which is based on scientific findings. The veterinary pathologist may contribute in this area as an expert witness as long as he plays by the rules of "forensic science".

Useful References

Court Room Testimony

Feder, Harold A., 1991. Succeeding As An Expert Witness: Increasing Your Impart and Income. Van Nostrand Reinhold , New York, New York, USA, 251 pages.

Froede, Richard C., 1997. The Scientific Expert In Court: Principles and Guidelines. AACC Press, 2101 L Street NW, Washington DC, 20037-1526. 92 pages.

Surosky, Alan E., 1993. The Expert Witness Guide for Scientists and Engineers. Krieger Publishing Co., Malabar, FL, USA. 222 pages.

Firearms and Bullet Wounds

DiMaio, Vincent J. M., 1999. Gunshot Wounds: Practical Aspects of Firearms, Ballistics, and Forensic Techniques, Second Edition. CRC Press, New York and Washington DC, USA. 402 pages.

Fackler, M.L. 1986. Ballistic Injury. Annals of Emergency Medicine 15: 1451-1455.

Fackler, M.L. 1988. Wound Ballistics: A Review of Common Misconceptions. JAMA 259 (18): 2730-2736.

General Forensic Pathology

DiMaio, Vincent J. M. and Dominick DiMaio, 2001. Forensic Pathology, Second Edition. CRC Press, New York and Washington DC, USA. 565 pages.

Knight, Bernard, 1991. Forensic Pathology, Oxford University Press, New York

Time of Death

Catts, E. Paul and Neal H. Haskell, 1990. Entomology and Death: A Procedural Guide. Joyce's Print Shop, Inc. PO Drawer 1606, Clemson, SC, USA 182 pages.

Dix, Jay and Michael Graham, 2000. Time Of Death, Decomposition and Identification: An Atlas. CRC Press, New york and Washington DC, USA. 112 pages.

Micozzi, Marc S. 1991. Postmortem Change in Human and Animal Remains: A Systematic Approach. Charles C. Thomas Publisher, Springfield, IL. USA. 124 pages.

Wildlife or Veterinary Forensic Pathology

Fudge, Alan M. (Editor) 1998. Forensic Veterinary Medicine (eight articles by various authors on various aspects of forensic veterinary medical applications) In: Seminars in Avian and Exotic Pet Medicine, Vol 7, No 4 October 1998, WB Saunders Company, Orlando, FL USA 230 pages.

Stroud, Richard K. and William J. Adrian, 1996. Forensic Investigational Techniques for Wildlife Law Enforcement Investigations, pp 3- 18. In: Noninfectious Diseases of Wildlife, Second Edition, Anne Fairbrother, Louis N. Locke and Gerald L. Hoff Editors, Iowa State University Press, Ames, Iowa, USA.

Walker, Danny N. and William J. Adrian (Editors), 2003. Wildlife Forensic Field Manual, Third Edition. (Multiple authors), Published by Association of Midwest Fish and Game Law Enforcement Officers, c/o David W. Oates, Nebraska Game and Parks commission, 2200 N. 33rd St., Lincoln, NE 68503 USA

Wobeser, Gary. 1996. Forensic (Medico-Legal) Necropsy of Wildlife. J. Wildlife Disease 32 (2) pp240-249.

Wildlife Toxicology

Beyer, Nelson W., Gary H. Heinz and Amy W. Redmon-Norwood (Editors), 1996. Environmental Contaminants in Wildlife: Interpreting Tissue Concentrations. SETAC Special Publications Series, CRC Lewis Publishers, Boca Raton, FL. 494 pages.

Mineau, P. (Editor), 1991. Cholinesterase-inhibiting Insecticides: Their Impact on Wildlife and the Environment, Chemicals in Agriculture Volume 2 , Elsevier Inc. New York 347 pages.

Smith, Greggory J. 1993. Toxicology and Pesticide Use in Relation to Wildlife: Organophosphorus & Carbamate Compounds, CRC Press Inc., Boca Raton, FL 33431, 171 pages.

Forensic Pathology For the Wildlife Veterinarian

Richard K. Stroud DVM MS

Veterinary Medical Examiner

US Fish and Wildlife Service

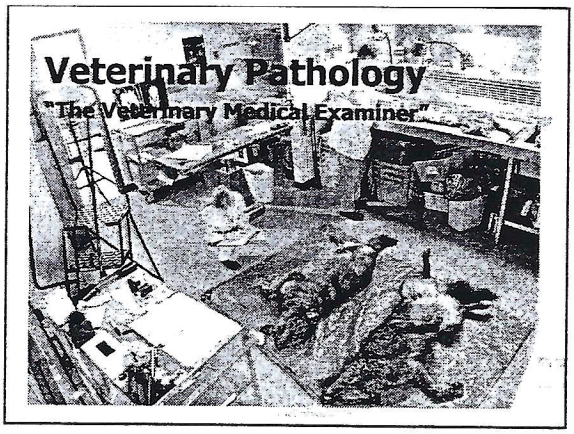
National Wildlife Forensics Laboratory

Ashland, Oregon

Law Enforcement

"an essential aspect of wildlife management"

- Scientific forensic evaluation of evidence obtained in criminal investigations by law enforcement agents requires a multiple disciplinary approach
- Veterinary medicine has an important part to play in the investigation, evaluation of evidence and prosecution of crimes involving wildlife



Forensic Medicine

"The applied use of medical knowledge, especially pathology to the purpose of law" Oxford Dictionary

"Forensic Science" - the application of scientific principles often through a multidisciplinary approach to determining a legal question

Recognizing Forensic Cases

- Submitted by authorities
- Animal abuse cases
- Insurance cases
- Malpractice concern
- Wildlife cases involving endangered species or other protected wildlife
- Environmental contaminant cases
- Animal involvement in criminal cases

Obligations in taking forensic cases:

- Process evidence in a manner consistent with forensic principles
- Provide objective scientifically based evaluations
- Preserve evidence integrity
- Maintain confidence regarding case
- Be available to provide professional quality expert testimony

Objectivity

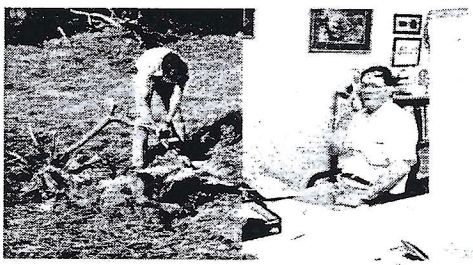
- In a forensic examination, it is not enough to place a label or "diagnosis" on a case. It is your responsibility to reconstruct the event as best you can within the constraints of the available evidence and without assumption or speculation.
- You are not an advocate for the defense or prosecutions - - - you are a seeker of truth for the court.

"Let the body speak" DiMaio

Forensic Investigation Includes

- Field investigation
- Proper collection, documentation and shipment of evidence
- Examination of evidence
- Documentation of observations
- Collection and documentation of additional "trace " evidence
- Official report
- Attorney or court presentation

Crime Scene Investigation



Field Investigation Communication

Objectives Of A Forensic Pathological Evaluation

- **Determine Cause of Death - -** *"Cause, Manner and Mechanism"*
- **Recover Trace Evidence**
- **Reconstruct Circumstances**
- **Estimate Time of Death**

Cause Of Death

- **The disease, injury or abnormality that alone or in combination is responsible for initiating the sequence of functional disturbances that ends in death**

Example: Gunshot wound to the wing of an eagle which eventually dies in an emaciated state due to Aspergillosis

COD = Gunshot

Mechanism Of Death

- **The structural or functional change that makes independent life no longer possible**

Example: Myocardial laceration from bullet wound results in internal hemorrhage and finally tissue anoxia

Manner of Death

- **A classification of the way in which the cause of death came about with special reference to social relationship and personal causation**

Example #1: Eagle dies of pesticide poisoning after eating legally poisoned rats (accident)

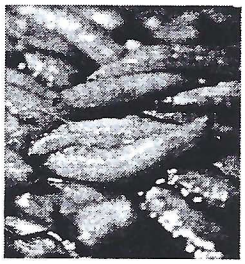
Example #2: Eagle dies of poisoning after eating on illegal poisoned bait (intentional)

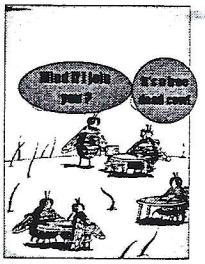
Time Since Death

- **"There is currently no single accurate marker of the time of death" Handbook of Forensic Pathology, 1990**

•Body Temperature
•Rigor Mortis
•Vitreous Humor Potassium Levels
•Entomology Studies–species and larval development
•Taphonomy (Weathering of bone)

Forensic Entomology



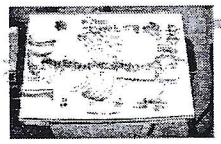


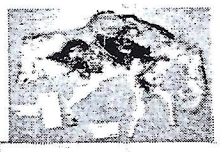
Time Since Death Considerations

- Environmental conditions
  - Alternating exposure to sun or shade
  - Water immersion
  - Dry heat
- Activity prior to death
- Species and/or size considerations
- How animal was transported
- Maggot infestation of wounds
- Systemic disease

Post Mortem Condition

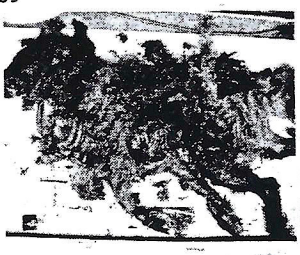
- Nothing is too decomposed to examine in a forensic case!
- Analysis and interpretation must consider effects of post mortem condition
  - pesticides continue to degrade post mortem
  - bullets corrode post mortem

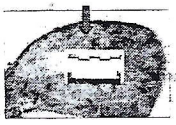




"Let the body speak"

- DiMaio and DiMaio 1989

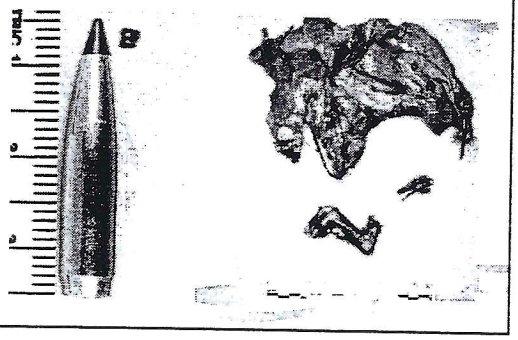




Trace Evidence

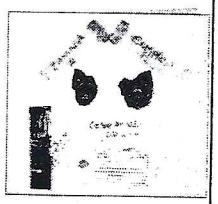
- Bullets , bullet fragments and pellets
- Burrs or other plant parts
- Items from gastrointestinal track
- Hair samples
- Tissue samples for chemical analysis
- Chemical residue
- Insects

Trace Evidence

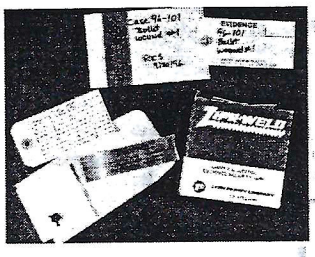


Evidence Subsample Processing

- Subsamples from carcass must have "chain of evidence"
- Use only "certified" laboratory with acceptable protocols for requested analysis and evidence handling
- An analyst in a laboratory is subject to the same potential for court subpoena (let him know this!)
- Samples that are altered or destroyed in analysis must be taken in duplicate to provide defense with sample for their own analysis



Chain of Custody



Sealing of Evidence

Trace Evidence Documentation

- Issue a separate identification # based on original item
  i.e. LAB – 1a: Bullet from LAB - 1
- Photograph or describe in situ if possible
- Make sure analysis is done using "court" acceptable techniques and evidence handling procedures
  Frye or Daubert Hearing
- Reference other reports when your conclusions are based on another's analysis

Photographic Documentation of Origin of Trace Evidence

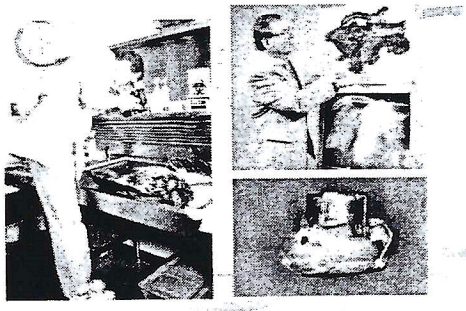
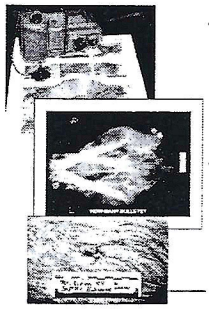


Photo Documentation



- 35 mm print film
  - negatives become part of official record
- Digital images
  - store and "lock" on a CD
- Radiographs are evidence in themselves
  - secured storage as evidence
  - use photo of radiograph for court
- All photos or radiographs must have case/evidence identification incorporated into photo

Analytical Procedures

- Daubert Hearings may be requested by the defense if new or "non-standard" procedure is used for analysis
  - -Basically new method is "tried" in court of law to verify that it is a valid method acceptable to the scientific discipline represented
  - -Judge acts as "gate keeper" for expert scientific testimony
- Instrument calibration logs available
- Controls run with samples as standard protocol
- Laboratory certification is a definite advantage

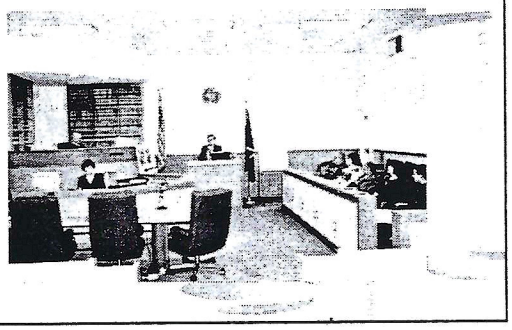
Forensic Necropsy Protocols

- History (don't start without it!)
- Identification (photograph, case #, description
- Radiograph (whole body when appropriate)
- Forensic Necropsy Report
  - External surface examination (photograph and describe lesions)
  - Internal examination (photograph and describe lesions)
  - Collected trace evidence
  - Analytical findings (toxicology, ballistics, etc.
  - List significant findings in order of importance
  - Opinion
- Evidence storage or return to submitter

Forensic Pathology Reports

- Do not give reports or discuss findings with anyone other than the submitter or his legal counsel
- Write report for the court, not for your colleagues in the pathology department
- "Discovery" – the process by which all your notes, photos, and other material relative to the case are obtained by the other side to search for inconsistencies

The Court



Trial preparation starts at the necropsy table!!!

- Anticipate how you would show a jury what you found and how it pertains to the case using photos or x-rays
- Record negative or normal observations in your raw data to document why you eliminated other possible explanations
- Anticipate the opposite side's explanation and be prepared to counter or support it by the demonstration of the facts

Pretrial Preparation

- Establish what you can and can not testify to based on:
  - your training and experience
  - your examination of the evidence
- Educate the attorney on the science and the conclusions you can support based on your findings
  - develop set of questions that your answer will provide explanation

Pretrial Preparation

- Make sure your written report is consistent with any other records, notes, or photos on file
- Use professional quality visual aids to present findings to judge or jury
- Provide CV, list of continuing education and previous legal testimony
  - keep a career list of numbers and types of necropsies, special exams, etc.

Rights of the Defense

- View your notes
- Examine your photo documentation or x-rays
- Re-examine all available evidence
- Split samples of analytical submissions

- Preserve the evidence in the original state if possible
- Provide unbiased scientific evaluation of evidence

The Expert Witness

Court Room Testimony

Witness of Fact – May only answer questions related to what was personally seen or experienced

Expert Witness – May offer an "opinion or interpretation" based on training, knowledge or experience

The judge will determine if you are qualified as an expert witness based on the evidence of your qualifications

The jury will determine if you are a credible witness based on your testimony

Courtroom Testimony

Qualifications as an " expert witness"

- Training - - Formal Schooling
- Experience - - Generally Related to Area
- Special Training and Experience - - residencies, seminars, personal tutorage
- Experience Specific to Subject - - i.e. how many similar cases have you examined?
- Publications and Presentations
- Professional Recognition and Activities

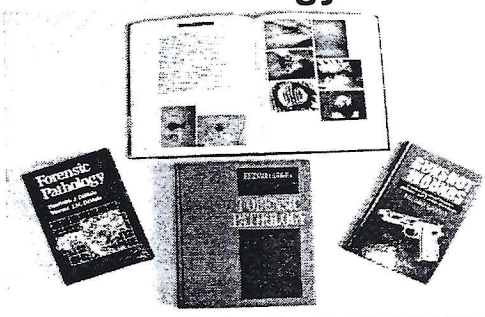
Court Room Testimony

- As an "Expert Witness"
  - Portray A Professional Appearance
  - Use Professional Quality Visual Aids
  - Answer Questions with confidence but not "Arrogance"
  - Don't let defense counsel "rattle you" by attacking your qualifications, judgment, procedures, ethics, etc., - - that is what he paid to do (nothing personal!)
  - Consider Educational Level of Jury
- Teaching Opportunity

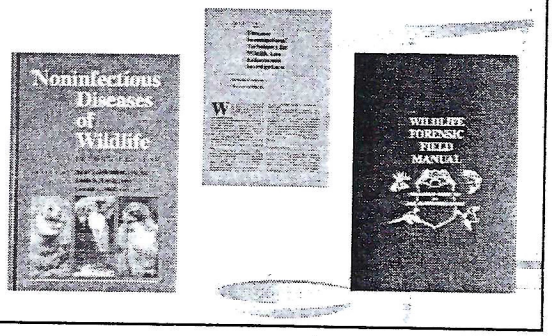
So Where Do I Learn About "Forensics"

- Published Material Related to Wildlife
- Formal Training Courses and Seminars (Human Related)
- Published Material Related to Human Forensics (including internet)
- Practical Experience Under A Mentor
- Self Taught

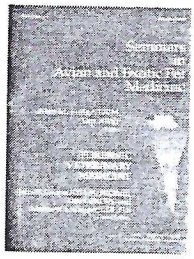
Human Forensic Pathology



Wildlife Forensic Resources



Seminars in Avian and Exotic Pet Medicine Vol. 7, No. 4, Oct. 1998



- Role of the Practicing Veterinarian as an Expert Witness - Harris
- Birds, Exotic Animals and the Law - Cooper
- Wildlife Forensics and the Veterinary Practitioner - Stroud
- Clinical Examination of the Avian Forensic Case - Forbes
- Forensic Necropsy - Munro
- Future Trends in Forensic Veterinary Medicine - Cooper

Forensic Death Investigations:

- **Gunshot**
- **Trauma**
- **Poisonings**
- **Unexpected sudden deaths**
- **Maltreatment (animal abuse)**
- **Environmental hazards**
- **Medical malpractice related deaths**

Gunshot Wounds

The Science of "Ballistics" is the study of the factors affecting the travel of a projectile to a target

The Science of "Wound Ballistics" is the study of the pathological effects of a projectile passing through a body

Objectives: Gunshot Wound Exam

Can you answer the following questions?

Type of weapon used

Number and type of projectiles (bullets/pellets)

Position of shooter relative to victim (Trajectory)

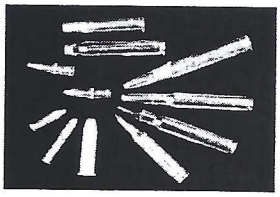
Lethality or incapacitation caused by wound

Duration of wound

Recovery of projectile

Type of gun

- Rifle
  - High velocity centerfire
  - Low velocity rimfire
  - Low velocity black powder
- Pistol
- Air Guns



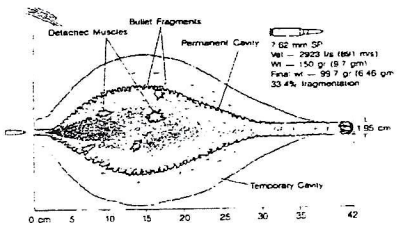
Type of Gun

- Shotgun
  - bird shot
  - buckshot
  - rifle slug

Type of Ammunition

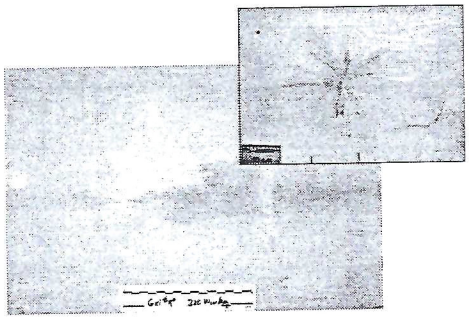
- Semi jacketed bullets
- Fully jacketed bullets (military)
- Barnes type solid copper bullets
- Solid lead bullets and shotgun slugs
- Lead, copper plate, steel, tungsten and bismuth shot

Wounding Dynamics



Based on wound dynamics, the pathologist may infer some information on the type of projectile

Wounding Dynamics



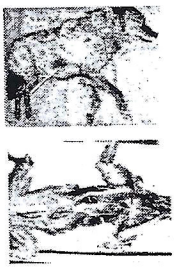
Projectile Wound Paths

Low Velocity

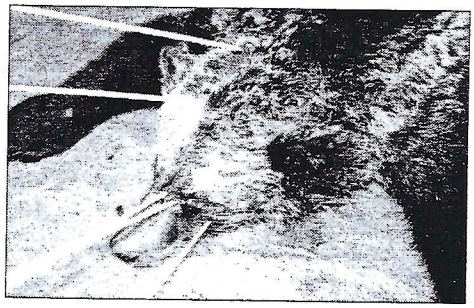
High Velocity

Trajectory

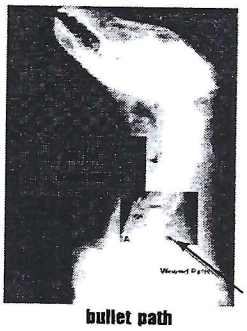
- The direction of the projectile relative to the shooter and the victim
- Important in many "self defense" cases
- May be key to finding bullet and/or casing in environment



"Self Defense "



"Self Defense"

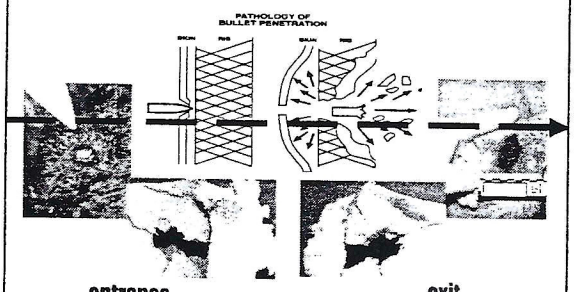


bullet path

entrance

exit

Defining Bullet Direction



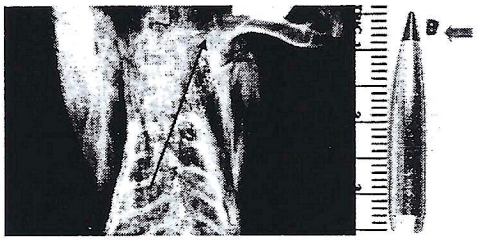
entrance

exit

Radiographic Examination

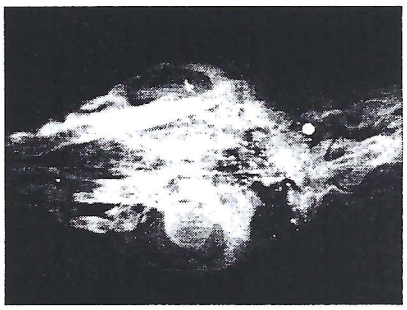
- Projectile Path (Trajectory)
- High Velocity vs Low Velocity
  - Rifle Bullet vs Shotgun Slug vs .22 Rimfire
- Projectile Location - DV and Lateral
- Projectile Type - Lead vs Steel Shot
- Bones Fractured

High Velocity Rifle Wounds



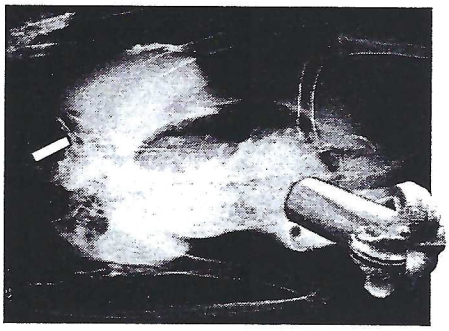
"Snowstorm" effect of high velocity bullet

Location of Projectile

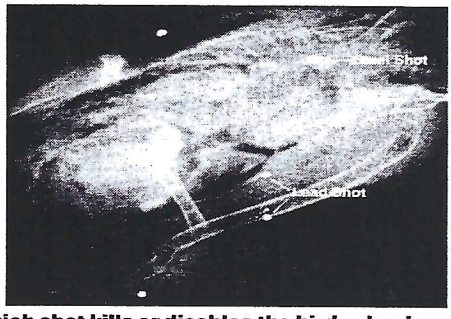


Bullet Jacket

Bullet Wounds Without Fragments

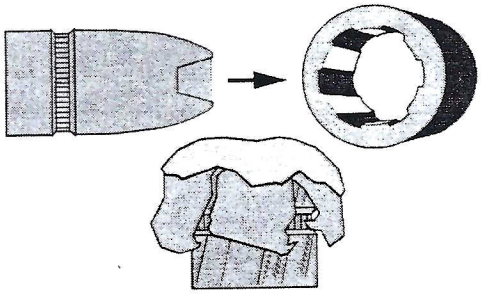


Lead vs Steel Shot



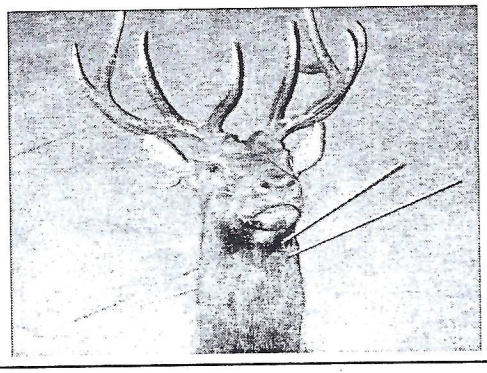
Which shot kills or disables the bird -- lead or steel?

Recovery of Bullets



TRANSFER OF CLASS AND INDIVIDUAL CHARACTERISTICS
FROM BARREL TO FIRED BULLET AND BULLET MUSHROOMING

Incapacitation and Lethality of Wounds



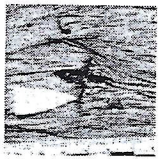
Arrow vs Gunshot Wounds

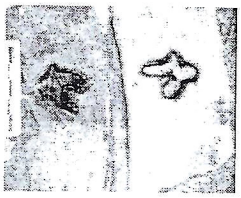
- Wound Characteristics - Incision wound rather than crushing or tearing
- Radio Dense Particles
- Lead Contamination
- Location In Carcass
- Pre Mortem Or Post Mortem?

The use of firearms to take big game illegally during archery season is wide spread.

Arrow Wounds

Cut hair pattern



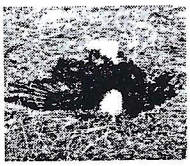


Evidence of hemorrhage

Bone fracture characteristics

Poisoning of Animals

Intentional poisoning of protected wildlife is wide spread in the United States.



An illegal market for restricted pesticides exits

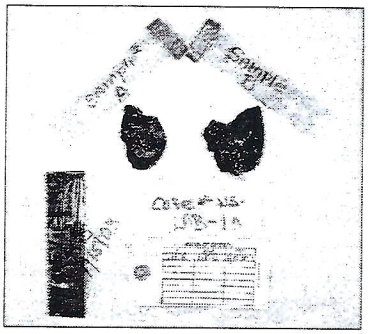
Objectives: Poisoning Examination

- Detect lethal poisons in illegally killed wildlife
- Identify source of poison
  - ingestion
  - contact
- Determine if primary or secondary target
  - primary consumer of poison bait
  - consumed another animal which was primary target of poison

Analytical Chemistry

- ID and Quantification
- Use established methods
- Use certified laboratory
- Split samples for defense

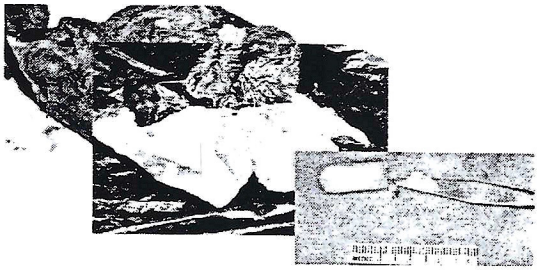
Split Sample of Evidence



Document Exposure Route

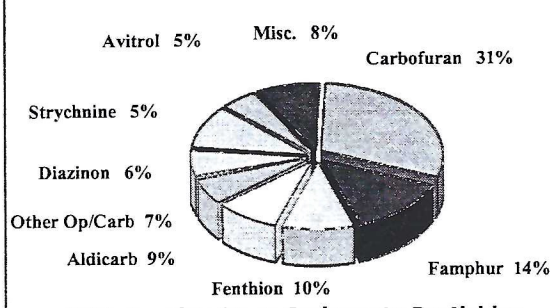
- Sequence Of Ingestion
- Identification Of Food Items
- Analysis Of Individual Items
- Consideration of Water or Cutaneous Route
- Consider Time Delay And Travel From Potential Source Of Poison

Identify Source of Poison



Cyanide capsule

Pesticides Found In Wildlife Poisonings

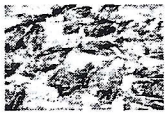


82% Involve OP or Carbamate Pesticides

Causes of Death in Eagles
N=756 Carcasses

- Disease 4%
- Electrocution 12%
- Trauma 13%
- Gunshot 22%
- Poisoned 37%
- Undetermined 12%

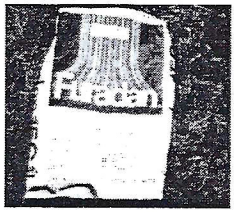
Poisons Found In Eagles
N=273



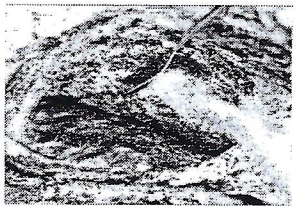
- Pentabarb 4%
- Fenthion 7%
- Famphur 10%
- Aldicarb 20%
- Carbofuran 37%
- Unidentified 20%

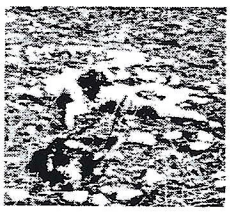
Carbofuran (Furadan)

31% of all wildlife poisonings
37 % of eagle poisonings



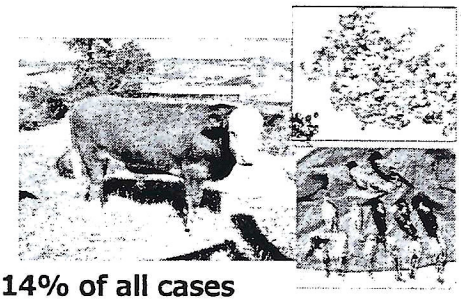
Aldicarb (Temik)





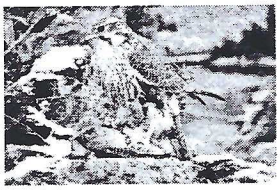
9 % of all cases
20% of eagles

Famphur (Warbex)

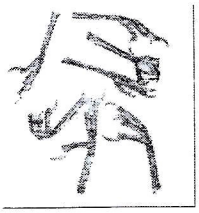


14% of all cases

Fenthion



10% of all cases



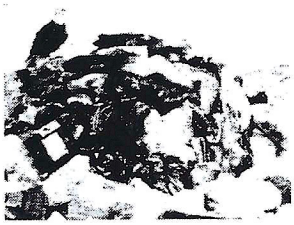
Contact bird poison
"Rid-a-bird Perches"

Strychnine

- Blue-Green Stained Grain
- Clear Liquid
- "Sawhorse Stance" if rigor not broken

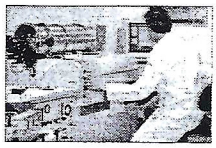
Pentobarbital

- Veterinary Sources
- Illegal or Inappropriate Disposal of Euthanized Carcass

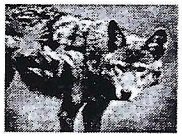


Toxicology

- ID and Quantification
- Use established methods
- Use certified laboratory
- Split samples for defense
- Brain or blood cholinesterase for OP and Carbamate pesticides
- Chain of custody and secure storage protocols

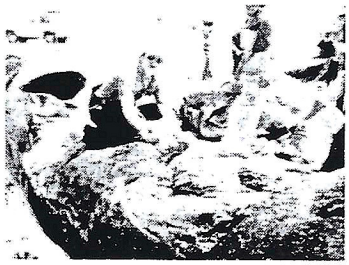


Poisoning Wildlife Is Illegal



- Most is due to illegal use of registered agricultural pesticides
- Secondary poisoning is common sequel to pest control activities
- Pathology examination is essential to document the route of exposure

Forensics is Fun!

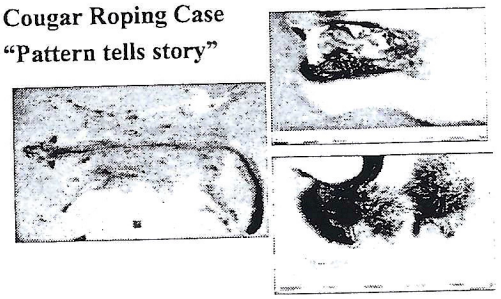


Trauma Wounds Of Forensic Importance

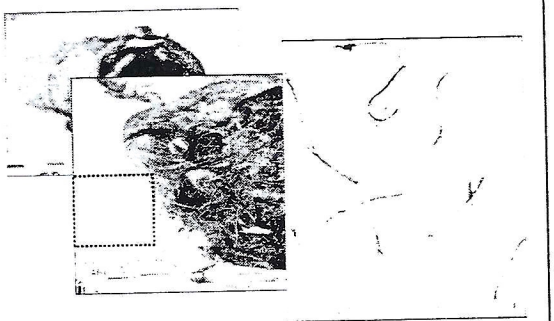
- Patterned Injury
  Does the pattern of lesions tell or confirm a story?
- Blunt Trauma Injury
- Sharp Trauma Injury
- Predator Injury
  Post Mortem Scavenger Injury

Patterned Injury

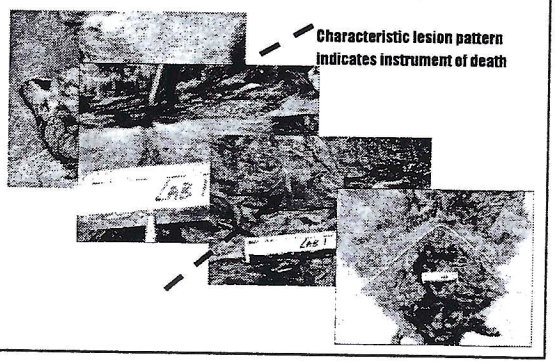
Cougar Roping Case
"Pattern tells story"



Patterned Injury

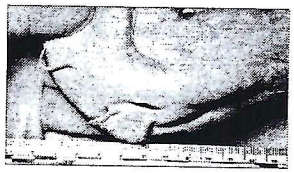


Patterned Injury



Sharp Force Injury

- Knife Wounds

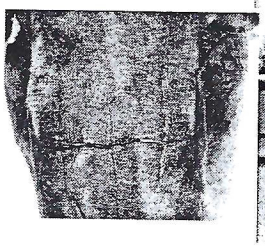


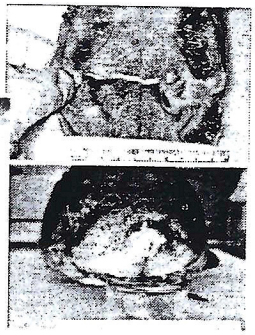
- Axe Wounds
- Arrow Wounds

Sharp Force Injury

"Sturgeon Axe Murders"

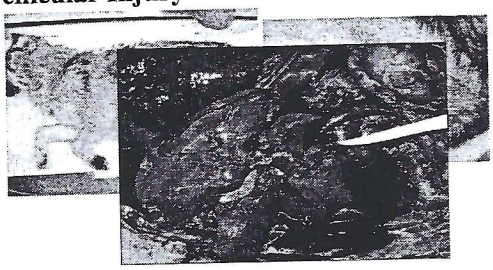
Lesions inconsistent with suspected COD





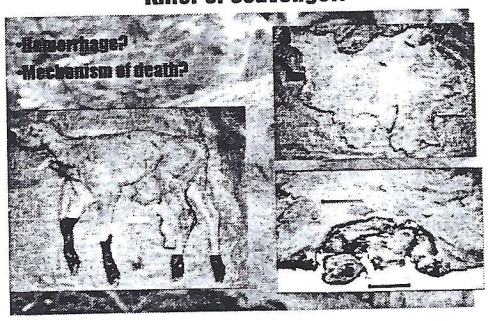
Blunt Force Injury

Vehicular Injury

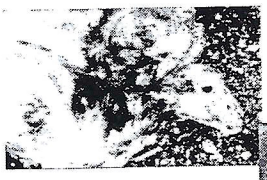


Livestock Predation

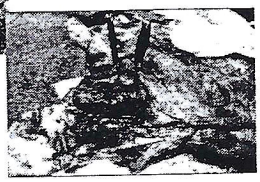
Killer or scavenger?



Livestock Predation



Deep muscle hemorrhage from neck fracture



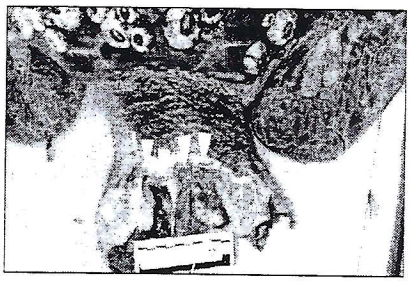
Premortem subcutaneous hemorrhage

Predator Related Trauma

"Gunshot Wolf" - - Looked like single entrance wound

Predator Related Trauma

"Mutilated Turtles"



Electrical Contact