COLORADO PARKS & WILDLIFE

Approaches to Field Investigations of Cause-Specific Mortality in Mule Deer *(Odocoileus hemionus)*

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COVER PHOTOS

Top: Mule deer doe ID Blue 4 on the Roan Plateau summer range

Bottom left to right:
1) Mule deer predation site in sagebrush habitat; 2) Canine punctures resulting from cougar predation;
3) Mule deer fawn entangled in a barbed-wire fence; 4) Example of avian scavenging

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APPROACHES TO FIELD INVESTIGATIONS OF CAUSE-SPECIFIC MORTALITY IN MULE DEER

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INTRODUCTION

Mule deer (*Odocoileus hemionus*) populations have steadily declined throughout their range since the mid-late 20th century due to various factors such as habitat loss and fragmentation, spread of invasive species, climate change, and fire suppression (deVos et al. 2003, Natural Resources Conservation Service 2005). Predation also plays a role in mule deer population dynamics, and in specific cases may also inhibit population growth rates (Ballard et al. 2001, Mule Deer Working Group Fact Sheet #1). The decline of mule deer populations has generated great interest and concern among wildlife managers, hunters, NGOs, private landowners, and researchers. Therefore, accurate evaluations of mule deer mortality sites are essential to determine the extent of cause-specific mortality for reconciling the concerns of these diverse interests and guide future management actions. Furthermore, determining cause-specific mortality of mule deer is important for research studies focusing on mule deer population dynamics.

Common sources of mule deer mortality include predation, disease, malnutrition, hunter harvest, vehicle collisions, fence entanglement, and pregnancy complications. Although predation of healthy deer is not uncommon, deer can also be predisposed to predation when they are sick, malnourished or exposed to inclement weather. Scavenging, where deer die from other causes and are consumed by predators, may give the misimpression that predation occurred. Thus, investigators must be able to separate scavenging from predation to adequately assess mule deer mortality factors.

The ability to accurately determine cause of death can be challenging and will depend on the evidence present at and around the mortality site and how quickly an investigator arrives on the scene. An investigator may find an intact carcass, only a few bones, or no carcass at all. Sometimes, only clumps of hair, pieces of hide, blood, or a radio collar put on the deer for monitoring purposes remains. Carcasses decompose and hides dry out rapidly in warm, dry weather, diminishing signs and causes of mortality. Blood, hair, and tracks can be destroyed or covered up by inclement weather, ultimately compromising the ability to conduct a comprehensive mortality site assessment.

Components of an effective mortality site investigation include:

- Evidence to distinguish predation from other causes of death (e.g., starvation, disease, accidents)
- Knowledge of resident predators and sign identification
- Knowledge of predator specific attack and feeding behaviors
- Collection of samples that may assist laboratory determination of disease/starvation
- Properly assessing mortality sites and the surrounding area
- Conducting thorough external and internal necropsies
- Distinguishing between lividity and hemorrhaging
- Body condition assessment by examining femur bone marrow and other body condition indices (e.g., heart and/or kidney fat deposits)

This technical report provides general guidelines for conducting mortality site investigations to help investigators distinguish predation from scavenging and other causes of death. General health indices are also provided to assess whether or not deer may have died from malnutrition or disease or if these factors may have predisposed deer to predation. Lastly, these guidelines will assist investigators in identifying predatory species or scavengers involved through the examination of physical evidence at deer mortality sites. The information presented here is based primarily on field experience gained from a long term research effort in northwest Colorado investigating mule deer mortality sites over several years (Anderson 2015) and literature review where referenced. We acknowledge that proximate and ultimate cause of death can be difficult or impossible to detect from field necropsy alone and examples presented here largely represent proximate causes of mortality; efforts discerning ultimate cause will require specific tissue sample collections, where possible, submitted to a veterinary diagnostic laboratory.

Within this technical report are numerous photographs documenting characteristics of predator attacks on mule deer and signs left by predatory and scavenging species. Additional pictures illustrate differences between healthy and unhealthy tissues and organs. While reading this document, be aware that each mortality investigation is unique and observations in the field may differ from illustrations provided here. Appendix I provides a sample necropsy form to assist in conducting mortality investigations.

SAFETY FIRST

We advise investigators to never handle an animal without gloves. Immediately after handling an animal, remove and dispose of gloves and wash hands. Wear long sleeves/long pants/closed-toed shoes when working in areas with vectors in the environment. Wear dedicated clothing that is washed regularly. Whenever possible, send the carcass to the lab for necropsy. In cases of suspected disease-related mortalities, consult with a veterinarian on unusual findings and take photos. Have an N-95 mask and eye protection available in case of a suspected zoonotic agent. If an investigator incurs an illness shortly after conducting a necropsy, consult a physician immediately to avert potentially life threatening circumstances.

GENERAL GUIDELINES FOR EVALUATING MORTALITY SITES

To document ultimate cause of death, it is important to locate the carcass and evaluate the mortality site as quickly as feasible. The first steps for a mortality site investigation are to cautiously approach the site to avoid disturbing evidence and search for clues on approach (e.g., hair, tracks, scat, broken branches, blood). The next step is to assess whether predation or scavenging occurred; an undisturbed carcass obviously rules out predation. The next steps are to determine the state of health for the animal and consider other possible causes of death if predation can be ruled out, or determine which predatory species may be responsible if predation is evident. We provide general guidelines to consider when carrying out mortality site investigations rather than step-by-step directions because methods may vary depending on what is found at each site (e.g., amount of carcass remains, signs of predators and scavenging, surrounding environment).

Items to include in your necropsy kit

- Mortality investigation/necropsy form
- Knife sharpener
- Bone saw to investigate femur bone marrow (a large rock may substitute)
- Measuring tape
- Whirl-pacs for organ and tissue samples
- Plastic sample jar with formalin to fix organ and tissue samples
- Large Ziploc bags for bones, pieces of hide, scat, etc.
- Coin envelopes for hair samples
- Disposable exam gloves
- Digital camera
- GPS unit
- Extra pens/pencils

Photo documentation

The importance of taking photographs while investigating mortality sites cannot be overstated. Photographs should be taken throughout the investigation to document evidence. Pictures will provide future reference and allow experts to assist in the evaluation. Be sure to take pictures of the entire mortality site to document tracks, scat, signs of a struggle (e.g., broken branches, blood splattering, matted vegetation), bone marrow, hemorrhaging and canine punctures. If a tape measure is unavailable, put an object of known size next to the evidence when taking pictures for size reference. Close up and distant photos are helpful to put the subject into context. Too many photos are preferable to not enough photos!

Site description

In situations where cause of death is uncertain, consider recording a description of the surrounding area where carcass remains and any predator or scavenging sign is found. In cases were carcass remains are wildly scattered, sometimes it is easier to draw a picture with estimated distances and brief descriptions.

Locate the carcass and mortality site

All mortality sites should be approached carefully to avoid disturbing possible predator or scavenger sign (e.g., tracks, scat, hair) that may be found near the carcass. When locating the carcass, keep in mind that predators or scavengers may have dragged, carried away, or cached the carcass away from the mortality site. It may be necessary to search a large area (>100 m radius) to find scattered carcass remains, predator or scavenging sign, or the kill site. Game trails, fence lines, water holes, dry washes, valleys and creek beds should be checked for predator sign and carcass remains.

Search for signs of a struggle and chase

While searching the area for predator sign look for evidence of a struggle and a chase scene. Broken or trampled vegetation, clumps of deer hair, or a drag trail of blood indicates predation may have occurred (Fig. 1 on pg. 10). A thorough search of the mortality site and surrounding area may be necessary to locate blood from the carcass because predators often drag prey from the kill site. Predators tracks along or behind a set of deer tracks are a good indication that a chase occurred and presence of blood confirms predation.

Search for predator and scavenging sign around the carcass

Search the area immediately around the carcass for predator and scavenging sign before handling the remains to avoid destroying evidence that may assist in identifying cause of death.

Common predator sign includes:

- Tracks
- Scat/urine
- Predator hair
- Deer hair
- Felid drag trail to a cache site
- Blood trails
- Blood on telemetry collars
- Blood on vegetation
- Matted or broken vegetation
- Felid or bear (Fig. 2) tree scratching site (occasionally present)

Look carefully for predator hair on broken branches and shrubs along a chase scene, in branches above the carcass, or on the ground. If predator hair is not immediately identifiable, it can be submitted to a wildlife forensics laboratory for identification. Coin envelops should be used for DNA samples instead of plastic bags because plastic will retain moisture that can destroy DNA.

Figure 2. Bear claw marks on a tree near a mortality site.

Documenting predator species from tracks

Some of the first evidence that may be found when approaching a mortality site are predator tracks. Combined with other predator sign, tracks can be helpful in identifying which predatory species was involved in preying upon or scavenging a deer. In cases where clear tracks are unavailable (e.g., hard, dry ground or melted snow) or the investigator is unable to identify species from clear tracks, photos with spatial reference may assist with subsequent identification. Photos should include a clear track, where possible, including a measuring tape or an object of known size in the photo, and other photos with spatial reference of a few to several tracks to assess stride length and track patterns. Even when the species is identified from tracks, it is useful to take a few photos for reference or subsequent confirmation. When measuring tracks for track identification (e.g., fresh, not melted out), measure the length of the track from the tip of the furthest toe pad to the bottom of the planter pad and the width of the track at the broadest point.

Assess the position of the carcass

Deer that die from disease, sickness, or malnutrition are usually found lying upright or on their side and in a bed with their legs folded under their body (Fig. 3a–b on pg. 10). Deer killed or scavenged by predators are typically found on their side with their legs extended and in or near thick cover (Fig. 3c–d on pg. 10). Commonly felids and occasionally bears (*Ursus* spp.) will cover a carcass with soil, ground litter, shrub branches and/or snow (i.e., caching the carcass), whereas coyotes (*Canis latrans*) occasionally will dig a hole in the ground or snow and bury the skull. Depending on the predator, portions of a carcass may be scattered across a kill site as opposed to having the legs extended on a whole carcass. For example, coyotes commonly scatter carcass remains of deer that they kill or scavenge. If the carcass is found with the legs extended it does not always suggest predation. Also, keep in mind that if the deer died from causes other than predation and the carcass was scavenged, the position of the deer will have changed.

Examine the carcass for external damage

Before conducting an internal necropsy, examine the outside of the carcass, take note of any abnormalities and record the condition of the exposed portions of the carcass. Look for canine punctures, wounds, lacerations, claw marks, and scrapes on the hide, and take note of any feeding patterns (Fig. 4). If the carcass has been partially consumed, describe how much flesh has been eaten and which bones have been chewed or fragmented. If claw marks are present, canids can be ruled out, and the location and width of claw marks can be used to distinguish between felid and bear predation. Felid claw marks appear as fine, almost razor-like cuts, whereas bear claw marks represent scrapes $\sim\frac{1}{8}$ in (0.3 cm) wide (Fig. 5 on pg. 11). Also, pay attention to distance between "lacerations" to differentiate between cuts and claw marks. Claw marks are spaced $\sim\frac{1}{2}$ $-1\frac{1}{2}$ in (1.3–3.8 cm) apart with typically 4 lacerations representing each claw, but all 4 claws may not register, especially with bear predation.

Figure 4. Cranial canine punctures from a cougar attack.

Examine the carcass for internal damage

Conduct a necropsy to examine the hide and underlying tissues to determine if any injuries occurred while the deer was still alive. If the deer was killed by a predator or suffered blunt force trauma immediately preceding death, evidence of bruising and hemorrhaging on and under the hide should be evident if most of the carcass is available for necropsy (Figs. 6–8). Also look for a broken neck, damaged vertebrae, a crushed skull, and punctures in bones and the trachea. Predators that kill deer with a bite to the throat usually damage the trachea (Fig. 9 on pg. 11). Bites to the throat often cause hemorrhaging, which contribute to death by suffocation (Wade and Bowns 1982).

While skinning the carcass, pay close attention to subcutaneous hemorrhaging and damage to the throat, base of the skull, neck, head and legs because these are common attack zones for predators (Fig. 10). However, be sure to skin the entire carcass rather than just the specific areas where predators are likely to attack to avoid missing trauma. In most cases of predation, external damage to the hide, such as canine punctures and claw marks, should correspond with any internal damage. Predators will also scavenge on and cause post-mortem damage (i.e., damage that does not cause hemorrhaging or bruising) to carcasses (Fig. 11). If hemorrhaging or bruising is not found in the tissue or hide of intact carcasses (Fig. 12), predation can be ruled out.

Figure 6. Neck hemorrhaging, bruising, and tissue damage from a case of coyote predation. Multiple canine punctures (circled) are commonly associated with coyote predation.

Figure 7. Small piece of mule deer hide exhibiting trauma found at a coyote predation site. Often only small parts of the carcass and hide will remain at a coyote/canid related mortality site.

Figure 8. Severe hemorrhaging and tissue damage on the hindquarters of a bobcat-killed mule deer.

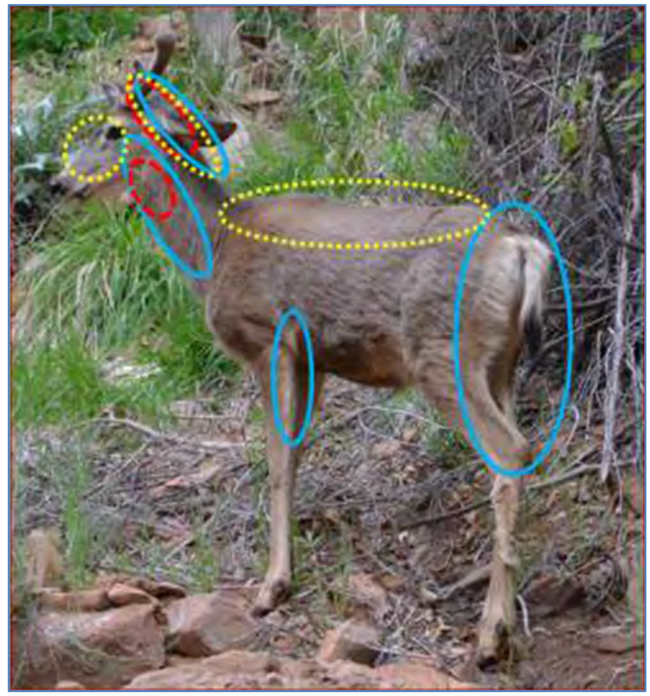

Figure 10. Common attack zones of cougars and bobcats (red ovals), coyotes (blue ovals), and black bears (yellow ovals) on a mule deer. Attack zones represent common bite wound areas and not necessarily where claw marks occur.

Figure 11. Post-mortem damage to the hide of a mule deer scavenged by coyotes. Lack of hemorrhaging around multiple canine punctures rules out predation.

Figure 12. Lack of hemorrhaging or bruising on hide and tissues of a mule deer that died from disease/malnutrition.

Contrasting hemorrhaging and lividity

Lividity is the process through which the body's blood supply stops circulating after the heart stops pumping. As a result of gravity, blood will settle in the lowest points of the carcass (Shkrum and Ramsay 2007). Blood pooling causes a discoloration of the hide and underlying tissue that looks similar to hemorrhaging (Fig. 13), and these effects can be evident within 20 minutes after death (references in Shkrum and Ramsay 2007).

Before conducting a necropsy, note which side of the carcass is down. If what looks like hemorrhaging on the carcass where blood has pooled is found, examine the hide again for punctures and claw marks and make cuts in the hide and underlying muscle to check for damage. Bruising into the hide or muscle suggests hemorrhaging, whereas lack of bruising (i.e., "white" coloration within the hide-cut) suggests lividity. In many cases, only the hide remains for investigations because muscle tissue is typically consumed.

Contrasting bruising and decomposition

When necropsying older carcasses where cause of death is not obvious, be aware that there are certain stages of decomposition that can also be confused with bruising of flesh (Shkrum and Ramsay 2007, Levy et al. 2010). Bruises occur when small blood vessels are damaged or broken as a result of blunt trauma, causing blood to leak into the surrounding tissue (Vanezis 2001). Similarly, during the process of decomposition, red blood cells break down and hemoglobin seeps from blood vessels into surrounding tissue (Shkrum and Ramsay 2007). As the carcass decomposes, fat, bone marrow and large areas of subcutaneous tissue turn green, purple, brown or reddish-brown in color (Acorn and Dorrance 1990, Shkrum and Ramsay 2007, Rao 2013). Bruises however, tend to be more localized and darker in color from clotted blood (Fig. 14 on pg. 12). Skin the entire carcass to determine degree of decomposition and presence of bruising. Keep in mind that decomposition occurs at a faster rate on portions exposed to the sun and in humid and hot environments. Also, decomposing animals may exude thin, watery blood from the nose, mouth or anus, whereas injured animals may have thick and clotted blood in the nose and mouth (Wade and Bowns 1982, Acorn and Dorrance 1990).

Figure 13. Comparison of lividity or blood pooling (top) versus hemorrhaging (bottom) for necropsy evaluation.

Measuring canine punctures

When measuring distances between canine punctures, be aware that canine spacing may become distorted during an attack because the hide stretches and twists as the prey attempts to evade the predator. The most accurate measurements are those obtained from punctures in bone such as the skull (Fig. 15 on pg. 12), but puncture distances in the hide can still be useful. Some predators, especially coyotes, will bite their prey multiple times, thus it may not be possible to distinguish and measure individual sets of canine punctures. The start and end point when measuring these distances should be the center of each puncture rather than the outer edges (Fig. 15). Measuring the width of each canine puncture may also be helpful for distinguishing between predators because larger predators will produce larger puncture wounds. Be aware that canines do not always puncture the hide during an attack and may leave a single puncture and a canine bruise or 2 canine bruises. Measuring distance between bruises/punctures can be helpful in determining predator species.

Examine the carcass for signs of health

Deer may be unhealthy from harsh winters that deplete their fat and protein reserves, disease, or old age. Predators kill healthy and unhealthy deer, but it is more energetically efficient for predators to kill unhealthy, weakened animals (McDougall 2004). In addition, there is a general relationship in predation efficiency when considering the predator:prey size ratio. For example, coyotes and bobcats (*Lynx rufus*) are more likely to take young of the year whereas cougars (*Puma concolor*) will prey on deer of all sex and age classes. Black bears (*Ursus americanus*) appear to be the exception and focus primarily on newborn ungulates. If sign of predation is evident, continue to examine the carcass for signs of underlying disease or malnutrition.

Consider the season

When investigating deer mortality sites, consider the time of year and why deer might be more susceptible to predation by certain predators, starvation, disease, or other factors. Also consider whether or not predators are more likely to be active during that season. For example, it would be extremely unlikely to find a deer killed by a bear during winter hibernation. However, bear predation on newborn fawns is relatively common in the spring/early summer. Other season considerations include wounding loss during fall hunting seasons, increased vehicle collisions during spring and fall migration, and potential for mortally fatal wounds during the fall rut for bucks.

Adult female mortalities during spring could be related to birthing complications. Pregnancy enhances doe susceptibility to predation because of reduced stamina or complications from birthing. Long duration of labor, abnormally large fetuses, and breached births (fetuses in abnormal positions) are pregnancy complications which can cause death (Acorn and Dorrance 1990) or increase predation vulnerability.

Deer are also more likely to die of malnutrition or hypothermia as winter progresses and their body condition declines. Exposure to harsh winter elements, combined with declining body condition can also make deer more vulnerable to diseases. In the summer, deer rarely die of malnutrition because there is usually an abundance of food. Deer that die from malnutrition in the summer are likely predisposed to malnutrition due to other factors such as a skeletal injury or disease.

Consider potential for disease or sickness

If the carcass under evaluation does not appear to have been predated, the carcass is intact, or the animal is in poor condition, consider possible disease or sickness as cause of death. In cases where disease is suspected or when cause of death can't be determined by field necropsy, the best course of action is to remove the entire carcass for laboratory necropsy. For transport, open the abdomen without puncturing the viscera, pack the abdomen with ice and transfer the carcass to a diagnostic laboratory as quickly as possible. Freeze the carcass if it cannot be transported within 24 hours, but understand that freezing will greatly hinder an accurate post-mortem evaluation. If the carcass cannot be retrieved, consider asking a veterinarian to perform a field necropsy. If a veterinarian is not available and a field necropsy is necessary, take photographs of every step, of all organs and especially anything that looks abnormal. If cellular phone reception is available, call a veterinarian for advice and send photographs by text if possible. The veterinarian can help decide what tissues to collect and how to collect them. If a veterinarian cannot be consulted, minimally take samples of lung, liver, spleen, kidney, and heart, in formalin as well as fresh, and collect the head for brain extraction. If there is no local diagnostic laboratory, the tissues and head can be mailed to a diagnostic laboratory overnight on ice. Because of the ecological implications of chronic wasting disease (CWD; Miller and Conner 2005), CWD testing is recommended for non-degraded carcasses of adult animals. Where possible collect the retropharyngeal lymph nodes for CWD testing where possible. If an intact neonate carcass is found, submit the entire carcass to the laboratory for evaluation.

Consider other possible causes of death

Examine intact antlered and antlerless deer for gunshot wounds if poaching is suspected. If poaching is suspected, state wildlife authorities should be contacted before the carcass is disturbed because the site is considered a crime scene. Deer found on roadsides or within close proximity to roads, with no indication of predation wounds or signs of disease, were likely hit by vehicles. Road-killed animals are usually quickly scavenged, especially by birds. Fresh road-killed deer can usually be easily spotted by looking for scavenging birds on roadsides.

Common injuries for deer hit by vehicles include:

- "Road rash"
- One or more broken or disjointed legs
- Ruptured diaphragm
- Broken vertebrae, ribs, and/or pelvis
- Hemorrhaging and bruising (blunt force trauma) covering a large area of the body

Deer may become entangled in fences by predators chasing them or during their natural movements. Predation can be ruled out when intact carcasses are associated with fence entanglements; however, be aware that trapped deer will have likely been scavenged (Fig. 16a–b on pg. 13). When assessing mortality sites, check nearby fences for carcass remains that are entangled in the fence, clumps of deer hair or flesh caught on barbed wire and blood beneath the fence (Fig. 16c–d).

Capture myopathy is a non-infectious muscle disease that is characterized by damage to muscle tissues brought about by physiological changes, usually following extreme exertion, struggle and stress (Spraker 1982). Deer may die from lactic acidosis or show muscular stiffness due to myopathy and become vulnerable to predation or die and become scavenged by predators. Thus, myopathy may be related to any mortalities occurring within a short time period following stress-related capture efforts. Based on deer movements using GPS data following helicopter net gun captures (Northrup et al. 2014), a 7-day censor period appears appropriate to minimize capture-related bias associated with demographic parameter estimates from monitoring studies.

Uncommon causes of death include falling through ice and drowning, hypothermia, becoming entangled in natural vegetation, and lightning strikes. When walking across thin ice on frozen lakes or rivers, deer sometimes fall through and drown or die from hypothermia due to exposure to cold water (Fig. 17), or suffer pelvic fractures after slipping on ice. If a deer carcass is found in or under the ice, skin the carcass to look for signs of predation. Deer that fall through ice may have first been chased on to the ice or attacked on the ice by predators (Fig. 18). In rare cases deer may become entangled in natural vegetation and die from dehydration and exhaustion (Fig. 19 on pg. 14).

Figure 17. Mule deer that fell through the ice and drowned.

Figure 18. Mule deer fawn that was attacked by coyotes after being chased onto the ice.

Investigating old mortality sites

Although it is best to investigate mortality sites in a timely manner, sometimes this is not feasible. Often the only remains may be part of the skeleton, a few bone fragments, small pieces of dried-up hide, or a deer's radio collar. However, cause of death might still be determined following these suggestions:

- Conduct a full site evaluation. Search for carcass remains and predator sign as normally would be done with a fresh carcass.
- Examine the bone marrow from both femurs or other large leg bones. If marrow from bones other than the femurs is examined, note this in the necropsy report. The marrow in the femur on the exposed side of the carcass will likely be more decomposed and dried out than the marrow on the downward side of the carcass. Be aware that decomposition changes the color and appearance of bone marrow (Fig. 20 on pg. 14). Also, because insect larvae eat bone marrow as carcasses decompose, all marrow may be consumed in older carcasses (Fig. 21).
- If the hide is pliable, stretch it out and look for canine punctures, lacerations, claw marks, bruising, and hemorrhaging, especially in areas where predators typically attack. In old carcasses bruising and hemorrhaging on the hide may still be apparent; however, be careful not to confuse decomposition with bruising. And be aware that maggots may leave holes in the hide that can be confused with puncture wounds.
- If the hide is dried out, consider taking it back to soak in water overnight so that it can be stretched out and inspected for trauma.

Figure 21. Bone marrow absent from the femur of a mule deer carcass that had been decomposing for ~2.5 months before conducting a necropsy. Bone marrow was missing from both femurs and was likely eaten by insect larvae. This deer died 1 day post capture and exhibited excellent body condition prior to death.

Figure 1. Predation characteristics at a mule deer mortality site including blood trail (left) and patches of hair and matted vegetation (right).

Figure 3. Mule deer mortality characteristics illustrating malnutrition/disease (a and b), malnutrition with avian scavenging (c), and coyote predation (d). Note undisturbed malnutrition/disease mortalities exhibit 1 or more legs tucked under the body and are either laying on their side (a) or in an upright position (b), whereas deer that were scavenged (c) or predated (d) have extended legs and are lying on their sides.

Figure 5. Razor-like claw marks from a cougar (left) versus a blunt and wider claw mark from a black bear (right).

Figure 9. Outer (left) and inner (right) tracheal hemorrhaging resulting from a cougar attack.

Figure 14. Comparison of old (3 months post mortem, left) versus fresh (right) carcasses for necropsy evaluation. Hide (top left) was removed from skull (bottom left) after soaking in water overnight. Dark pink and purple areas on skull and hide (left) indicate where hide was still attached to the skull. Brown area on top of skull illustrates where hide was missing from the skull. Right: bruising on hide and tissues over rib cage from a mule deer that was injured from a vehicle collision and ultimately killed by coyotes.

Figure 15. Canine punctures from a cougar neck bite (left) and cranial punctures inflicted by a bobcat (right). Trauma associated with punctures in both examples indicates wounds occurred pre-mortem. Canine puncture distances (arrows) and widths (blue lines) measured in bone may be more accurate than hide punctures because the hide may twist and stretch as the prey attempts to evade the predator. Distances between punctures should be measured between puncture centers (yellow arrows), rather than between the outermost edges of punctures.

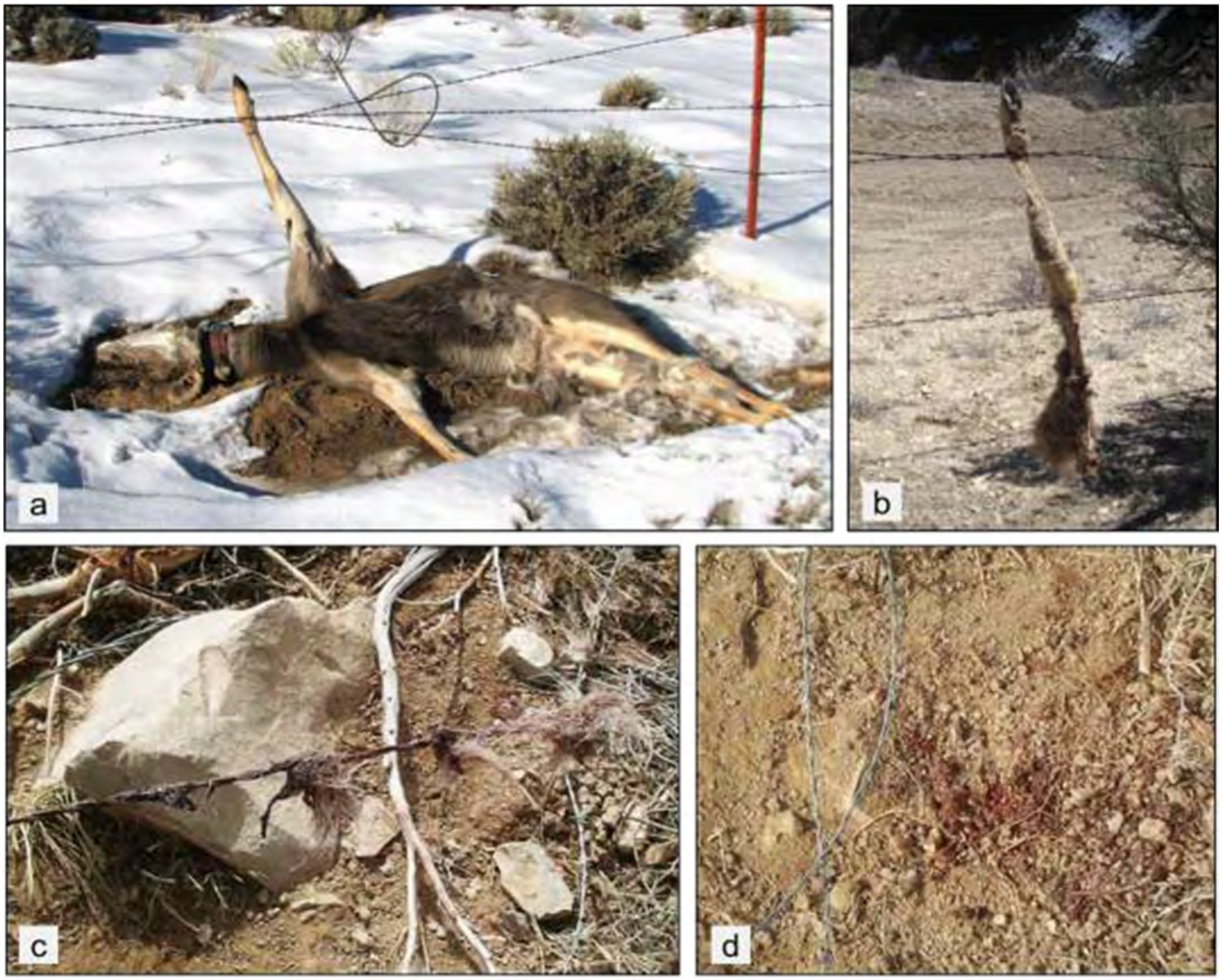

Figure 16. Mule deer caught in barbed-wire fences that were either minimally scavenged by birds (a) or completely scavenged by coyotes (b). Examples of hair and flesh caught on barbed-wire fence (c) and blood associated with fence entanglement (d) where a deer died before being scattered by scavengers; blood and hair may be the only evidence of fence entanglement when carcasses become scavenged and dispersed.

Figure 19. Mule deer fawn that became entangled in a shrub and died from dehydration and exhaustion. Deer hair and broken branches indicated the fawn struggled for some time prior to death.

Figure 20. Bone marrow inside (left) and removed (right) from a femur of an old mule deer carcass. Marrow turned dark brown in color and desiccated after being exposed to the sun for ~1.5 months.

Even after a thorough investigation, determining specific cause of death is often difficult for older carcasses. In some cases, it might be determined that predation occurred, but the predator species cannot be identified. If cause of death cannot be determined, it is recommended to classify it as an unknown mortality. A conclusion of undetermined cause of death is acceptable and preferable to incorrectly assigning cause based on inconclusive evidence.

Conclusively stating predation occurred

The best way to conclusively state predation occurred is to find evidence of canine punctures associated with hemorrhaging and bruising on the hide or in underlying tissues of the carcass. If the carcass is old or if there are minimal remains, finding these signs may be difficult. In these cases, consider other predator sign present and use best judgment. For example, any evidence that bleeding occurred such as blood trails or blood splattered on vegetation along with fresh predator sign confirms predation; even a bloody collar without a carcass may provide evidence that the animal was attacked prior to death.

Limitations when determining cause of death

In studies using radio-collared deer with VHF mortality sensors, investigators are often delayed in reaching carcasses because the mortality sensors on collars do not activate for several hours (usually 4–8 hrs.) after the animal has stopped moving. Because predators and scavengers move carcasses while feeding, detection of mortalities can be further delayed for a few days. In addition, some mortality sensors are highly sensitive to movement and can switch back to a live signal due to wind, rain or snow. Shifting telemetry pulse rates from any of the above factors may give the impression of a false mortality, but we recommend promptly investigating each site to enhance ability to assess mortality cause. Investigators may also be delayed in reaching a carcass because of inclement weather, rugged terrain, or obtaining access to private property. Telemetry monitoring during periods when carnivores are typically inactive (e.g., mid-day) and mortality signals are more easily detected may enhance early identification of mule deer mortalities.

ASSESSMENT OF HEALTH AND BODY CONDITION

Examine the carcass for signs of dehydration

In fresh carcasses of healthy animals, the eyes completely fill the sockets whereas sunken eyes are evident for dehydrated animals (Wade and Bowns 1982, Acorn and Dorrance 1990). Dehydration is usually difficult to detect for wildlife mortalities because investigators are often delayed in reaching mortality sites. Carcasses rapidly desiccate as they are exposed to the elements, especially in temperatures above freezing; thus, this is only a reliable indicator for fresh carcasses. The back end of the deer should also be checked for evidence of diarrhea which can cause dehydration (Acorn and Dorrance 1990).

Examine the carcass for signs of malnutrition

Check for fatty deposits on and around the organs, if present, and evaluate the bone marrow from a femur or another large leg bone, such as the tibia, if both femurs are missing. As body condition declines in ungulates, it is believed there is a sequential order in which fat reserves are generally depleted. This starts in subcutaneous depots, followed by fat in the viscera including fat on the kidneys and heart, and finally within the bone marrow (Harris 1945, Cederlund et al. 1989, Cook et al. 2007). Healthy deer typically have mesentery fat and firm, white fat deposits on the heart, pericardium (i.e., membrane around the heart) and kidneys (Figs. 22–24 on pg. 23; Kistner et al. 1980). Because fat deposits are generally metabolized in the bone marrow as a last resort, femur marrow consisting of white deposits denotes the deer did not likely die of starvation. Deep red and gelatinous marrow may suggest malnutrition as a contributing factor (Fig. 25 on pg. 24; Cheatum 1949, Wallmo 1981) or likely related to the ultimate cause of death. Caution should be exercised when assessing presence of fat on organs and in marrow with fawns, especially when fawns are rapidly growing; fawns use available energy for growth and thus have less stored fat compared to adults (Kistner et al. 1980). Marrow samples from young fawns are usually pink-red in color.

When detailed assessment of body condition is required, fat around organs, such as the kidneys and heart can be scored (Kistner et al. 1980), or collected to determine fat indices (Cook et al. 2007). Intact femurs and mandibles can also be collected, and marrow from these bones can be dried and weighed to measure fat content (Neiland 1970, Cederlund et al. 1989, Cook et al. 2007). Kidney fat indices are most useful when deer are in moderate condition whereas marrow indices are most reliable for deer in poor condition (references in Kistner et al. 1980, Cook et al. 2007).

Determine the age of the deer

It may be helpful to determine the age of the deer because older deer have reduced vitality and may be predisposed to disease and death from other causes, including predation. Evaluating tooth wear and eruption is an effective method for determining the age of fawns and adult deer (Fig. 26). http://store.msuextension.org/publications/OutdoorsEnvironmentandWildlife/MT200107AG.pdf)

Figure 26. Example of extreme tooth wear from a mule deer that died of malnutrition.

CONSIDERATIONS WHEN INVESTIGATING NEONATE MORTALITIES

Neonates are very susceptible to predation and can be easily consumed or carried away by predators or scavengers. Therefore, it is important to evaluate mortality sites with as little delay as possible. Even if the mortality site is located quickly, often there is little or no evidence present to determine cause of death. Viable neonates will have breathed, walked, and fed. When examining the remains of a neonate consider the following to determine whether or not the deer was born alive:

- Has the neonate breathed? Newborn animals that breathed will have spongy, light-pink lungs (Fig. 27), whereas stillborn animals will have firmer and less spongy lungs (Taylor and Njaa 2012). Place a sample of the lung in water to see if it floats. Lung tissue that floats usually indicates the neonate breathed; lung tissue that sinks usually indicates the neonate was stillborn (Winter and Clarkson 2012). When conducting this test, keep in mind that there are exceptions. Stillborn lungs may still float because as carcasses decompose the lungs can fill with post-mortem gas, causing them to float (references in Große Ostendorf et al. 2013).
- Has the neonate walked? The bottom of neonate hooves and tips of dewclaws are covered with a soft semi-gelatinous sulfur pad which wears away within 24 hours of birth as a result of walking (Fig. 28 on pg. 25; Haugen and Speake 1958). Stillborn neonates should still have the material attached to their hooves. Also, hooves are soft and grayish in color at birth, but they harden and darken within 24 hours (Haugen and Speake 1958).
- Has the neonate fed? Milk present in the stomach of the neonate indicates a live birth (nursing; Winter and Clarkson 2012). A lack of milk in the stomach does not necessarily indicate the animal was stillborn, as abandonment is a possibility (Fig. 29 on pg. 25**)**.
- Has the neonate been licked clean? Adult females lick their neonates to rid them of placenta and consume the membrane to minimize predation risk. A neonate that was not cleaned was likely stillborn or abandoned (Fig. 30).
- Is there a blood clot at the end of the navel cavity? A blood clot at the end of the naval cavity indicates that the fawn was bleeding into the umbilical cord when the cord separated from the placenta (live birth), whereas the lack of a clot may suggest a still birth or abortion (Winter and Clarkson 2012). Additionally, an umbilical cord that is shriveled further indicates that death likely occurred after birth (Winter and Clarkson 2012).

When conducting necropsies on neonates, keep in mind that they may have died before walking, feeding, or being licked clean if predators attack and kill them or the does during parturition.

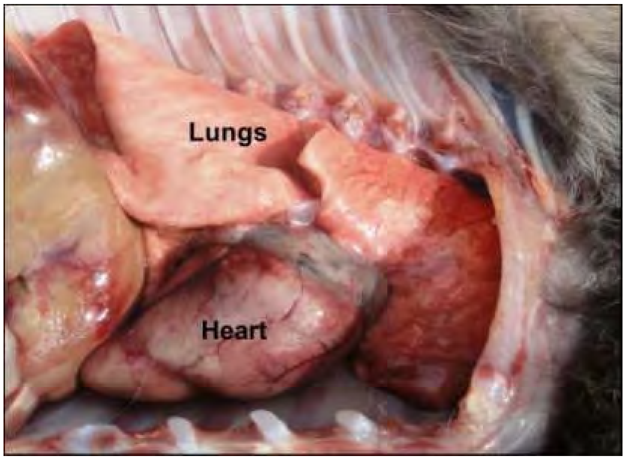

Figure 27. Neonates that have breathed will have spongy, light-pink lungs.

Figure 30. Near full-term mule deer fetuses from a doe that died of malnutrition. Stillborn neonates will look similar in that they will not be licked clean.

IDENTIFYING THE PREDATOR

Colorado currently has 4 predatory mammals that commonly prey on mule deer including cougars, bobcats, coyotes and black bears. Domestic dogs (*Canis familiaris*) will also occasionally kill mule deer and golden eagles (*Aquila chrysaetos*) will kill neonates during late spring and early summer. Each predatory species exhibits a characteristic behavior in the way that they chase, kill and feed on mule deer. Predation pressure on mule deer varies seasonally and certain predators exhibit more seasonal predation behavior than others. Furthermore, each species has a preferred habitat type for killing prey. When predation is the cause of death, the identity of the predator can usually be determined from characteristic signs (e.g., tracks, scat, hair, predation and feeding behavior) found at and around the kill site. The following section describes the killing and feeding behavior and common predator sign of species that prey on mule deer in Colorado. Other predators such as wolves (*Canis lupus*) and grizzly bears (*Ursus arctos*) also prey on mule deer, but these species do not (grizzlies) or rarely (wolves) exist in Colorado. Similarly, Canada lynx (*Lynx canadensis*) and red foxes (*Vulpes vulpes*) in Colorado may also prey on mule deer, particularly on fawns, but lynx rarely, if ever, occupy deer winter range at lower elevations. We never documented red fox predation, but characteristics will closely resemble coyote predation. Predation behaviors addressed here represent traits common to the 4 Colorado mammal species, domestic dogs and avian species. Scat, tracks, and other predator sign are briefly discussed below to assist field necropsy investigations, but we recommend other track and sign books for more detail (Murie 1974, Halfpenny and Biesiot 1986, Elbroch 2003). Extreme cases in track and scat size and canine spacing may be encountered that occur outside the ranges described below, but our descriptions should fit most of the referenced carnivores encountered within the western Continental US.

Cougars and Bobcats

Predation behavior

Cougars and bobcats kill deer in a very similar manner, though the size of their prey may differ. Due to their large size, stealth, and speed, cougars are able to kill mature deer, but they also prey on a variety of large and small animals, including fawns (McKinney 2003, McDougall 2004). In contrast, because of their smaller size, bobcats commonly prey on small mammals. However, they will take young deer (fawns, yearlings) and weakened adults on occasion. Cougars and bobcats usually kill their own food, but they will also occasionally scavenge (McDougall 2004); some caution should therefore be exercised when investigating suspected felid kills. Both species are primarily nocturnal and hunt from cover by either stalking and surprising, or waiting and surprising their prey (Elbroch 2003a, McKinney 2003). Because cougars are large and stealthy hunters and tend to be lay-in-wait predators, they typically exhibit a short chase with minimal signs of a struggle. On the other hand, due to their smaller size, chase scenes and signs of struggle may be more extensive at bobcat kill sites.

Cougars and bobcats most commonly kill mid- to large-sized deer with a single bite to the throat (suffocation by crushing the trachea, Fig. 31 on pg. 26). Cougars will also sometimes kill ungulates by biting the top of the skull (occasionally crushing it) or back of the neck (damaging or severing the spinal cord, Figs. 32 and 33). Because they are smaller, bobcats can typically only cause damage to the vertebrae or break the neck of fawns; we rarely documented spinal cord damage caused by bobcats. Breaks in the neck caused by either felid species are generally neatly severed. In some cases, both felid species will also bite the side of the face or muzzle. With both cougar and bobcat kills, canine punctures and hemorrhaging are often found in and around the trachea, top of the neck or skull, and/or sides or base of the skull, though hemorrhaging is typically more extensive with bobcat kills (Figs.31–39 on pg. 26,18-20). Claw marks are also frequently found on the back, neck, face, flanks or shoulders of deer where these predators grasp their prey before administering a killing bite, but claw marks may be found on any part of the body (Figs. 35 and 40 on pg. 19 and 26). Claw marks from felid attacks are very thin, even razor-like, and scratches to the hide can be difficult to detect without close examination. Unlike canids, felids will only bite their prey multiple times if they need to secure their grip; single bites are most common. Cougar's upper canines measure ~$1\frac{1}{2}$–2 in (3.8-5.1 cm) apart, and lower canines measure ~$1\frac{1}{4}$–$1\frac{5}{8}$ in (3.2–4.1 cm) apart (C. Anderson, unpublished data). Upper bobcat canines measure ~$\frac{5}{8}$–$1\frac{1}{8}$ in (1.6–2.9 cm) apart, and lower canines are ~$\frac{1}{2}$–1 in (1.3–2.5 cm) apart (Elbroch 2003a). Additionally, cougar canine punctures measure ~$\frac{1}{2}$ in (1.3 cm) in diameter (Halbritter et al. 2008), whereas bobcat canine punctures measure ~$\frac{1}{8}$ in (0.3 cm) in diameter. Although both cougars and bobcats exhibit relatively focal and efficient predation behavior, in general, bobcats typically cause more overall trauma to deer due to their smaller size which requires them to expend more energy when taking down large prey (Figs. 8 and 41 on pg. 5 and 27).

Figure 32. Crushed mule deer skull from cougar predation pre (top) and post (bottom) skinning. Canine puncture distance (arrows) measured 1.5 in (3.7 cm; bottom).

Figure 33. Canine puncture in cervical vertebrate (arrow) of a mule deer from cougar predation.

Figure 34. Canine punctures and hemorrhaging along dorsal cranium of a cougar-killed mule deer

Figure 35. Localized hemorrhaging around the trachea (top, bottom) and ribcage (top) of a mule deer (top) from cougar predation. Throat damage resulted from a bite wound(s) and rib damage resulted from claw marks.

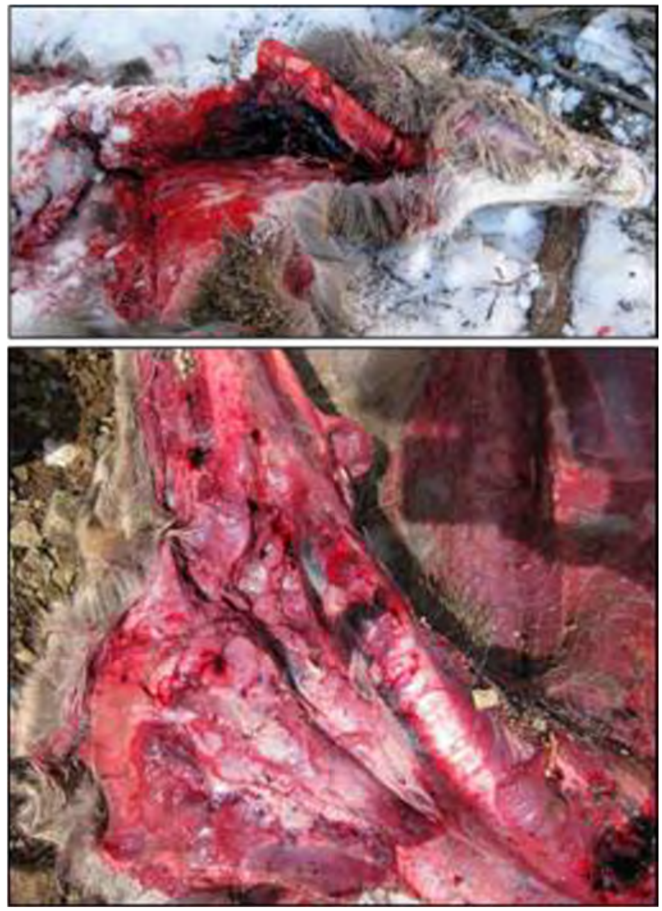

Figure 36. Extensive hemorrhaging in neck around trachea (top) versus minimal hemorrhaging on and around trachea (bottom) as the result of bobcat predation of 2 mule deer. In cases of bobcat predation, trauma severity will vary with deer condition and size.

Figure 37. Extensive hemorrhaging on the mandible of a mule deer as a result of bobcat predation. Extensive trauma also associated with multiple bite wounds at the base of the skull.

Figure 38. Hemorrhaging on neck and trachea with cranial canine punctures measuring 5/8 in (1.5 cm) apart resulting from bobcat predation.

Figure 39, Hemorrhaging in neck tissue as a result of bobcat predation on mule deer.

Feeding behavior

Cougars and bobcats also feed on deer in a similar manner. Both species usually drag deer to secluded places with cover, such as under a low-hanging tree or rock, to feed, but cougars will sometimes carry their prey (Figure of drag trail in Cougar Network, Puma Identification Guide, http://www.cougarnet.org/facts/). Cougar drag trails from kill sites to the initial feeding sites or drag trails between feeding sites can be >1,000 ft. (300 m) and sometimes over rough or vertical terrain (Elbroch 2003a). Blood, deer hair, and felid tracks are often found along or in drag trails.

Cougars typically consume an adult deer within 3–4 days following a predation event (Anderson and Lindzey 2003). However, neonates killed by cougars or bobcats may be completely consumed in one feeding. The feeding entrance typically occurs on the upper portion of the abdomen, behind the ribs, where felids clip or pluck hair from the skin, leaving "bald" openings near the point of entrance (Fig. 42 on pg. 27). Feeding progression usually begins through this opening where internal organs, especially the heart and lungs, are often consumed first before moving on to muscle tissue (Figs. 43 and 44 on pg. 28 and 29). However, bobcats will occasionally feed on the neck, shoulders, or hindquarters before consuming internal organs (Figs. 45 and 46 on pg. 20 and 30). Both felid species typically do not consume the rumen or intestines, which they remove from the carcass (Fig. 47 on pg. 30). After consuming internal organs, ribs are then usually neatly sheared away and eaten, followed by the hind leg tissue (Fig. 48). Cougars and bobcats typically chew off pieces of flesh and leave clean-cut edges where they feed (Figs. 44 and 49). Additionally, cougars are able to break large leg bones of mature deer whereas bobcats generally cannot break these bones; therefore, bobcats sometimes sever and separate leg bones from the carcass at the joints (Fig. 50 on pg. 31; Elbroch 2003a). Furthermore, cougars and bobcats generally do not widely scatter carcass remains across the kill site. Remains may become scattered as scavengers arrive once felids leave the carcasses.

Figure 45. Neck muscle of a mule deer eaten by a bobcat prior to consuming internal organs, which were still present.

Figure 48. Mule deer vital organs, excluding the stomach and intestines, and most ribs and flesh around ribs consumed by a cougar.

Figure 49. Anterior view of a mule deer ribcage neatly chewed off by a cougar and all internal organs consumed or removed.

After feeding on a carcass, cougars and bobcats commonly cache the remains under soil, litter, shrub branches, trees, “plucked” hair and/or snow (Figs. 51 and 52 on pg. 32 and 33). They also sometimes cache the carcass in different locations after each feeding. Bobcat cache sites may be distinguished from cougar cache sites by measuring the length of scratches in the ground litter or snow. Because bobcats are smaller than cougars, they usually only reach out ~0.3 m to cover their prey whereas cougars will reach out ~1 m (Acorne and Dorrance 1980, Wade and Bowns 1982). Length of scratches varies among individuals however; scratches may not be evident in the substrate.

Cougar and bobcat sign

Front tracks of cougars are typically 3–4 in (7.6–10.2 cm) wide and relatively round in appearance (Fig. 53a on pg. 34). Rear tracks may be slightly longer than wide when compared to the round appearance of the front track (Fig. 53a). Consistent with all carnivores, rear tracks are typically ~10% smaller than fore-tracks (except for black bears, see below; McDougall 2004) and track sizes from adult females usually occur in the lower portion of the range whereas adult male track sizes typically occur in the higher portion of the range. Tracks are asymmetrical and the planter pads exhibit 2 lobes in the front and 3 lobes in the rear. Because felids have retractable claws, toe nail marks rarely register in the substrate (Fig. 54 on pg. 35), unless they are walking on slick surfaces such as ice, mud, or crusted snow.

As with all felids, bobcat tracks exhibit the same characteristics as cougar tracks with the exception that they are smaller in size with smaller feet (Figs. 53b, 55, and 56 on pg. 34, 36 and below). Fore-tracks of bobcats typically measure 1½–2⅝ inches wide and are otherwise identical to cougar tracks.

Figure 56. Bobcat tracks versus cougar tracks. Photo taken by Benjamin Maletzke (Washington Department of Fish and Wildlife) in Washington.

Cougar and bobcat scats are usually segmented, tubular ropes with blunt ends or one tapered end, but ropes may be one great length and both ends are occasionally tapered (Figs. 57 and 58 on pg. 22 and 37; Elbroch 2003b, McDougall 2004). Scats from both species often contain bone chips with animal hair (especially deer hair in the case of cougar scats) wrapped around the outer surface in a spiral fashion (McDougall 2004). However, like all carnivores, scat appearance varies depending on what the predator last consumed. For example, cougars typically eat internal organs first, and scats from this feeding are usually gray with some hair (McKinney 2003). Intermediate feedings produce scats consisting of bone chips and more hair whereas scats from a final feeding usually consist almost entirely of deer hair (McKinney 2003). Scats of mature cougars typically measure 1–1½ in (2.5–3.8 cm) in diameter, whereas scats of mature bobcats usually measure ½–1 in (1.3–2.5 cm) in diameter (McDougall 2004). Also, hair scats are about twice as large in diameter and persist longer than meat scats.

Figure 57. Example of cougar scat.

Male cougars and bobcats will often make territorial scrapes, also called scratches, which are mounds of soil, grass, leaves, or snow (Fig. 59 on pg. 38). Cougar scrapes are usually 6–8 in (15–20 cm) high (Wade and Bowns 1982), 20–36 in (51–91 cm) long (Elbroch 2003b) and about 10–12 in (25–30 cm) wide. Due to their smaller size, bobcat scrapes usually only measure 12–18 in (31–46cm) long (Elbroch 2003b). Cougars and bobcats will also occasionally make deep scratches in trees (scratching post), often in soft pines and ~24 in (61 cm) above the ground (measurement for bobcats only), near kill sites to mark their territory (McDougall 2004).

Coyotes

Predation behavior

Coyotes are generalist foragers, eating a variety of food including small mammals, snakes, lizards, plants, fruits, nuts and deer (McDougall 2004). They hunt their own prey and opportunistically scavenge dead animals or those killed by other predators. Coyotes usually begin hunting at dusk, though they will occasionally hunt during the day. Deer are typically hunted by coyote packs (2 or more coyotes) in order to improve the task of taking down a large prey species (McDougall 2004).

Coyotes tear at deer as they chase them, repeatedly biting the head, neck, throat, shoulders, flanks, and/or hindquarters to secure their hold as they take them down. Sometimes coyotes will shred the ears of fawns during the chase. Repeated bites result in multiple canine punctures and severe tissue damage and hemorrhaging (Figs. 60–64 on pg. 38, 39, 45). In most cases, coyotes ultimately kill deer by suffocating them with a bite to the throat just behind the jaw and below the ear (Fig. 65); however, wounded deer may also die from significant blood loss and shock. When coyotes hunt in packs (typically 2–3 coyotes), 1 coyote will attack the head and throat while 1 or 2 others simultaneously attack the hindquarters and flanks. The upper canines of western coyotes measure ~1–1⅜ in (2.5–3.5cm) apart and the lower canines are ~⅞–1¼ in (2.2–3.2 cm) apart (reference chart for multiple studies in Bergman et al. 2010), but distances between punctures are often difficult to measure because coyotes usually bite their prey multiple times. Canine punctures measure ~⅛ in (0.3 cm) in diameter (Halbritter et al. 2008).

Figure 65. Severed trachea with hemorrhaging at base of neck from coyote predation.

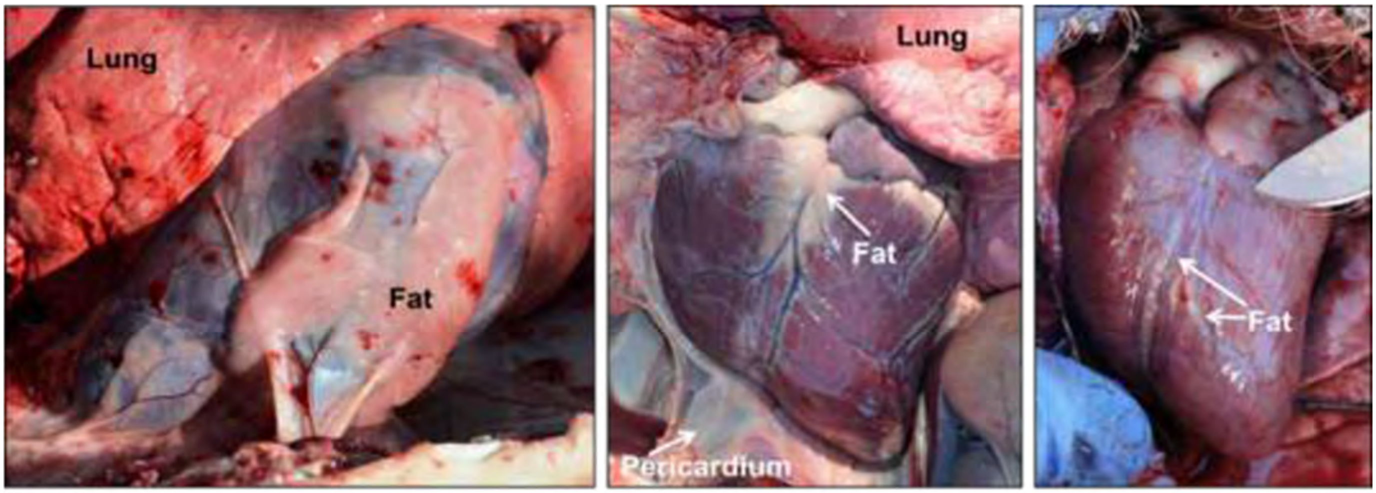

Figure 22. Adult mule deer pericardium (heart membrane) fat (left) and fat deposits on the heart of an adult female (middle), versus a heart from a newborn fawn (right) with minimal fat. Noting the presence of fat deposits on both the pericardium and heart are useful for assessing body condition. Young fawns and malnourished adults/yearlings exhibit low fat reserves.

Figure 23. Adult mule deer with an abundance of kidney fat (left) indicating the animal was in good body condition versus minimal kidney fat of a newborn fawn (right).

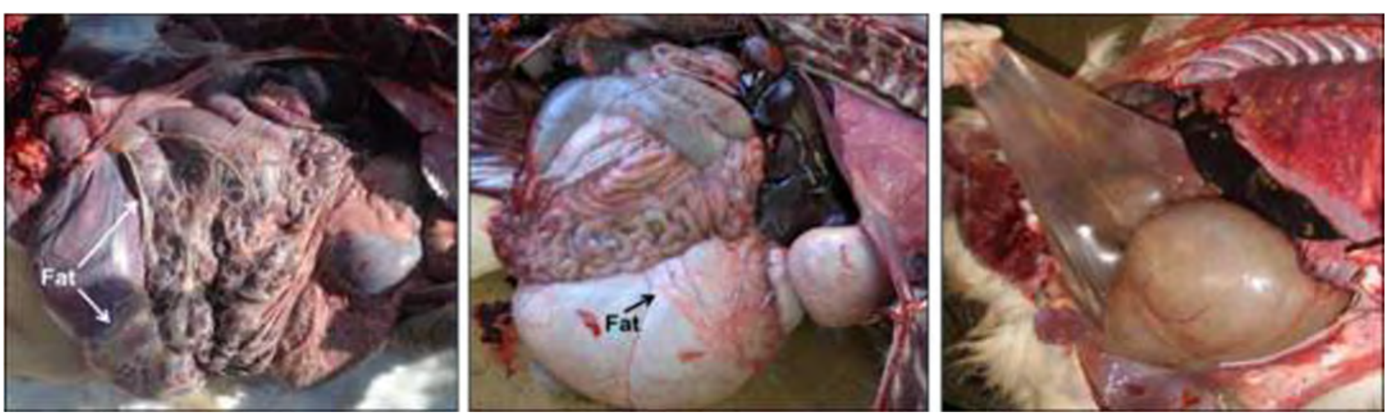

Figure 24. Moderate (left), minimal (middle), and no (right) mesentery fat around organs in mule deer. Deer in good body condition will have moderate–high levels of mesentery fat.

Figure 25. Bone marrow from a femur can be ranked on a scale of 1–4, to give insight into the body condition at time of death. A rank of 1 (white, hard and waxy) indicates the deer was in healthy condition at time of death whereas a rank of 4 (deep red in color and gelatinous) indicates the deer was in poor body condition at time of death. Note that severely emaciated animals with chronic malnutrition can exhibit marrow that is gelatinous and nearly colorless (bottom photo), suggesting consistency is more diagnostic than color.

Figure 28. Stillborn neonates will exhibit soft, semi-gelatinous sulfur pads on the bottom of the hooves (left), which will wear away and the hooves will harden within 24 hours as live neonates become active (right).

Figure 29. Lack of milk in the stomach of a newborn fawn that died of malnutrition (left) vs. clotted milk found in the rumen of a young fawn.

Figure 31. A cougar suffocating a mule deer with a bite to the throat (left; photo by F. Lindzey, Wyoming Cooperative Fish and Wildlife Research Unit), and cougar canine punctures in the trachea (arrows) exhibiting exterior (top right) and interior (bottom right) hemorrhaging.

Figure 40. Exterior (left) and interior (middle and right) claw marks from cougar (left and middle) and bobcat (right) attacked mule deer. The underside of the hides reveal bruising/hemorrhaging around claw marks indicating damage occurred antemortem.

Figure 41. Evidence of extensive trauma along the spine (bruising evident in hide once skinned) resulting from bobcat predation.

Figure 42. Bald areas illustrate clipped/ plucked hair from cougar (left) and bobcat (right) feeding behavior. Felids will typically clip or pluck hair from the carcass at the point of entry where they access the internal organs.

Figure 43. Examples of point of entry on mule deer following 4 cougar predation events to access internal organs. Organs completely consumed (top left), all consumed except for rumen which was still in chest cavity (top right), or not yet consumed or removed (bottom left and right).

Figure 44. Three examples of point of entry on mule deer fed on by bobcats to access internal organs. Point of entry behind or through ribs where organs were likely consumed first (top left), front left side of ribcage opening revealing internal organs which were partly consumed (top right), and 2 points of entry (circled) on a minimally cached carcass (bottom). Bobcats, similar to cougars, leave clean-cut edges at the feeding entrance.

Figure 46. Mule deer carcass remains from bobcat predation pre (left) and post (right) skinning. Note that hindquarters were partially consumed before the internal organs. Hemorrhaging was localized to the mandible and base of skull (Figure 37). Carcass was cached twice.

Figure 47. Stomach of a mule deer found neatly set aside ~10 m from carcass at cougar predation site (left) and intestines within body cavity of a mule deer which was killed by a bobcat (right). In the case of cougar predation, the entire stomach was set aside rather than just the rumen.

Figure 50. Two views of mule deer remains illustrating disarticulated forelimbs at joints following bobcat predation/feeding.

Figure 51. Examples of mule deer carcasses cached by cougars.

Figure 52. Examples of bobcat cache sites ranging from the carcasses being minimally to extensively covered. Note bobcat scratches in the snow (top left) and soil (bottom right).

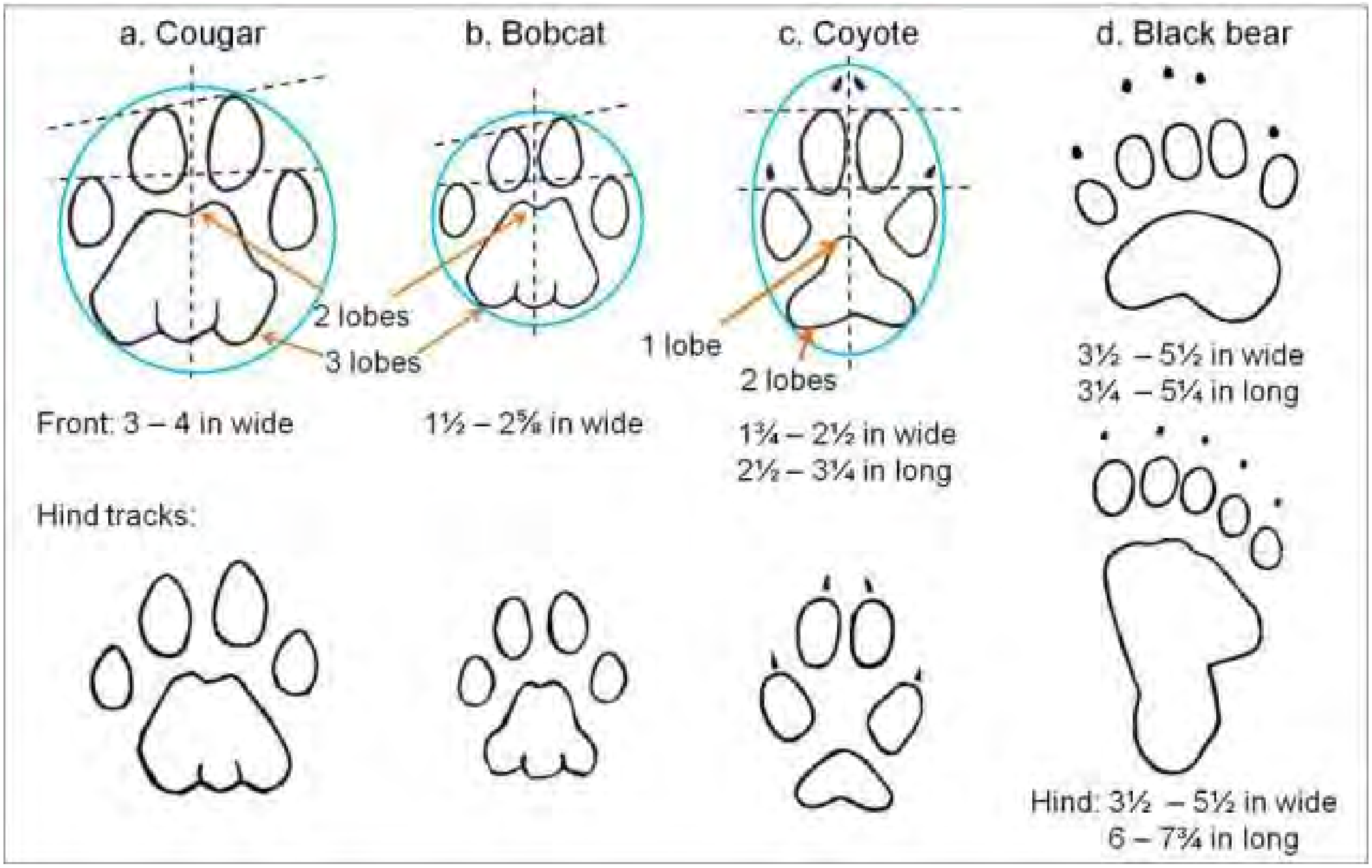

Figure 53. Front (top row) and hind (bottom row) track illustrations for 4 common predators of mule deer in Colorado. Note differences between felid (a and b) and canid (c) tracks including round versus oval shape, lack of claw marks versus claw marks, and bilateral asymmetry versus symmetry. Black bear (d) tracks are unique in comparison and should be easily distinguished from the other 3 carnivores.

Figure 54. Examples of cougar tracks. Front and hind tracks often overlap (top left and bottom). Top left photo of tracks in mud by Benjamin Maletzke (Washington Department of Fish and Wildlife).

Figure 55. Examples of bobcat tracks. Top right photo of tracks in mud by Benjamin Maletzke (Washington Department of Fish and Wildlife).

Figure 58. Examples of bobcat scat found at mule deer mortality sites.

Figure 59. Scratch made by a male cougar.

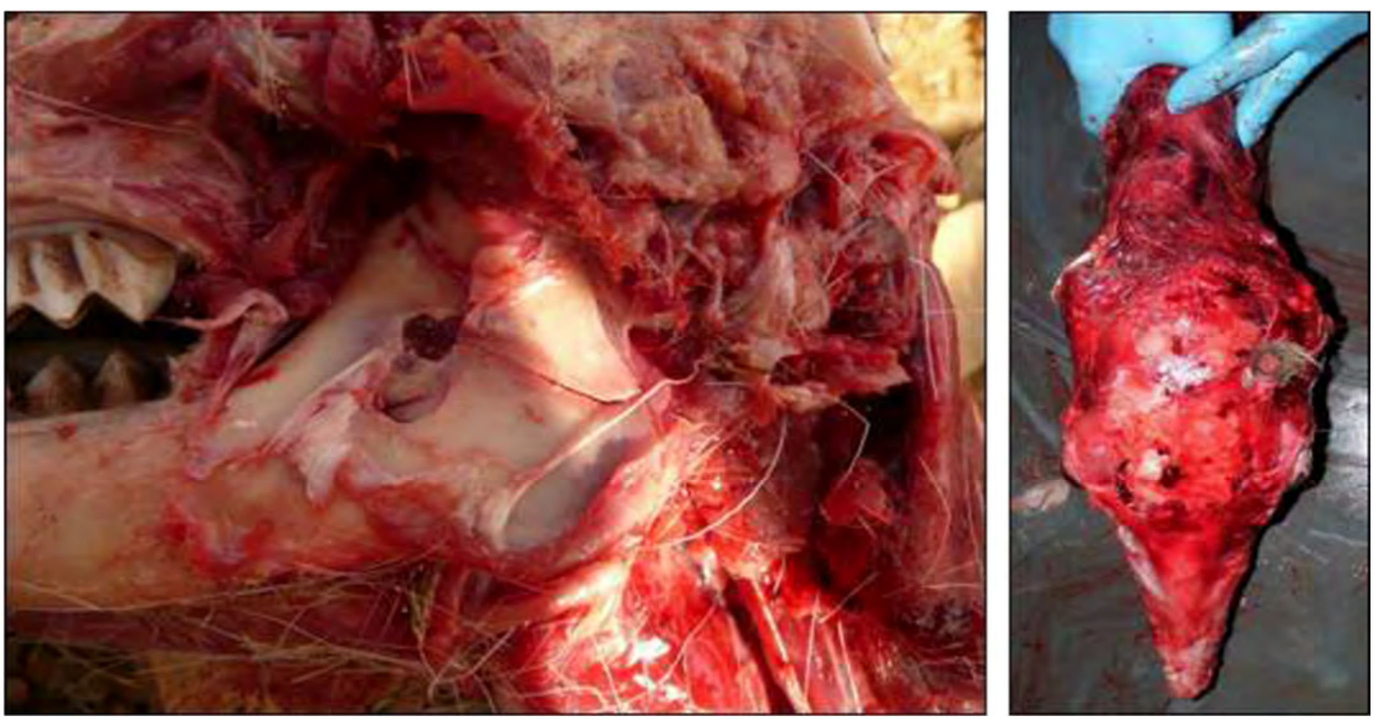

Figure 60. Two canine punctures from multiple bites and fractured mandible (left), and multiple punctures in dorsal and posterior surfaces of skull with hemorrhaging (right) caused by coyote predation of two mule deer.

Figure 61. Severe hemorrhaging in the neck and lower jaw and hide caused by multiple canine punctures from coyote predation.

Figure 62. Two patches of hide with hemorrhaging from the hindquarters of a coyote-killed mule deer.

Figure 63. Trauma to the throat and flank (left) and rump (right) of a mule deer resulting from coyote predation.

Coyotes will sometimes chase deer for considerable distances depending on the terrain. During times of heavy snowfall or crusted snow conditions, chase scenes may be shorter because coyotes can run on top of the snow while deer break through and have reduced mobility in deep snow. A deer may be taken down multiple times before it ultimately dies. Chase scenes, blood trails, and blood scattered across the ground and vegetation are commonly found at coyote kill sites (Fig. 66 on pg. 45).

Feeding behavior

Coyotes often begin feeding on the flesh of the hindquarters and continue forward on the carcass until only the rumen, clumps of hair, parts of the skeleton, head and hide remain (Figs. 67 and 68 below and on pg. 46). Occasionally parts of the intestines are also found at coyote predation sites, but unlike felids, coyotes commonly feed on the intestines (Cougar Network, Puma Identification Guide, http://www.cougarnet.org/facts, accessed 6 Feb 2015). When feeding on young animals, coyotes usually start with the abdomen and consume the stomach containing milk (Wade and Bowns 1982). The amount of carcass remains located at a site will depend on the size of the deer and how much time has passed since it was killed.

Figure 67. Example where nearly all flesh of a mule deer that was killed and fed on by coyotes was consumed before internal organs. Lungs were partially consumed.

Unlike felids, coyotes are very "messy" when eating deer carcasses. Patches of loose hair (as opposed to "shaved/plucked" hair) and carcass remains are often scattered widely across the kill site because individual coyotes drag and move pieces of the carcass several times as each looks for a place to feed in solitude (Fig. 69 on pg. 47; Elbroch 2003a). Often, the rumen is removed from the carcass and rumen contents are scattered across the kill site (Fig. 70). While feeding, coyotes will tear off patches of the hide and leave ragged edges on muscle tissue, tendons and bones. Coyotes will also heavily chew on the hide, ears, face, and bones, especially the ribs, legs, spinal column and pelvis (Figs. 71 and 72 on pg. 48 and 41). Chewed and splintered ribs are especially common on deer fed on by coyotes (Fig. 73 on pg. 48). Some coyotes will also chew off the muzzle (Fig. 74 on pg. 49). Unlike larger carnivores, coyotes generally do not break large bones in mature deer; they will, however, occasionally break the femurs in fawns and yearlings (Fig. 75 on pg. 49).

Figure 70. Rumen contents of a mule deer scattered at a coyote predation site.

Figure 72. Carcass remains of an adult mule deer doe at a coyote predation site. Coyotes heavily chewed the ribs, hide, side of the face, and muzzle.

Coyotes sometimes bury pieces of the carcass, mainly the skull, under snow or soil to hide remains from other coyotes or when food is scarce (Fig. 76; Acorn and Dorrance 1990, Elbroch 2003a). It is also worth noting that coyotes, and canids in general, often treat radio collars as "chew toys" and move them from feeding sites. It is not uncommon to find telemetry collars carried off and buried by coyotes. In cases where a carcass is not found upon conducting a mortality investigation, if the radio collar collected GPS locations, it may possible to find the kill site by examining the location data and identifying the kill site (location clustering and activity sensor indicating periodic inactivity). We have documented coyotes moving GPS collars >1 mile from initial mortality sites.

Coyote sign

After feeding, coyotes usually clean themselves by rolling on the ground and rubbing blood off their muzzle, chin, and throat (Wade and Bowns 1982, Acorn and Dorrance 1990, Elbroch 2003a). They may also urinate, defecate, and leave scratch marks and numerous tracks around the carcass.

Coyote tracks differ from felid tracks in that they are longer than wide, symmetrical, exhibit toe nail marks, and exhibit more spacing between the planter pads and toes. The planter pads exhibit a single fore-lobe with 2 lobes in the rear, and the outer toes exhibit more of the outward

Figure 76. Detached mule deer head buried by a coyote. Coyotes commonly carry off and bury the head and telemetry collars of scavenged and predated mule deer.

orientation versus the more forward orientation of felid toes (Fig. 53 on pg. 34). Coyote fore-tracks are typically 1¾– 2½ in (4.4–6.4 cm) wide and 2½–3¼ in (6.4– 8.3 cm) long (Figs. 53c, 77 on pg. 34 and 50). Larger tracks exhibiting the canid characteristics described above are likely from domestic dogs. Larger canid tracks could also be from wolves, but lone dispersers have only rarely been documented in Colorado to date without any pack activity being recorded.

Coyote scat appearance varies depending on diet, but often their scats are tubular and segmented (Fig. 78 on pg. 51; Elbroch 2003a, McDougall 2004). Scats consisting mostly of berries or vegetation tend to be tubular with minimal or no twisting and can have blunt or tapered ends (Elbroch 2003a). After eating meat and internal organs their scat may be semi-liquid or loose tubes of crumbly material with blunt ends (Elbroch 2003a). Scats consisting mainly of hair and bone tend to be twisted ropes with sharply tapered ends (Elbroch 2003a). Coyote scats typically measure ½–1¼ in (1.3–3.2 cm) in diameter.

Coyote scavenging

Coyotes frequently scavenge other predator kills and deer that died from other causes. Therefore, careful analysis of mortality sites is necessary to determine the initial cause of death. Because coyotes widely scatter carcass remains, it can be difficult to find sufficient evidence to determine if coyotes killed or scavenged the deer. Sometimes the only remains are blood, hair and bits of flesh and bone, especially with young fawns. In cases where there is not much of the carcass remaining, look carefully for torn patches of hide and scattered clumps of hair, keeping in mind that the wind may have blown hair away. Also, look carefully for splattered blood on vegetation and the ground because this might be the only indication that predation occurred.

Domestic dogs

Domestic dogs occasionally chase and kill deer, sometimes in rural areas where dogs are often free-roaming and guarding livestock. Dogs usually do not kill for food, but rather they mutilate or kill deer instinctively (Elbroch 2003a). Dogs will chase and run next to a deer, biting any part they can reach.

Deer killed by dogs are characterized by:

- Mutilated carcass with bites to the head, neck, flank, ribs, shoulders, and hindquarters.
- Carcass with hemorrhaging indicating predation, but the carcass may not be consumed to a great extent.
- Wounds with greater tearing and shearing of the muscle versus the crushing wounds of wild predators.
- Dog tracks.
- Dog scat.

Because dogs and coyotes attack deer in a similar manner, finding direct evidence is necessary to distinguish between the two types of predators. Coyotes kill deer far more often than dogs kill deer, but be careful not to overlook dog predation.

Black bears

Predation behavior

Black bears are omnivores that will opportunistically feed on a variety of food sources, including plants, berries, acorns, insects, carrion, and young or impaired ungulates. They rarely prey on adult deer, except when they are vulnerable during parturition or when they are in a weakened state, but will prey on newborn ungulates within the first few weeks following birth.

Black bears attack with great force, often causing massive hemorrhaging and bruising under the hide where they grasp and bite. When attacking adult deer, black bears will typically grasp them sometimes leaving claw marks, and inflict bite wounds dorsally anywhere along the spine between the neck and lumbar region. Occasionally, they will inflict bite wounds to the face or skull to kill their prey prior to feeding (Fig. 79). When attacking young fawns, black bears will bite any surface of the body where they can grip the animal (Elbroch 2003a). Claw marks with associated hemorrhaging are sometimes found on the shoulders or anterior portion of adult deer (Fig. 80), measuring ~½ in (1.3 cm) between individual marks (Halbritter et al. 2008) and appear as ~⅛ in (0.3 cm) wide scrape marks. However, bear claws, which are dull and non-retractable, do not pierce or cleanly cut the hide like the sharp, retractable claws of felids. Additionally, claw marks and overall trauma from bear predation may be less evident with young fawns given the ease at which they can be caught and dispatched. Upper canines of adult black bears are ~1¾–2½ in (4.4–6.4 cm) apart, and lower canines measure ~1⅛–2¼ in (2.9–5.7 cm) apart (Elbroch 2003a). Canine punctures measure ~½ in (1.3 cm) in diameter (Halbritter et al. 2008).

Black bears generally do not pursue their prey for great distances (McDougall 2004); thus, sign of a chase may be minimal or lacking. At bear predation sites of larger prey there is frequently sign that an intense struggle took place. Large areas of flattened vegetation and beds where the carcass was consumed with nearby scat often indicate that a bear was present at the site. Bear hair on antlers, broken bones, trees, and shrubs are also commonly found at these sites. Blood splattered on vegetation may also be evident.

Figure 79. Black bear canine punctures (arrows) on top of mule deer skull.

Figure 80. Claw mark and hemorrhaging on black bear hide.

Feeding behavior

Black bears sometimes begin feeding on neonates before they are dead (Elbroch 2003a) and they usually drag larger carcasses to cover to feed in seclusion (Fig. 81, on pg. 52 left photo; Elbroch 2003a, Halbritter et al. 2008). Deer hair and blood on vegetation or the ground can sometimes be found along drag trails.

All deer carcasses we encountered from bear predation were largely consumed (Fig. 82 on pg. 52), especially neonate carcasses; thus we were unable to identify which parts of the deer bears typically consume first. However, Wade and Bowns (1982) noted that many black bears tended to feed on the shoulders and neck of livestock before secondarily feeding on the viscera with a point of entry usually through the shoulders or hindquarter. Black bears have also been documented feeding on the udders of lactating ungulates (Elbroch 2003a), and grizzlies commonly consume the udder and brisket of domestic livestock (Anderson et al. 2002; also see Fig. 81, right photo). Black bears are very "messy" feeders. When feeding on ungulates, it is characteristic for black bears to skin out and invert ("banana peel") the hide from the hindquarters to the neck, occasionally leaving the hide draped over the skull (Fig. 83a on pg. 53). They will also invert the leg hide toward the hooves, sometimes leaving strips of tendons (Fig. 84 on pg. 54). Similar to coyote predation sites, rumen contents can usually be found scattered around the carcass remains, but this scattering tends to be more localized at bear predation sites (Fig. 83b on pg. 53). It is also common to find parts of the skull, jaws, and vertebrae within a small area at the feeding sites. Black bears will frequently crush the skull and eat the muzzle of their prey (Figs. 83d, 85, and 86 on pg. 53, here and 55). They also sometimes break large leg bones in mature deer while feeding, though this is more commonly seen with yearlings and fawns. Often, leg bones of neonates are broken or crushed with the hide pealed down over the hooves (Fig. 87). Although black bears usually completely consume neonates in one feeding, they frequently leave skull and jaw fragments and parts of legs at these sites (Fig. 88) similar to cougars.

Figure 85. Skull of a yearling mule deer found at a black bear predation site. The eye orbits were crushed and the rostrum consumed, which is typical feeding behavior for black bears.

Figure 87. Leg of a newborn mule deer fawn with the hide inverted down the leg as a result of black bear predation and feeding behavior; feeding behavior appears similar for all age classes of prey.

Black bears do not widely scatter carcass remains, but they may scavenge on remains that were already scattered by other predators (Fig. 89). They also occasionally cover the remains to consume later (Fig. 81 on pg. 52, right photo).

Figure 88. Remains of a newborn mule deer fawn at a black bear predation site. Bone fragments and parts of all four legs, which were broken at each radius and tibia, remained. The head and neck with the hide peeled back was also found at this site (not pictured).

Black bear sign

Black bear tracks are generally larger and unique in appearance from the other predator tracks described above. The fore-track is slightly wider than long excluding claw marks, typically measuring 3½–5½ in (8.9–14 cm) wide and 3¼–5¼ in (8.3–13.3 cm) long. Rear tracks are loosely comparable to human tracks exhibiting an indentation along the arch of the hind foot, and are much longer than wide, typically measuring 3¼–5¼ in (8.3–13.3 cm) wide and 6–7¾ in (15.2–19.7 cm) long (Figs. 53d and 90 on pg. 34 and 55).

Figure 89. Mule deer scavenged by a black bear and birds (cause of death undetermined). Note that the carcass is not widely scattered, which is typical at black bear predation and scavenging sites.

Black bears will frequently defecate near the carcass after or while feeding. Their scat appearance varies greatly depending on their diet, which varies seasonally (Fig. 91 on pg. 56). In general, black bear scat tends to be brown to black in color, massive in size, and is often left in copious amounts (McDougall 2004). When eating a diet consisting mainly of vegetation and insects, their scat tends to be fibrous, cylindrical, smooth, and unsegmented with blunt ends (McDougall 2004). When black bears primarily eat berries, their scat tends to be shapeless and loose, or tubular with blunt ends and filled with seeds. After eating meat and internal organs their scat is generally shapeless or in loose patties with fur, bones, and stringy roots often linked in segments (Elbroch 2003b). Segments of bear scat usually measure 2–8 in (5.1–20.3 cm) long with a diameter of 1–2½ in (2.5–6.4 cm; Elbroch 2003b, McDougall 2004).

Figure 64. Hemorrhaging of tissues surrounding the elbow (left) and hide and in tibio-crural joint (right) from coyote predation of 2 mule deer.

Figure 66. Blood pooling (top 2 left), splatter (bottom left) and trail (right) resulting from a coyote predation event.

Figure 68. Remains of a mule deer fawn found at a coyote predation site. A piece of the hide was found near the majority of the remains (bottom right). Patches of hide and other remains are typically scattered around coyote predation sites (Figure 69).

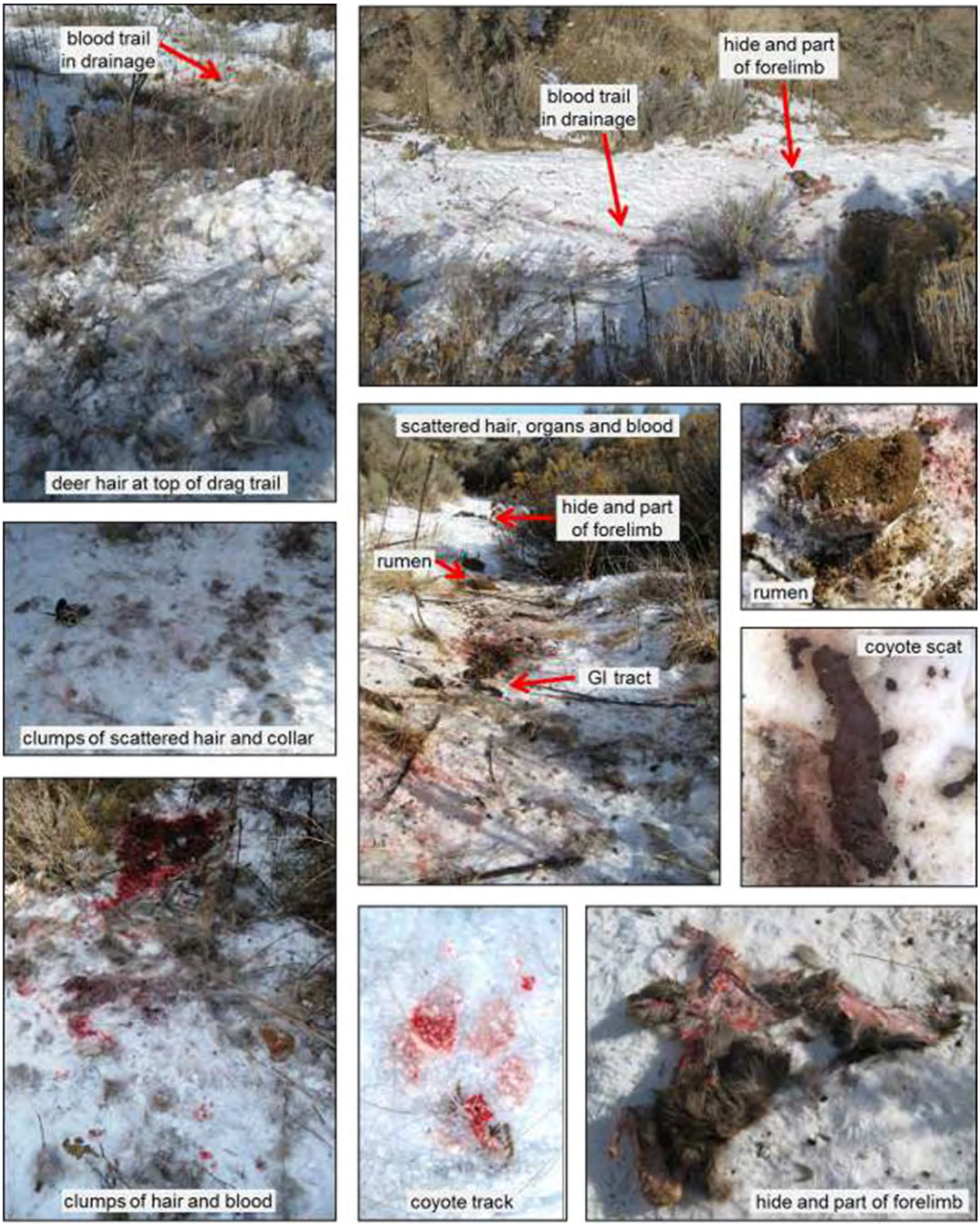

Figure 69. Example of how mule deer carcass remains and coyote sign are commonly scattered across coyote predation sites.

Figure 71. Mule deer carcass remains (left) with close-up photo of the head (right) at a coyote predation site illustrating characteristic feeding behavior. The ears and hide on the head were heavily chewed on and the hide was partially stripped off the face.

Figure 73. Mule deer ribs that were chewed on by coyotes at two separate coyote predation sites. Note ragged appearance of chewed ribs, which differ from felids where clean edges are more common.

Figure 74. Examples of mule deer carcasses where the muzzle was eaten by coyotes.   Also note that the hide is torn off parts of the face in each example.

Figure 75. Mule deer fawn remains at a coyote predation site. Note that one of the femurs is broken as a result of coyotes chewing on the carcass. Coyotes are generally unable to break the femurs of mature adults, but they do occasionally break the femurs of fawns and yearlings.

Figure 77. Examples of coyote tracks in mud and snow.

Figure 78. Examples of coyote scat.

Figure 81. Mule deer carcass that was killed and fed on by a black bear. Black bears will often drag larger prey to cover to feed in seclusion (left). Note feeding entrances at brisket, abdomen, and hind quarter, and evidence of prior caching from scattered vegetation within feeding entrances (right).

Figure 82. Remains of a mule deer doe at a black bear predation site.

Figure 83. Ewe bighorn sheep remains and predator signs at a black bear predation site including(a) inverted, "banana peeled" hide, (b) flattened vegetation and scattered rumen contents, (c) bear scat, and (d) tip of rostrum consumed. Photos by Heather Halbritter (Colorado Parks and Wildlife).

Figure 84. Characteristic peeling (hide inversion) of mule deer leg hide found at black bear predation sites for an adult doe (top left) and yearling doe (bottom left). Black bears will also occasionally leave strips of tendons or hide on the legs (right).

Figure 86. Skull fragments from a mule deer found at a black bear predation site after attempting to piece the skull back together (left and top right).

Figure 90. Black bear front track (left) and hind foot (right). Front track photo by Benjamin Maletzke (Washington Department of Fish and Wildlife).

Figure 91. Examples of black bear scat. Middle left picture taken by Heather Halbritter (Colorado Parks and Wildlife).

Bear scavenging

Black bears commonly scavenge carrion, so it is important to closely investigate all predator sign at mortality sites with bear sign. The age of the carcass and bear scat, pre-mortem body condition of the deer, and all predator and scavenging sign should be considered before making a conclusion.

When scavenging, black bears will exhibit typical feeding behavior (i.e. "banana peeled" hide, crushed skull, muzzle consumed). Identify hemorrhaging and canine punctures in areas of the carcass where black bears normally attack. If there is not enough of the carcass remaining, look carefully for blood splatter and signs of a struggle. Also note if there is a lack of other predatory species sign at the mortality site. For example, if the carcass is not widely scattered and bones such as ribs are not chewed on, coyote predation and scavenging can be ruled out.

Golden Eagles

Predation behavior

Although golden eagles (*Aquila chrysaetos*) commonly scavenge ungulate carcasses, they will occasionally attack and kill young fawns (Boyer 1948, Riney 1951), young livestock (Wade and Bowns 1982, Acorn and Dorrance 1990), and in rare cases, older fawns, adult deer and pronghorn (Lehti 1947, Clawson 1948, reference in Riney 1951). When hunting ungulates, eagles will sometimes fly low over the herd several times before swooping down to attack their selected prey (Watson 1997). Some eagles use their talons to grip the neck or the back of a deer and hang on with their wings outstretch for balance until the animal collapses from exhaustion, shock, or internal injury (Watson 1997). In other instances, eagles have been reported repeatedly striking ungulates on the upper back and ribs with their talons, creating multiple puncture wounds (Lehti 1947, Clawson 1948, Deblinger and Alldredge 1996).

Eagles use their talons for closing around the backbone of their prey and puncturing large internal arteries, especially the aorta in front of the kidneys (Wade and Bowns 1982). Seized prey usually die from a combination of shock and internal hemorrhaging from punctured arteries or collapse of lungs when the ribcage is punctured (Wade and Bowns 1982). When killing domesticated lambs, eagles will grasp them anywhere on the head, neck or body, but they are usually grasped from the front or side (Wade and Bowns 1982). In Colorado, we confirmed eagle predation on 3 fawns that were <1 week old. In one case, talon punctures were in the head and penetrated the brain (Fig. 92 on pg. 59). In another case, an eagle was observed on the fresh carcass and a single talon puncture wound was found penetrating the right shoulder and into the anterior aspect of the chest. Talon punctures are generally much deeper than canine punctures and talon wounds to the head that penetrate the brain are fatal. The front 3 talons of eagles typically leave punctures 1–3 in (2.5–7.6 cm) apart, with the puncture from the hallux (i.e., the talon on the back of the foot) 4–6 in (10.2–15.2 cm) from the puncture made by the middle talon (Wade and Bowns 1982). Sometimes fewer than 4 talons will puncture the hide, particularly in young animals (Wade and Bowns 1982).

Feeding behavior

Deblinger and Alldredge (1996) reported that after bringing down pronghorns, eagles began feeding on the dorsal surface of their prey with a point of entry through the talon puncture wounds. In two instances, pronghorns appeared to be paralyzed from spinal injuries, but they remained alive for ≥10 minutes after the eagles began feeding (Deblinger and Alldredge 1996).

Investigations by Wade and Bowns (1982) on carcass remains from livestock killed by eagles revealed that eagles leave the skeleton relatively intact with the legs and skull attached to the hide. Ribs, legs, the backbone, and the skull in large carcasses heavily fed on by eagles will generally be intact with most flesh and viscera, excluding the rumen, consumed (Wade and Bowns 1982). However, in very young animals, the ribs often are neatly clipped off close to the vertebrae and eaten; the sternum is not usually consumed (Wade and Bowns 1982). They also found that eagles will often remove the hard palate (i.e., the thin and bony plate located in the roof of the mouth) and floor pan of the skull and eat the brain. Additionally, eagles will neatly shear off ears, tissues, and tendons, and turn the hide inside out as they feed (Wade and Bowns 1982). They will also sometimes pick the hide clean, erasing signs of hemorrhages, making it difficult to determine cause of death (Wade and Bowns 1982).

Golden eagle sign

Golden eagles will usually defecate on or around the carcass on which they are feeding. Look for white streaks at the feeding site. The solid form of golden eagle droppings are irregularly cylindrical, brown in color, and ~¾–1½ in (1.9–3.8 cm) wide by 1⅜–3¾ in (3.5–9.5 cm) long (Elbroch and Elbroch 2001).

Scavenging Birds

Magpies (*Pica hudsonia*), turkey vultures (*Cathartes aura*), bald eagles (*Haliaeetus leucocephalus*), golden eagles, ravens (*Corvus corax*), red-tailed hawks (*Buteo jamaicensis*) and other birds commonly scavenge deer. In rare cases, they may kill deer that are injured or entangled in fences. Typically, attacks and feeding begin at the eyes, nose, navel, rectal area, and open wounds (Wade and Bowns 1982, Acorn and Dorrance 1990). When birds scavenge large deer that died from disease or malnutrition that have not yet been visited by mammalian predators, carcass remains (ribs, legs, vertebrae and skull) will be relatively intact with flesh and viscera either completely or partially consumed (Figs. 93 and 94). Scavenging birds usually defecate on or around carcasses on which they are feeding, leaving characteristic white streaks and/or cylindrical pellets at mortality sites (Fig. 95). They also often kick up dirt on to carcasses while feeding and leave tracks and wing impressions in the snow (Fig. 96 on pg. 60). Scavenging birds will also sometimes carry parts of carcasses to cliff ledges to feed in seclusion. Newborn ungulate radio collars are sometimes found on or below cliff ledges with carcass remains (Fig. 97 on pg. 60).

Figure 93. Mule deer that died from capture myopathy and was scavenged by birds. Note plucked eyes and intact ribs with flesh and viscera consumed.

Figure 94. Mule deer fawn killed by coyotes and scavenged by ravens. Ravens left the carcass upon our arrival and thus had only partially consumed the flesh between the ribs.

Figure 95. Avian scat left at a deer carcass scavenged by birds. White streaks or clumps of uric acid (white portion of droppings) are commonly found on and next to carcasses scavenged by birds.

Figure 92. Talon punctures from a golden eagle in the back of the skull (top), which penetrated the brain (bottom left), and on the front of the face (bottom right) of a <1 week old mule deer fawn.

Figure 96. Blood, deer hair, avian tracks (left), and avian wing impressions in snow (right) from scavenging birds at a mule deer mortality site.

Figure 97. Radio collar and skull of neonate mule deer found on a cliff ledge (circled top left and right). Leg of neonate found directly below cliff (bottom). Cause of mortality was unconfirmed, but an avian scavenger or predator carried the remains to the cliff to feed in seclusion.

SUMMARY AND FIELD REFERENCE GUIDES

Table 1. Common sign of four predators of mule deer in Colorado.

	Cougar	Bobcat	Coyote	Black bear
Sign of chase	Often minimal	Minimal-extensive depending on size of bobcat and deer	Often extensive	Minimal or none
Common locations for canine punctures	• Throat & trachea • Top of neck • Top or base of skull	• Throat & trachea • Top of neck • Back, side, or base of skull	• Throat & trachea • Top of neck • Jaw • Skull	• Spine between neck & lumbar region • Face or top of skull (Canines do not always puncture hide- look for bruises from canines)
Multiple canine punctures	Uncommon	Uncommon	Very Common	Common
Claw marks	Fine, razor-like claw marks on the back, sides, shoulders, neck or face	Fine, razor-like claw marks on the back, sides, shoulders, neck or face	None	Scrape like claw marks on shoulders or anterior portion ~⅛ in (0.3 cm) wide.
Other associated trauma	• Broken neck or damaged vertebrae • Largely crushed skull (occasionally rostrum)	• Damaged vertebrae, occasionally broken neck	• Hemorrhaging on hindquarters, elbows, and/or flanks	• Massive bruising/ hemorrhaging on top of shoulders, back, ribs, and/or hindquarters • Largely crushed skull and/or muzzle
Cached carcass	Very common	Very common	Never (Head sometimes buried, which is distinctly different than a cache)	Occasionally
Drag trail	Very common	Very common	Common	Common
General order of consumption of adult deer	• Internal organs 1st • Muscle tissue 2nd	• Internal organs 1st • Muscle tissue 2nd	• Muscle tissue 1st • Internal organs 2nd	• Muscle tissue 1st • Internal organs 2nd
Feeding entry Point	• Upper abdomen or behind ribs to access organs	• Upper abdomen or behind ribs to access organs	• Anus or muscle tissue exposed during attack	• Brisket, udder or muscle tissue exposed during attack
Characteristic Feeding behavior	• "Plucked" hair around entry to access internal organs	• "Plucked" hair around entry to access internal organs	• Torn patches of hide and clumps of hair widely scattered	• Inverted hide ("banana pealed")
Tidiness when feeding	Clean-cut edges around feeding points	Clean-cut edges around feeding points	• Messy: ragged edges on bones/flesh • Rumen broken open/scattered	• Messy: chewed & fragmented bones • Rumen broken open/scattered
Able to break large leg bones of mature deer	Yes	Generally, no	Generally, no	Yes
Carcass widely scattered	No	No	Yes	No

Table 2. Approximate range of upper and lower canine spacing and canine and scat diameter [inches (in) and centimeters (cm-in parentheses)] for 4 predatory species of mule deer in Colorado. Measurements span from canine centers and are reported from personal experience and adapted from literature (Bergman et al. 2010, Halbritter et al. 2008, Elbroch 2003a).

	Cougar	Bobcat	Coyote	Black bear
Measurement	~in (cm)	~in (cm)	~in (cm)	~in (cm)
Upper canine spacing	1½–2 (3.8–5.1)	⅝–1⅛ (1.6–2.9)	1–1⅜ (2.5–3.5)	1¾ –2½ (4.4–6.4)
Lower canine spacing	1¼–1⅝ (3.2–4.1)	½–1 (1.3–2.5)	1–1¼ (2.5–3.2)	1⅛ –2¼ (2.9–5.7)
Canine diameter	½ (1.3)	⅛ (0.3)	⅛ (0.3)	½ (1.3)
Scat diameter	1–1½ (2.5–3.8)	½–1 (1.3–2.5)	½–1¼ (1.3–3.2)	1–2½ (2.5–6.4)

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APPENDIX I:

MORTALITY INVESTIGATION FIELD FORM

DEER MORTALITY FIELD FORM

MULE DEER ID: ________________

Recovery Date: ___________________ **Date Heard Dead:** __________________

Date Known Last Alive: _________________ **Estimated Days Dead**: _______________

Collector: _______________________________

Age Class: Adult / ≥6 Mo. Fawn / ≤6 Mo. Fawn **Sex:** Male / Female

Zone: ____ UTME: _____________________ UTMN: _____________________

Location Description:

Property Owner / Manager: Phone:

COLLAR INFORMATION

Signal when collar was located: Mortality Signal / Live Signal

Collar Location relative to carcass: On Carcass <10m / 10-50 m / >50 m / No Carcass

Describe any damage/chew marks/tears to the collar:

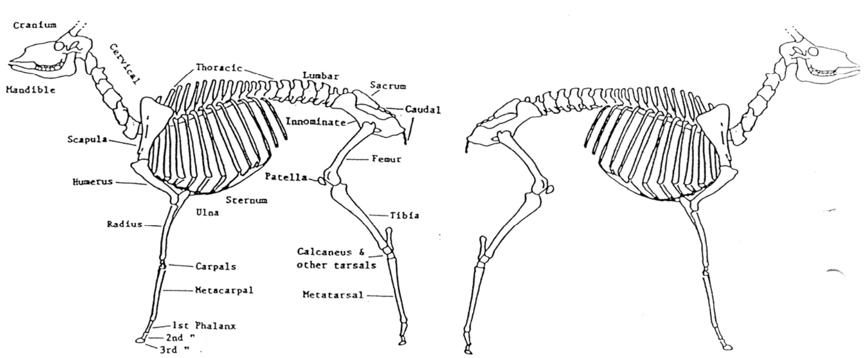
REUSE COLLAR: Yes / No (*explain*)

CARCASS DESCRIPTION

Were you able to locate the carcass or any portions of the carcass? Yes / No

If yes, was the carcass completely intact? Yes / No

If not intact, use the diagram below to indicate portions found / not found (*circle one*):



Was a necropsy conducted? Yes (attach necropsy results) / No

FEMUR MARROW FAT (break the femur or lower jaw and circle ranking below)

1. White, hard, and waxy
2. Pink to red in color and firm
3. Pink to red in color and soft
4. Deep red in color and gelatinous

CARCASS FIELD EXAMINATION

Describe the condition of exposed portions and the internal organs of the carcass

(*Look for canine punctures, wounds, and abnormalities. If the carcass has been partially consumed, describe where and how much flesh has been consumed, bones which have been chewed or fragmented, etc.*)

Estimated Age (*look at molars & incisors*):________

SITE DESCRIPTION

Snow Cover: None / <50% Cover / 50 - 100% Cover / 100% Cover

If snow exists, days since snowfall: ________

Check all that are present in the area surrounding the carcass or carcass remains:

___ Predator Tracks: Coyote / Cougar / Bear / Dog / Eagle / Other: _________________

Do tracks or anything else indicate that a chase had occurred? Yes / No

___ Scat: Coyote / Cougar / Bear / Dog / Eagle / Scavenging Bird

___ Blood (look for on both ground and vegetation)

___ Drag Trail

___ Deer Hair (Describe the quantity and whether its evenly scattered across the site or in patches)

___ Matted vegetation indicating that predators/scavengers had been at the site

___ Broken shrub branches indicating a struggle may have occurred

DEER MORTALITY FIELD FORM

Expand on anything, which may help identify mortality cause. If the carcass remains are dispersed across the site, describe or draw a picture indicating the position of carcass remains (head/skull, bones, hide, rumen, etc.) relative to one another with approximate distances:

MULE DEER ID: ________________

KEY TO CAUSE OF MORTALITY

(Check all that apply)

Malnutrition

___ Intact carcass ___ Nothing indicates predation

___ Minimal femur marrow fat remaining (Rank: 4) ___ No scavenging by coyotes

___ No signs of disease ___ No hemorrhaging

Coyote Predation (Upper canines measure ~1–1⅜" apart; lower canines measure ⅞–1¼" apart; canine diameter ~⅛" often difficult to measure distance given multiple bites & paired punctures)

___ Canine punctures to the throat, neck, or head
___ Hemorrhaging on throat, neck, head, hind legs etc.
___ Tear marks on one or both hind quarters
___ Coyote/deer tracks indicating a chase occurred
___ Blood scattered across the ground and/or on
___ Patches of loose hair (not plucked), torn pieces of vegetation hide, and/or detached portions of the carcass spread widely across site
___ Chewed/broken bones (such as ribs) have ragged edges

Mtn Lion/Bobcat Predation (Mtn Lion: Upper canines measure ~1½–2" apart; lower canines roughly measure ~1¼–1⅝" apart; large canine diameter [~½"] relative to coyotes/bobcats [~⅛"] || Bobcat: Upper canines measure ~⅝" to 1⅛" apart; lower canines: ~½–1" apart; distance measurements are often easier to make on felid kills than on coyote kills, due to lower bite wound frequency)

___ Cache site (carcass commonly cached under shrub branches, ground litter, plucked hair, or occasionally snow
___ Canine punctures on the neck, throat, or head
___ Hemorrhaging on back or side of neck or base of skull
___ Claw marks on neck/back of shoulders
___ Drag marks to the cache site
___ Broken neck (or damaged vertebrae)
___ Skull largely crushed (scattered skull bone fragments and jaw bones)
___ Plucked hair
___ Tree scratching at site
___ Lion tracks/Lion scat
___ Carcass not widely scattered across the area
___ Bobcat tracks/bobcat scat (scat may be covered)

Bear Predation (Upper canines measure ~1¾ -2½" apart; lower canines measure ~1½ -2" apart; canine diameter ~½")

___ Massive hemorrhaging/bite marks around neck, top of head/skull, and/or tops of shoulders
___ Fawns: Bruised hind quarters & crushed ribs; blood in lungs, blood in nose and mouth
___ Massive bruises on back of hind quarters, ribs, and/or front shoulders
___ Bear scat/tracks/beds
___ Bear hair on antlers, trees, or brush
___Hide "banana" peeled back to neck and down legs
___ Huge area of flattened veg surrounding carcass
___ Hole in brain cavity; eaten nasal area
___ ≥ 1 burial pile covered w/ dirt
___ Abundant hemorrhaging on skin

No. of Pictures Taken: ____ **Camera:** Digital / Non-Digital (roll,neg#'s: ________________)

Cause of Mortality: ____

Briefly explain your basis and any key evidence for determining cause:

COLORADO PARKS & WILDLIFE

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