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Animal scavengers as agents of decomposition: the postmortem succession of Louisiana wildlife

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ANIMAL SCAVENGERS AS AGENTS OF DECOMPOSITION: THE POSTMORTEM SUCCESSION OF LOUISIANA WILDLIFE

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ABSTRACT

Four adult pig carcasses were placed within a wildlife center in Baton Rouge, Louisiana, in order to determine what conditions animals utilize carrion and which animal species engage in scavenging. The cadavers were deposited without any protective covering and wildlife cameras were placed around the pigs in order to document animal scavenging. In two cases cameras showed that coyotes were the initial animal scavengers followed by opossums. In another case coyotes were inferred to have scavenged the pig due to discovering a similar pattern of disarticulation as compared to the previous two scenes. In the third case turkey vultures skeletonized the pig within twenty-four hours. In this case, the site had less tree cover than the other sites, thus making the cadaver more accessible to avian scavengers. In cases where coyotes interacted with the carrion, the skeletal remains were recovered in a linear distribution with the cranium in the original location of the body, the mandible a few feet away from the cranium in the direction of coyote movement and the remaining skeletal remains in line with the first two skeletal elements in the direction of movement. One bone was found with discernable animal gnaw markings. Because this bone was recovered in the late stages of decomposition I infer that carnivorous animals are more likely to gnaw on bones near or after full skeletonization of a body. Precipitation was found to be a determining factor in animal scavenging as animals did not interact with the cadavers on days when it rained on a day following a day when it rained.

INTRODUCTION

Using 175 cases analyzed at the Louisiana State University Forensic Anthropology and Computer Enhancement Services Laboratory (FACES) between 1984 and 2005, Manhein et al. (2006) determined 49% of rural body dumps occur in a wooded environment and 78% of urban body dumps occur in an open environment. Many of these cases show evidence of animal disturbance in the form of scattering.

Animal scavengers often interact with corpses left in outdoor, open and wooded environments. During taphonomic analysis the investigator should attempt to reconstruct a detailed post-depositional history in order to accurately calculate postmortem interval (PMI) and differentiate between perimortem and postmortem trauma. Such an analysis should include all possible agents of decomposition, including the presence of animal scavengers.

The forensic literature contains a plethora of information related to the utility of insects in estimating PMI (Morton and Lord 2006). Numerous studies illustrate the utility of invertebrates in time-since-death determinations due to the regular successional patterns and developmental cycles of insects (Anderson and Cervenka 2002; Greenberg 1991; Johnson, 1974). Most of these studies, however, limit the focus of time-since-death to the function of insects and thus control for vertebrate scavengers by either protecting the corpse with a cage or placing the body in a fenced ‘body farm.’ In a natural, outdoor setting bodies rarely remain shielded from the native fauna, and animals may therefore alter the scene and the cadaver.

Vertebrate scavengers routinely consume the eggs and larva present on and inside carrion in addition to disarticulating, moving, trampling, consuming and gnawing on the cadaver. Vertebrate scavengers, therefore, likely interrupt and alter invertebrate activity. Rodriguez and Bass (1987:124) stress the importance of identifying the presence of animal activity on both bones and the condition of the site, as interpretation of the death scene can be "greatly hindered" through disruption caused by animals. In cases where vertebrate scavengers disturb a body, the forensic anthropologist should attempt to identify the source of postmortem movement and trauma in order to reconstruct the original scene. The forensic anthropologist should also use multiple techniques to calculate PMI in addition to entomological evidence, as animal scavengers may have altered the typical succession of insects.

In addition to developing entomological techniques, forensic anthropologists have established direct relationships between the decay of adjacent factors, such as clothing (Marshall et al. 2009) and hair (Collier 2005), with that of a cadaver, and associated time-since-death with the growth of surrounding flora (Coyle et al. 2005) and the strength of a cadaver's odor (Vass et al. 2008). Nevertheless, little research exists which employs vertebrate scavenging to aid in the determination of PMI. Several studies (Blumenschine 1995; Haglund et al. 1989) have certified that vertebrate scavengers disarticulate human remains in a consistent sequence, disarticulating and or consuming particular elements before others. Additional studies have sought to establish a relationship between the distance that animal scavengers carry particular elements from the original location of the body and time-since-death (Manhein et al. 2006).

Nevertheless, little research exists to determine if a particular species of animal has a tendency to utilize carrion before or after another animal species. If such a succession does exist, it would prove useful in forensic anthropology. Through associating animal gnaw marks on bone with a particular animal species, the forensic anthropologist may improve the accuracy of a time-since-death estimation. The present study aims to determine if a regular succession of vertebrate scavengers visiting carrion exists, if these animals have a tendency to utilize carrion at a regular time after death, and if these animals leave gnaw marks on bones specific to their species.

REVIEW OF LITERATURE

Haglund and Sorg (1997:13) define forensic taphonomy as "that part of forensic anthropology which focuses on reconstructing events during and following death by collecting and analyzing data about the depositional context." PMI considers the taphonomic processes that have affected a corpse in hopes of determining the length of time an individual has been deceased. Establishing an accurate PMI is an integral part of the forensic anthropologist's case report. PMI can potentially affect the outcome of a case as the time-since-death estimation provides a timeline.

To calculate an accurate PMI, the forensic investigator must take all of the depositional variables which have potentially affected a cadaver's rate of decomposition into account. Animal scavenging is one agent of decomposition that often affects human carrion in outdoor environments. Various accounts have illustrated the high likelihood for animal scavengers to interact with human carrion left in outdoor, open areas (Bartelink and Bright 2009; Devault et al. 2003, 2004; Dirkmaat and Adovasio 1997; Mann et al. 1990; Murad 1997; Oliver and Graham 1994; Rodriguez and Bass 1987). DeVault et al. (2003) state that vertebrate scavengers, rather than invertebrate scavengers, consume most available animal carcasses. The authors also emphasize the importance of animal carrion as an integral component of nearly all carnivores' diets, even the diets of those thought of as "vociferous predators" (Devault et al. 2003: 232). Mann et al. (1990) emphasize the high likelihood for vertebrate scavengers to interact with human corpses left in open areas. The authors note that if a badly decomposed body should surface in an open area without evidence of carnivore feeding, the assailant most likely moved the body into an open environment subsequent to insect colonization. This conclusion is based on the discrepancy between the time of exposure to invertebrate and vertebrate scavengers, and emphasizes the significance of animal scavengers as common and consistent agents of decomposition.

PMI Studies and Animal Scavenging

Despite the presence of vertebrate scavengers, many time-since-death studies control for animals in order to record solely the effects of agents such as insects and weathering. For instance, the University of Tennessee Anthropology Research Facility (ARF) is surrounded by a chain link fence and a wooden privacy fence, for the purpose of keeping both human and wildlife populations out of the ARF. Despite these barriers, Bass (1997) has noted the presence of opossums, mice and avian scavengers inside the facility. In decomposition studies conducted outside of 'body farms,' a researcher will often enclose carrion in protective cages in order to control for vertebrate scavengers. Despite this shield, animals often find ways to infiltrate cages (Dupuis 2005; Gremillian et al. 2005; Payne 1965; Watson and Carlton 2003). The tendency for vertebrate scavengers to interact with carrion, despite man-made barriers, shows the resilient nature of many animal species and again stresses the importance of including animals in taphonomic analysis.

Disarticulation Patterns

When animals consume and gnaw on cadavers they tend to disarticulate skeletal elements. Archaeologists started investigating this process well before forensic anthropologists began to apply disarticulation patterns to PMI estimations. Andrew Hill has conducted extensive research on the application of disarticulation patterns to the reconstruction of archaeological sites. In “Butchery and Natural Disarticulation: An Investigatory Technique”, Hill (1979a) attempted to compare the way nature disarticulates carcasses with patterns of hominid butchery. Hill used a sample of *Bison occidentalis* butchered by North American Paleoindians and a natural assemblage of modern *Damaliscus korrigum* (African topi) to make such a comparison. In order to reconstruct the disarticulation sequence of the African topi, Hill estimated the length of time various joints last after death by recording the frequencies of intact joints relative to all the other joints in the assemblage. Hill (1979a: 271) determined that disarticulation patterns vary “only slightly” between the human-butchered sample and the naturally disarticulated sample. Nevertheless, Hill’s sequence of natural disarticulation provided a foundation for reconstructing archaeological sites and estimating PMI.

In “Disarticulation and Scattering of Mammal Skeletons”, Hill (1979b) noted the importance of disarticulation patterns to paleoecological matters. Among other things, Hill listed estimating the interval between death and burial, determining past environmental conditions and explaining the spatial patterning of bone assemblages as applications for disarticulation patterns. In a later study, Hill and Behrensmeyer analyzed how 18 African mammal species become disarticulated (1984). The authors concluded that “great overall consistency” (Hill and Behrensmeyer 1984: 375) existed between the patterns of disarticulation between these species. Blumenshine (1986) came to the same conclusion and utilized the overall uniformity in carcass consumption to differentiate between bone assemblages created by scavenging and hunting. This consistent patterning provides a regular temporal sequence to reconstruct the taphonomic history of fossil, archaeological and forensic assemblages.

William D. Haglund has conducted sizeable work on the subject of disarticulation sequences. Using a sample of 53 forensic cases from the Pacific Northwest, Haglund (Haglund 1997a; Haglund et al. 1989) revised Hill's (1979a, 1979b) categorization for modern topi and Haynes' (1980) stages of damage for Pleistocene and recent North American mammals to a five stage sequence of human disarticulation. This classification system has proven consistent across a variety of environments. The five stages have correlated with the results of similar studies and forensic cases (Carson et al. 2000; Kjorlien et al. 2009; Reeves 2009). Haglund's analysis illustrates the high likelihood for animal scavengers to affect cadavers placed in outdoor environments and further exemplifies the overall regularity of animal scavenging. Table 1, derived from a subset of Haglund's data (1997a: 368), shows the key characteristics of each of the five stages of human disarticulation and the associated PMI of each stage.

Table 1. Stages of Canid-Assisted Scavengers (N = 37) Modified from Haglund 1997a.

Stage	Condition of Remains	Range of Observed Postmortem Interval
0	Early scavenging of soft tissue with no body unit removal	4 hours to 14 days
1	Destruction of the ventral thorax accompanied by evisceration and removal of one or both upper extremities including scapulae and partial or complete clavicles	22 days to 2.5 months
2	Lower extremities fully or partially removed	2 to 4.5 months
3	All skeletal elements disarticulated except for segments of the vertebral column	2 to 11 months
4	Total disarticulation with only cranium and other assorted skeletal elements or fragments recovered	5 to 52 months

Due to the nature of disarticulation, in which animal scavengers may carry skeletal elements away from the location of a body, a correlation between distance of element dispersal and time-since-death may exist. In a spatial analysis of 175 forensic cases in Louisiana, Manhein et al. (2006) found a positive relationship between the shortest distance skeletal elements become scattered from a body and PMI. The authors assert that cadavers found with skeletal elements in close proximity to one another tend to have a relatively short postmortem interval. The data did not yield any relationship between the greatest or average distance that skeletal elements become scattered from a body and PMI. Manhein et al. (2006) point out that additional factors, not addressed in their study, may contribute to dispersal patterns, including the presence and behavior of animal scavengers. Kjorlien et al. (2009) found a predictable pattern to exist in the scattering of skeletal remains. The authors' research shows that animal scavengers consistently move skeletal elements in a direction away from human activity. A consistent spatial pattern does therefore exist in animal scavenging; however, the authors do not mention a relationship between distance of dispersal and PMI.

Scene Recovery

Often some remains cannot be recovered at scenes where animal scavengers have had access to a corpse. Many authors note loss of information at scavenger-ravaged sites, as animal scavengers tend to disperse, conceal, and consume skeletal remains (Bartelink and Bright 2009; Komar and Potter 2007; Milner 1989; Rodriguez and Bass 1987). Komar and Potter (2007) point out the positive relationship between the percent of a body recovered and positive identification. Because the successful recovery of skeletal elements from a scene can affect the outcome of a case report, methods should be established to improve the odds of successfully recovering skeletal elements. Increased knowledge of indigenous animal scavengers and their behavior should provide clues as to the location of skeletal elements.

Despite the problems associated with the loss of skeletal elements, knowledge can arise from a lack of remains. For example, Haynes (1981) notes that the underrepresentation of phalanges, ribs, vertebrae, carpals, and tarsals can indicate the presence of canids, because wolves, dogs and coyotes often consume these elements.

For instance, Haglund et al. (1988) claim that recovery rates for the bones of the upper extremities range from 50% to 20%, those of the lower extremities range from 65% to 42%, and bones of the axial skeleton range from 73% to 61%. These percentages show the preference and ease of disarticulating particular skeletal elements by animal scavengers and highlights the "recognition value" of various bones (Haglund et al. 1988: 992). The recognition value refers to the differential likelihood for a person to recognize a particular skeletal element and as a consequence recover that particular bone. For example, the most easily recognizable skeletal element, the human cranium, has a high recovery rate do to its large size and distinguishable shape, while hard to recognize bones such as the phalanges and the patella have a low recovery rate.

Animal Markings

In archaeology, paleobiology and forensic anthropology, bones are often observed with animal markings. During skeletal analysis, in the aforementioned fields, specialists must differentiate between animal and human bone modification. Much work has been conducted on animal bones in the archaeological record, in order to determine if different groups of hominids were using tools, scavenging for meat, or hunting (Andrews and Cook 1985; Binford 1981; Blumenschine 1995; Bunn 1991; Dominguez-

Rodrigo and Piqueras 2003; Edge 1984; Haynes 1980, 1983; Hill 1979a, b; Hill and Behrensmeyer 1984; Marean and Spencer 1991).

Bunn (1991) expresses the common dilemma of confusing bone markings made by tools with bone markings made by various taphonomic processes. He says that it is "unfortunate that some researchers continue to make claims for cut marks…without meeting any of the accepted criteria for their identification" (Bunn 1991: 453). Part of these criteria includes identifying animal markings on bones based on previously observed animal gnawing patterns.

Using controlled zoo studies, Binford (1981) conducted a vast amount of research pertaining to the differences of gnaw marks and tool marks on bone. Binford correlates tooth pit size with the size of the working tooth and its function, noting that crushing, grinding and piercing create different marks which correlate to particular mechanical motions as well as the use of different teeth within the dental arcade. He recognizes four types of tooth markings on bone: *punctures*, where bone collapses under a tooth; *pits*, where bone depresses under a tooth; *scores*, where teeth are dragged across bone; and *furrows*, where repeated gnawing creates undulations in bone. The specific actions of eating and gnawing create these various markings. Thus, Binford's classifications can help to differentiate between tool use and carnivore interaction. Binford's research also aids in differentiation between carnivore taxa.

The same categorization of markings can also prove useful for differentiating between perimortem trauma and postmortem animal interaction. Ubelaker (1997) emphasizes the need to distinguish between animal gnawing and human alterations in a forensic context. He notes that when differentiating between perimortem and postmortem trauma, researchers often confuse spiral fractures created by animal scavengers with similar spiral fractures resulting from perimortem trauma. Ubelaker states that spiral fractures can be created by trampling and carnivore chewing as well as by "foul play-associated trauma" (1997:82). Just as archaeologists and paleobiologists study patterns in animal gnawing to identify correctly bone markings, forensic anthropologists should also use the available research on animal gnawing and gather additional data in order to identify correctly markings on bones.

In addition to creating postmortem marks on bone through gnawing, animals also damage bone through trampling. Trampling can cause extensive breakage to bones, possibly obscuring perimortem trauma and other postmortem damage. Andrews and Cook (1985) found that in a farm environment, a majority of bone movement and dispersal resulted from kicking and trampling by livestock. Also, Behrensmeyer et al. (1986) note that trampling marks made by humans appear similar to cutmarks, even at the microscopic level. Bone markings inflicted by trampling may therefore be misidentified as markings inflicted by tools. Animals affect corpses in a variety of ways and identifying their presence as post-depositional agents can influence interpretations of both archaeological assemblages and forensic scenes.

Canids

In addition to identifying animal gnaw markings on bone, some research has been conducted to differentiate between the various animal taxa creating marks on bone. Selvaggio and Wilder (2001) note the importance of identifying the presence of specific carnivore species through tooth marks in order to understand palaeoenvironments. Dominguez-Rodrigo and Piqueras (2003) note a need for a global sample of tooth marks and their ranges of variation in order to differentiate among animal taxa. They call for further research in tooth pit sizes as well as bone destruction processes in order to create a more effective methodology for identifying the maker of gnaw marks on bone. In a study using 125 carcasses from the Arctic, Haynes (1983) devised a system to delineate patterns of bone gnawing caused by canids, hyenas, bears and felids. Generally, in a forensic context, when a differentiation is made between the bone markings created by large carnivores and rodents, the forensic investigator rarely attempts to make an inference as to the particular species of the agent creating such marks.

Nevertheless, many species of animals interact with carrion. Due to differences in tooth and jaw morphology as well as behavior, specialists may be able to infer the animal species affecting a cadaver based on patterns of gnaw markings. Animals from the family Canidae, including dogs, wolves, foxes, coyotes and jackels, are the most frequently reported scavengers of carrion. In forensic anthropology, markings caused by large carnivores are frequently attributed to canids, often without significant evidence to rule out other animal taxa (Haglund 1997a; Haglund et al. 1989; Kent 1981; Kjorlien et al. 2009; Milner 1989; Watson 1997; Wiley and Snyder 1989). For example, in Haglund et al.'s (1989) "Canid Scavenging/Disarticulation Sequence of Human Remains in the Pacific Northwest" and Haglund's (1997a) "Dogs and Coyotes: Postmortem Involvement with Human Remains," the authors attribute disarticulation exclusively to canids. The remains in the sample used in both Haglund et al.'s (1989) and Haglund's (1997a) studies, however, all derived from real cases and were thus not monitored during decomposition. In both Haglund's (1997a) and Haglund et al.'s (1989) analyses, the authors neglect to provide evidence to establish canids as either the primary or singular agents responsible for disarticulating remains.

Bears

Various species of bears may also be responsible for human disarticulation (Carson et al. 2000; Merbs 1997; Murad and Boddy 1987). Carson et al. (2000) assert that bear scavenging is often mistaken for canid disarticulation due to similar patterns of damage. The authors conclude that differences exist in the various bone assemblages left behind by bears and canids, as "bears are more likely to exploit the axillary skeleton…while canids scavenge the extremities and organ cavities" (Carson et al. 2000: 526).

Rodents

According to White and Folkens (2005: 57), rodent gnawing "can be just as destructive" as gnawing by large carnivores. Rodent gnawing also has a distinctive appearance, often consisting of a parallel series of furrows (Tsokos et al. 1999). Bones extensively gnawed by rodents are often interpreted as having been skeletonized for long periods of time, due to the need for rodents to wear down their incisors and introduce minerals into their diet (Bartelink and Bright 2009; Tsokos et al. 1999). An inconsistency in this approach exists as various researchers have observed rodents consuming flesh from cadavers during the early stages of decomposition (Haglund 1997b; Klippel and Synstelien 2007; Rodriguez 1997; Ropohl et al. 1995). Regardless of when rodents consume or gnaw on corpses, their status as decomposing agents is consistent and the effects of rodents should be considered in taphonomic analysis.

Birds

Avian scavengers regularly interact with remains (Jennelle et al. 2009) and can significantly affect the rate of decomposition. Crows, hawks, vultures and buzzards often aggressively consume corpses. Turkey vultures can completely skeletonize an adult pig over a period of three hours to five days (Morton and Lord 2006; Reeves 2009). Crows regularly consume carrion, but they do not leave marks on bone (Asumura et al. 2004; Bass 1997). Birds consume carrion differently than do mammalian scavengers. Due to their jaw morphology, birds consume carcasses through pecking and grabbing onto soft tissue with their beaks and pulling soft tissue from the body (Oliver and Graham 1994). Avian scavengers also consume corpses that are easily observed from above. Therefore, bodies in open areas have a greater probability of attracting avian scavengers.

Herbivores

Pigs and various herbivores have also been observed consuming carrion. Greenfield (1988) notes that the major difference between pig-chewed bone and canid-chewed bone is the presence of shovel-shaped teeth marks from pigs and the presence of puncture marks from dogs. Sutcliffe (1973) found that herbivores gnaw on carrion bones as a symptom of phosphorous deficiency, thus producing alteration on bone. These herbivores included cattle, red deer, reindeer, muntajac deer, camel, giraffe, wildebeast, kudu, gemsbok and sable antelope.

Raccoons and opossums may interact with carrion more regularly than the archaeological or forensic literature reflects. Although these two species often interact with cadavers placed outside to study taphonomic processes (Devault et al. 2004;

Hoffman 1987; Jennelle et al. 2009; Klippel and Synstelien 2007; Mann et al. 1990; Morton and Lord 2006; Rodriguez 1997; Synstelien 2009; Synstelien et al. 2005), gnaw markings are rarely attributed to either species. Raccoons and opossums may represent fundamental, yet unexplored, agents of outdoor decomposition.

Geographic Location and Weather

Obtaining an understanding of the native fauna in a geographic region can aid in the construction of a post-depositional history. O'Brien et al. (2007: 194) note the "scarcity" of region-specific scavenging studies. Regional differences exist in the native fauna and annual behaviors of scavengers. Postmortem trauma, therefore, varies regionally as well. Thus, taking the environment into consideration during taphonomic analysis can prove "imperative" to the identification of postmortem artifacts (O'Brien et al. 2007: 198). For example, Galloway (1997) found that scavengers utilize carrion much later in the Southwest, compared to the patterns Haglund (1997a) and Haglund et al. (1988) observed in the Pacific Northwest.

Seasonal and weather conditions may also affect scavenger activity. For instance, DeVault et al. (2004) notice that vertebrates tend to consume less carrion as temperature increases.

Insect and Animal Scavenging

Campobasso et al. (2001) state that the combination of insect and animal scavenging dramatically accelerates the decomposition of organic matter. Devault et al. (2003) have found a certain level of competition to exist among animals, insects and microbe scavengers. The authors note that microbes produce toxins, which deter animal scavengers from utilizing carrion. Vertebrate scavengers must therefore obtain corpses rapidly in order to out-compete microbes. Insect activity changes with scavenger involvement and conversely scavenger involvement alters insect activity. For example, if scavengers rapidly remove soft tissue, insects will have little involvement with the corpse. On the other hand, intense insect activity will sometimes attract large animals to the specimen to feed on insects, which in turn will diminish the number of insects on the corpse and lessen their influence on decomposition.

As many taphonomic studies have demonstrated, the environment affects insect activity, which in turn affects animal activity and the overall decomposition process. Haglund et al. (1988: 995) warn that "local estimates of rate and time of death should be made with extreme caution and should be based on local experience with animal scavengers and environmental conditions of the particular region of recovery."

Wildlife Studies and Law Enforcement

Just as forensic anthropologists should look towards wildlife studies to increase their knowledge of scavenging, forensic techniques can aid in various aspects of wildlife law enforcement. In fact, according to Beattie et al. (1975, cited in Edge 1984), much of State Fish and Game agencies' enforcement research pertains to time-since-death determinations. Watson and Carlton (2003) found that the same entomological data used in time-since-death estimations in human deaths also apply to deceased wildlife.

Edge (1984) demonstrates the applications of PMI determinations for enforcing hunting season. Many states have "checking stations," where sportsman must stop to have their kills examined for demographic data such as age and sex. The officials at these stations also roughly assess PMI by evaluating rigor, pupil diameter and carcass temperature. If a carcass shows advanced signs of one or more of these characteristics, the officer may suspect that the animal was killed before legal hunting season, or during the night. In these cases, the game is either confiscated after a confession or additional evidence such as witness statements is used to determine probable cause for hunting out of season.

Pigs as Human Proxies

The domestic pig (*Sus scrofa domesticus*) often serves as a model for human decomposition. Due to similarities between the integumentary, cardiovascular and digestive systems of pigs and humans, pigs serve as the most frequently utilized human proxy (Bustard and McClellan, 1996). Pigs putrefy at a similar rate to humans of the same mass (Campobasso et al., 2001; Swindle et al., 1994). Nevertheless, no research exists to determine if animal scavengers utilize human carrion in a different manner than pig carrion.

Identifying Animal Scavenging

Although animals often affect outdoor corpses, detecting their presence can prove problematic. Discerning gnaw markings, as described previously, can identify the presence of animals. However, when gnaw markings are either not present or undistinguishable, other methods should be employed. In “A Case with Bear Facts,” Murad and Boddy (1987) analyze scats to identify animal species that interacted with a corpse. Murad (1997) describes several methods for assigning a species to animal scats found on scene, noting that knowledge of faunal activity can have a positive effect on evaluating a forensic scene.

Schulz et al. (2006) utilize molecular genetics to identify the species of animal scavengers by taking swabs from wound areas. This technique, however, depends largely on the quantity of DNA recovered and the degree of DNA degeneration of a sample and therefore can prove challenging in animal scavenged cases, where scavenger saliva may become mixed with a cadaver's DNA from open wounds. Therefore, an investigator should aim to recover as much animal DNA from a scene as possible, in the form of saliva and fur, in order to utilize this technique.

Nevertheless, new methods should be developed and current methods, such as delineating species type through gnaw markings, should be further researched to improve interpretations of postmortem activity.

Wildlife Cameras

In many controlled studies, species identity has been determined through video and picture recordings (Jennelle et al. 2009; Kjorlien et al. 2009; Klippel and Synstelien 2007; Marshall et al. 2009; Morton and Lord 2006; O'Brien et al. 2007; Reeves 2009; Synstelien 2009; Synstelien et al. 2005). Wildlife cameras have become relatively accessible and affordable due to their widespread use in hunting. These cameras prove useful in scavenger studies. Morton and Lord (2006: 478) call cameras "very beneficial" in experimental environments.

The most obvious application for cameras is the potential for unequivocal identification of the animal species acting on a sample. Researchers could also assign markings found on bones to particular species through camera evidence. In addition, the camera may indicate in which direction scavengers move body elements.

Cameras can also be useful beyond simple species identification; additional information can be obtained about scavenger activity. For instance, researchers can determine if a relationship exists between PMI and the location of scattered skeletal elements. Overall, cameras offer many prospects for the forensic anthropologist.

Summary

Scavengers have been largely left out of controlled studies of taphonomic processes. While the standard forensic textbook may dedicate a section to scavengers in a taphonomy chapter, scavengers have not been appreciated as a substantive agent in decomposition. Numerous taphonomic studies control for scavengers as if animals will contaminate the study, when, ironically, taphonomy aims to investigate agents that break down specimens. Archaeologists have conducted research on scavengers in order to answer questions about markings on bones and disarticulation sequences. The field of forensic anthropology can benefit from these studies as well as potentially add scavenger studies to the literature, which in turn may benefit archaeology. There are many areas that warrant investigation within the branch of scavenger taphonomy, including scavenger anatomy, behavior and disarticulation sequences. Future studies should allow for weathering, invertebrates and vertebrates to act on samples so that a more accurate idea of natural decomposition may be devised and applied to forensic cases. Modern camera technology has provided researchers with an affordable means of documenting precisely animal activity on corpses. “A fuller understanding of animal scavenging can prove invaluable in forensic investigations” (Haglund 1997a; 367).

MATERIALS AND METHODS

From May 14th, 2010, through August 18th, 2010, four domestic pig (*Sus scorfa*) cadavers were placed at the Waddill Wildlife Refuge and Outdoor Education Center (WWR), located in East Baton Rouge Parish, LA. The WWR comprises 115.6 ha of mixed flatwoods, is buffered by an additional 120 ha of undeveloped land and borders the Comite River. Major flora include sweet gum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), white oak (*Quercus alba*), yellow poplar (*Liriodendron tulipifera*) and loblolly pine (*Pinus taeda*) (Watson 1997; Watson and Carlton 2003). The center is owned and operated by the Louisiana Department of Wildlife and Fisheries. The WWR was chosen for this project due to its status as a wildlife center and the associated unrestricted movement of native fauna. Four sites within the WWR were chosen for four separate trials (Figure 1.). Each site was located between ten and thirty feet from a nature trail.

Figure 1. Google Inc. (2009) Aerial View of WWR with Sites indicated.

The pig cadavers used for these experiments came from the Louisiana State University School of Veterinary Medicine (LSUSVM). The carcasses derive from a surgical class at the LSUSVM and had undergone euthanasia subsequent to use as educational live-tissue surgical models. The pigs underwent anesthesia prior to surgery and were euthanized by potassium chloride intravenous injection. The LSUSVM made the decision to euthanize these animals independently of my research; no animals were harmed for the purpose of this study.

On May 6th, 2010, the LSUSVM conducted a surgical lab using four pigs. The animals had no known preexisting conditions. Students of the LSUSVM made an approximately 9 inch sagittal incision along the midline of the abdomens of both Pig One and Pig Two (Figure 2.). Multiple surgeries were then performed on these pigs. All bodily tissue that was removed due to these surgeries was placed back into the abdominal cavities without suturing to ensure that bias was not introduced into the study by loss of organs. In order to prevent fluid leakage, the abdominal cavity was sutured prior to euthanasia. No bones were altered during these surgeries.

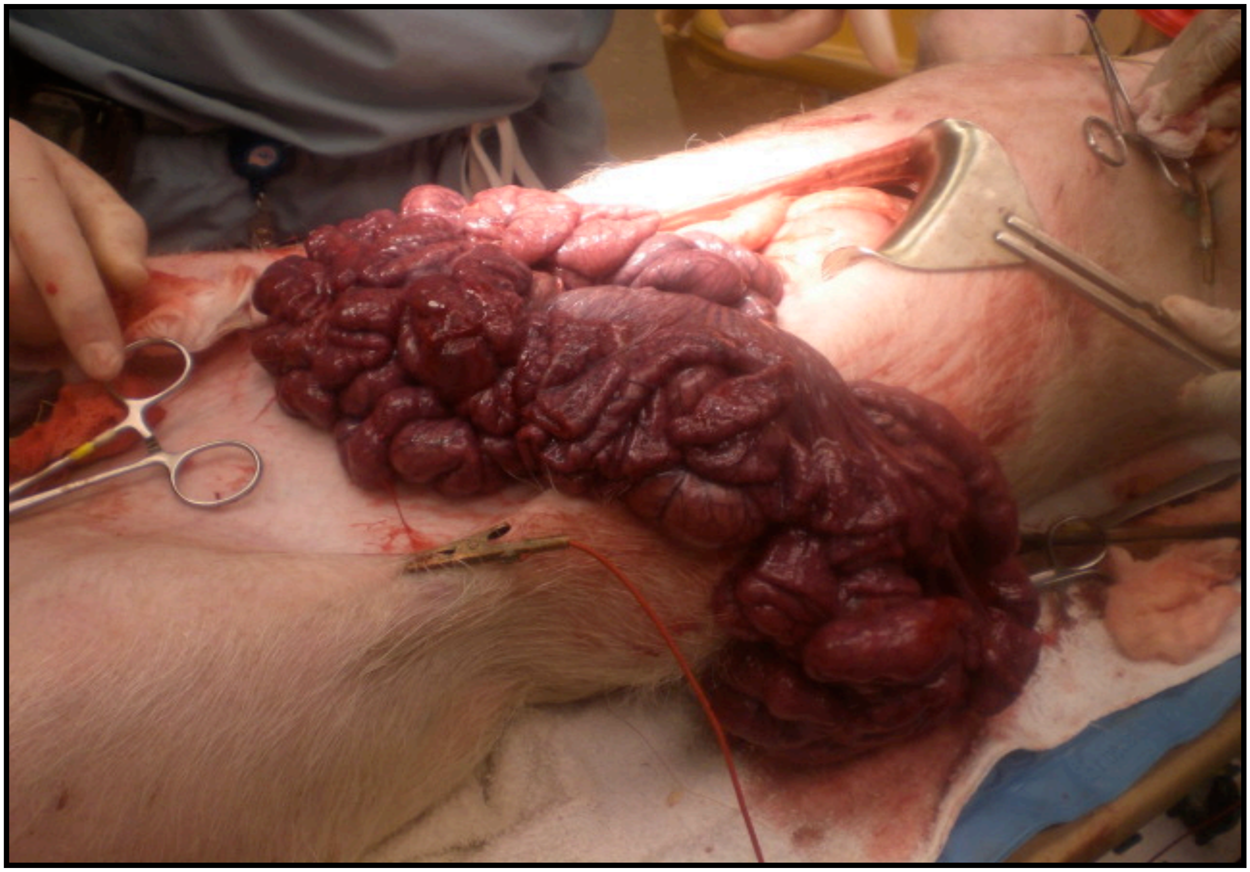

Figure 2. Pig One Undergoing Surgery at LSUSVM

Both Pig Three and Pig Four underwent arthroscopic surgeries (Figure 3.). Five incisions were made on Pig Three, while five were made on Pig Four. Multiple surgeries were performed on these pigs. In order to prevent fluid leakage, all incisions were sutured prior to euthanasia. No bones were altered during these surgeries.

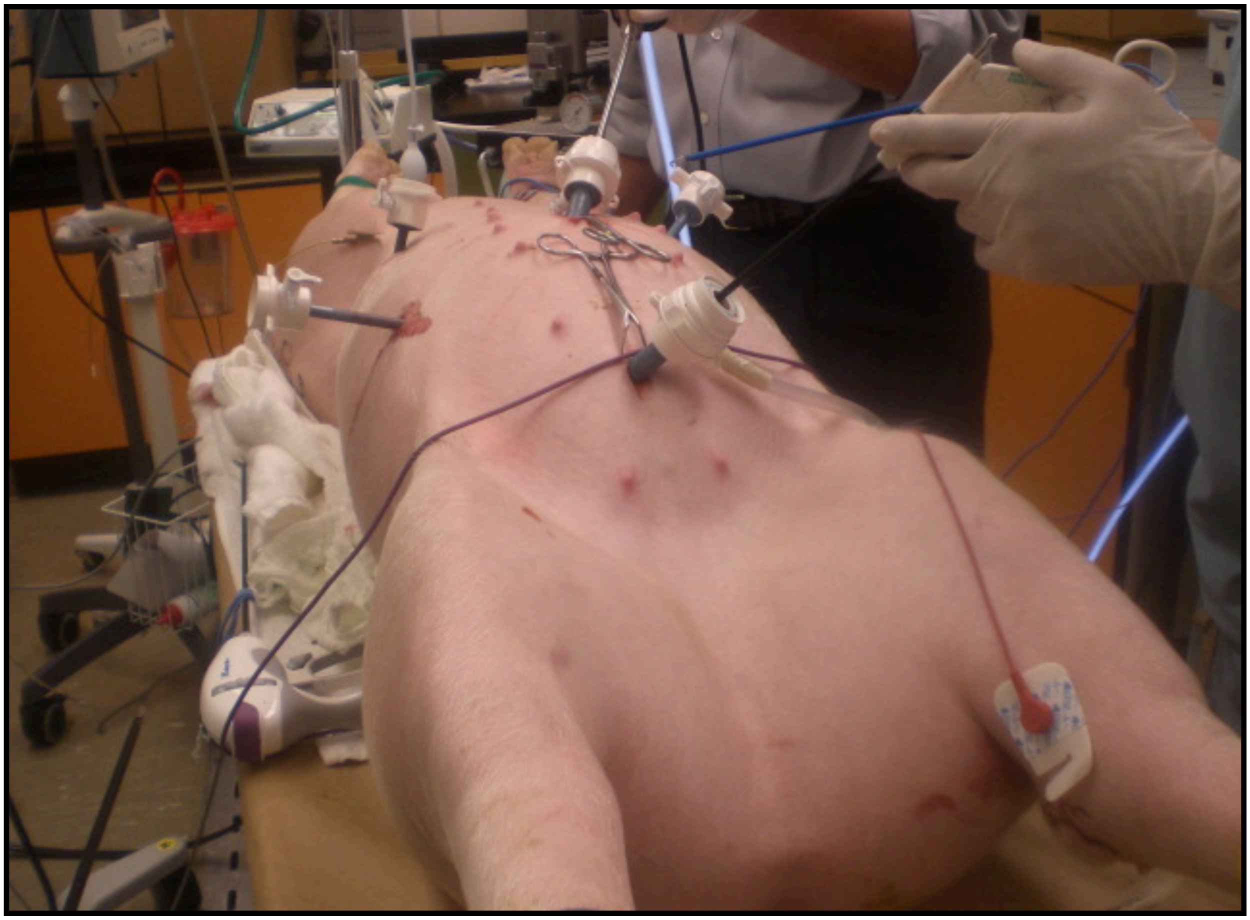

Figure 3. Pig Three Undergoing Arthroscopic Surgery at LSUSVM

Pig One was refrigerated after the surgery and removed from refrigeration on May 14th, 2010. Pigs Two, Three and Four all underwent freezing and were all removed from the freezer on September 27th, 2010. Because no research exists to indicate whether or not freezing carrion alters scavenger activity, any significant differences between the scavenger activity associated with the first pig and the subsequent three pigs will be recorded.

The study attempts to simulate simple surface deposit scenarios. The area chosen for these experiments is heavily wooded with a significant tree canopy to reduce visibility to avian animals and therefore make avian scavenging unlikely. The pig cadavers were easily available to terrestrial scavengers. This setting represents one of many possible body dump environments and can therefore only be compared to cases with similar environmental constraints.

On the first day of each experiment the pig cadavers were placed at various sites within the WWR without any cage or barrier surrounding them. Every day of the study the cadavers were photographed and the site was mapped to record decompositional change and disarticulation. The cadavers were photographed with a Casio Exilim 7.2 Mega Pixel camera, and the scenes were hand-sketched. Meteorological data were obtained using a high-low thermometer, portable weather station and rain gauge.

Between two and five motion-sensitive trail cameras were used to record movement around the cadavers. The cameras used were Bushnell 5.0 Mega Pixel Trail Cameras with infrared night vision technology. These cameras function 24 hours a day, place a date, time and moon phase stamp on every image, and can record 15 seconds of video footage in audio video interleave (AVI) format. AVI allows for synchronous audio-video playback. The cameras used for the study run on 4 D-cell batteries and store information on a SD card. The batteries and SD chips were collected as needed, between 11:00 A.M. and 3:00 P.M., during times when animals are least likely to be feeding. The cameras were attached to trees or supported by other flora surrounding the cadaver and were placed in a distribution to allow for multiple camera angles. Multiple cameras were necessary in order to record the full range of behavior surrounding the cadaver, as well as to infer the direction an animal scavenger may move a particular element away from the body. The footage from the cameras was analyzed for the species type, activity, areas on the cadaver that an animal gnawed, direction of disarticulation and times of interaction with the corpse. All activity recorded on the cameras was written down and compared to each additional trial.

In cases where an animal scavenger disarticulated and moved an element of the remains away from the original location of the body, an attempt was made to determine the direction in which the element was taken and find it. If found, one of the cameras was moved from its original location and placed in view of the removed element to capture any additional behavior surrounding the removed element. In cases a removed element was unable to be located, the loss of the element was simply recorded.

After a pig cadaver became completely skeletonized, the bones were collected and examined for gnaw, trampling and scratch markings. An attempt was made to correlate markings on the bones with the animal species that made them by identifying the parts of the cadaver that animals interacted with through camera footage.

RESULTS AND DISCUSSION

Trial One

The first trial of this experiment began on May 14th and lasted until June 7th, 2010, totaling 25 days. Between these dates, the maximum temperatures ranged from 77º F to 95º F with a mean maximum temperature of 89º F (Figure 4.). The minimum temperatures recorded on-site ranged from 68º F to 75º F with a mean minimum temperature of 71º F. Humidity ranged from 72% to 98% with a mean of 85%. Overall, temperatures and humidity remained fairly constant. Precipitation varied considerably over the study period with 12 out of the 25 days having some rain. The presence of rain seems to have had some effect on scavenging activity as all evidence of animal scavenging coincided after a day when it did not rain and on a day when it did not rain (Figure 5.).

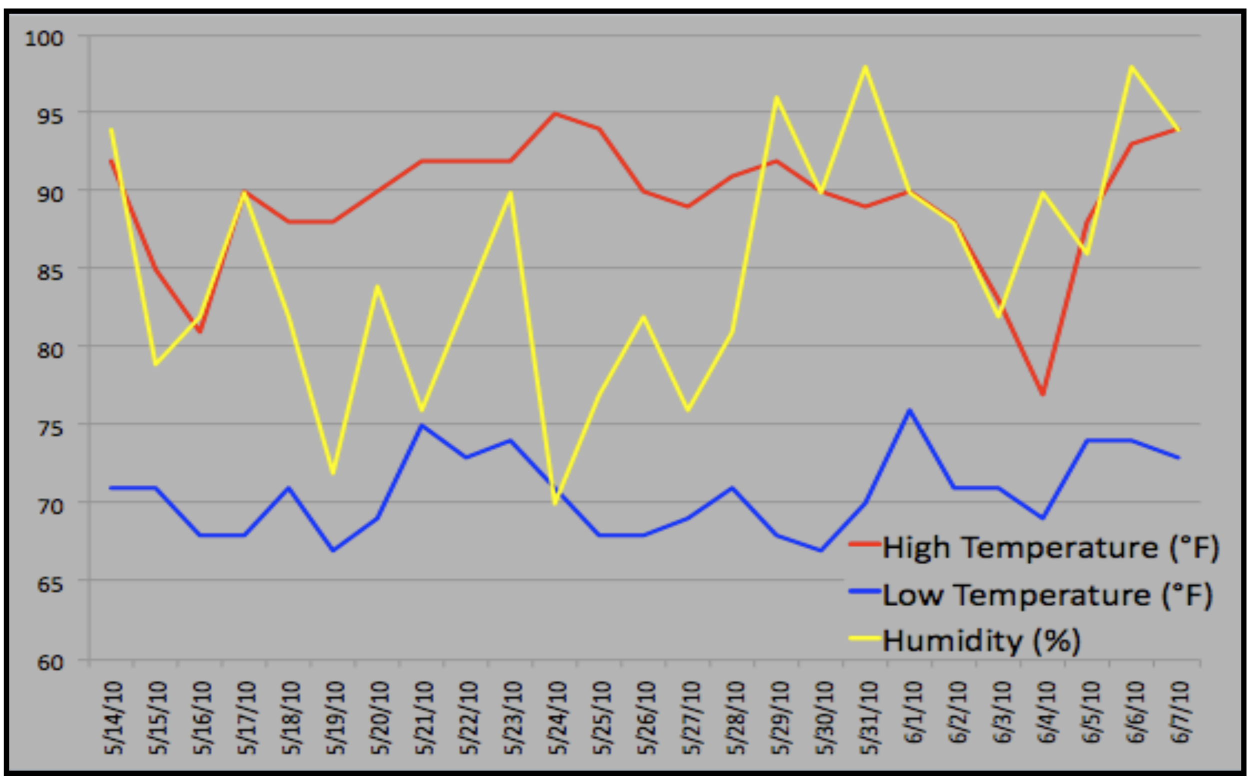

Figure 4. Site One: On-Site Humidity and Maximum and Minimum Temperatures.

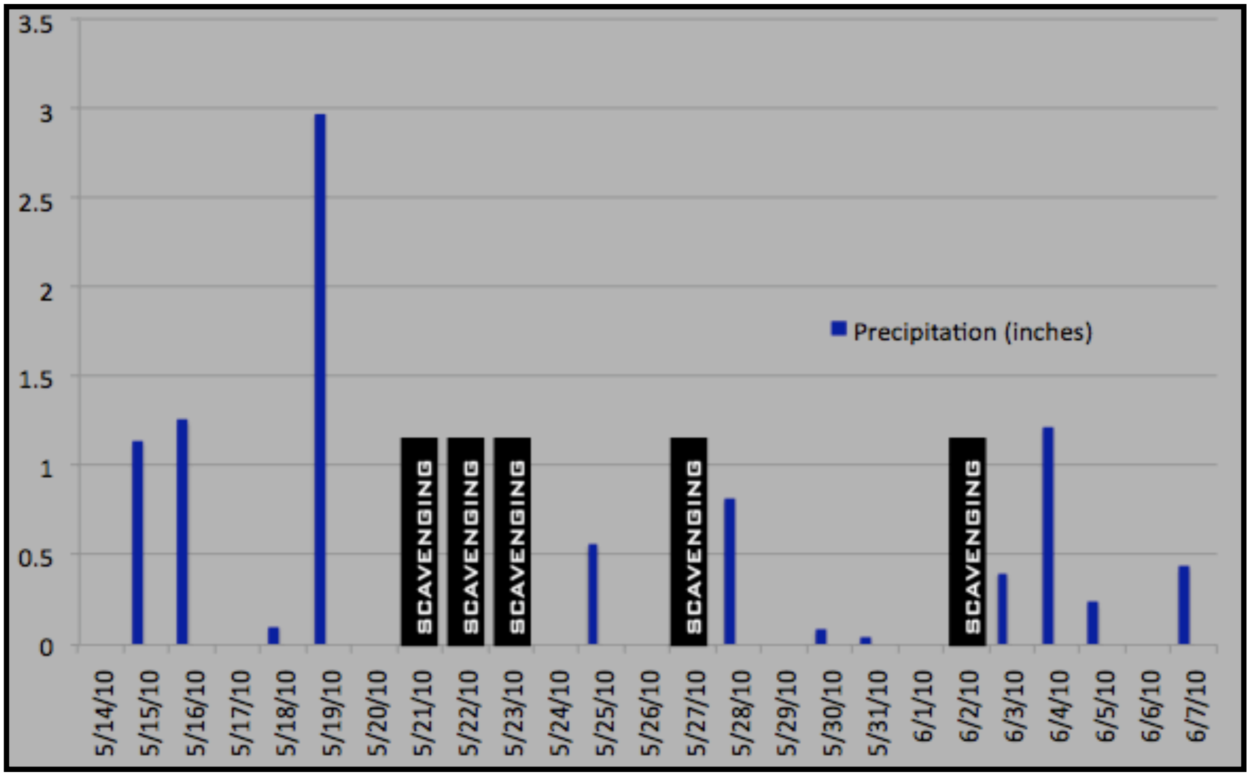

Figure 5. Site One: Precipitation and Days when Animal Scavenging was Present.

Pig One had a mass of 116 pounds, as determined by the LSUSVM. Pig One was removed from refrigeration on May 14th at 11:00 A.M. and transported to the WWR and placed at Site A at 12:17 P.M. Pig One was placed in the supine position on a dirt surface with no vegetation underneath it. Four trail cameras were placed around the pig, each with a different time interval. The time interval is the amount of time elapsed between taking photographs while a camera is sensing motion. One camera was placed approximately four feet above the ground, approximately six feet away from the pig's right side, with a one second time interval setting; another was placed approximately three feet off of the ground, at approximately four feet away from the pig's head, with a 15 second time interval setting; another was placed on the ground, at approximately eight feet away from the pig's left side, with a 20 second time interval setting; and another at approximately five feet off the ground, at approximately five feet away from the pig's hind-limbs, with a 35 second time interval setting (Figure 6.).

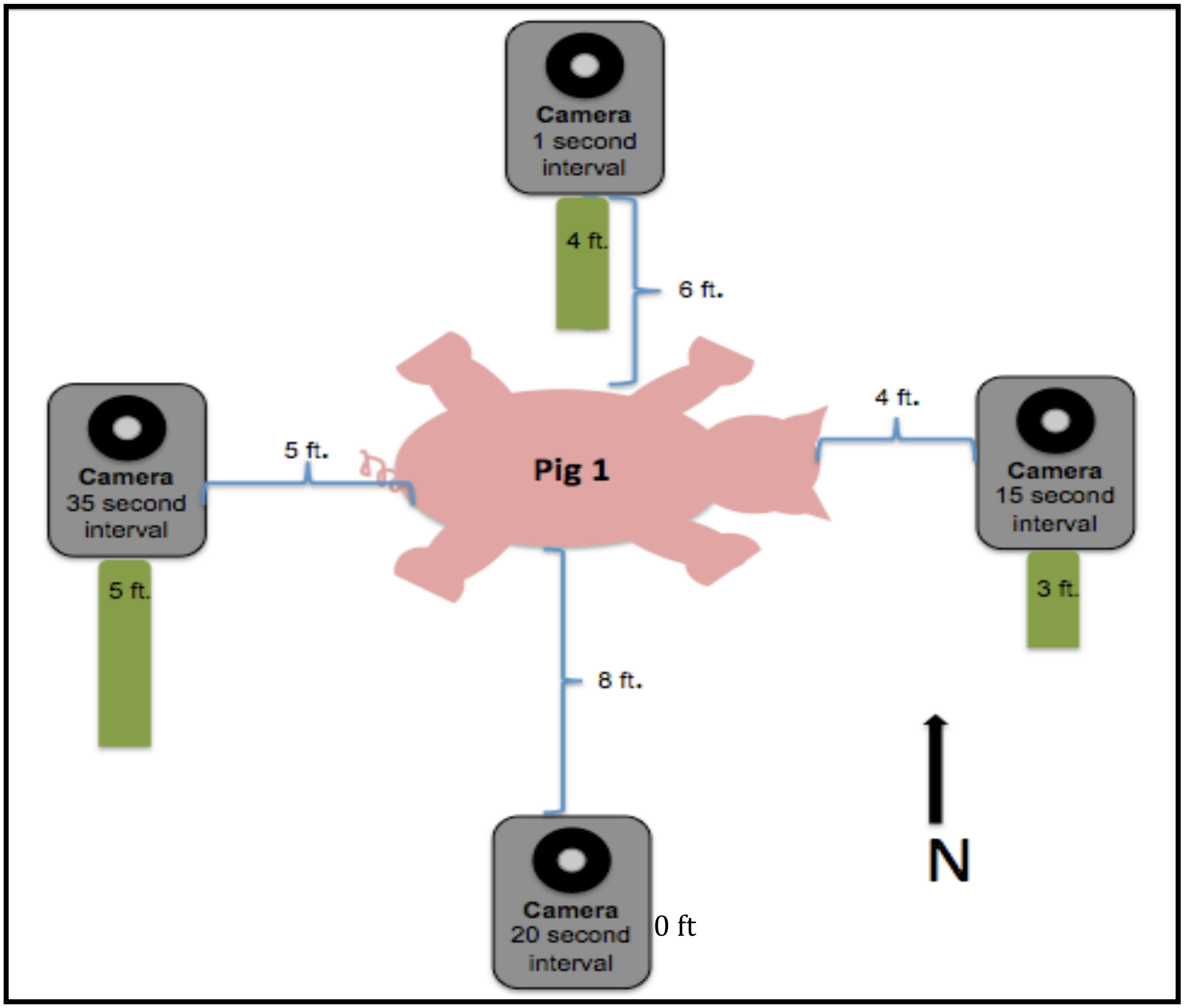

Figure 6. Site One: Distance and Elevations of Wildlife Cameras.

The fresh decomposition stage lasted four days (Days One – Three). Within minutes of Pig One's placement on May 14th (Day One), flies began to arrive on the carcass. Flies settled around mouth, eyes and the surgical incision. On May 15th (Day Two) at 11:42 A.M., egg masses were recorded inside the oral cavity, around the eyes and on the surgical incision. Ants were also present and appeared to be feeding on eggs and maggots. On May 16th (Day Three) at 1:16 P.M., egg masses were recorded in the oral cavity, around the eyes, in the ears, on the knees of the hind-limbs, on the abdomen and around the rectum. A maggot mass temperature of 90° F was recorded from inside the mouth. A significant increase in fly activity around the carcass was noted.

On May 17th (Day Four), Pig One entered the bloat stage of decomposition. Minimal fly activity was observed at 2:35 P.M., with maggot migration recorded up to five feet away from the carcass. On May 18th (Day Five) at 12:13 P.M., moderate blowfly and beetle activity was observed. Pig One's face was partially skeletonized, with a rupture observed under the right forelimb and around the rectum and the intestines were eviscerated. On May 19th (Day Six) at 1:15 P.M., Pig One's face was fully skeletonized, three right ribs were clearly visible and the area around the rectum was observed to be hollow. Fly, maggot and beetle activity were high and the carcass had a strong odor of decay. On May 20th (Day Six) at 12:00 P.M., the mandible and cranium were separated from the body.

On May 21st (Day Seven) at 2:42 P.M., evidence of animal scavenging was observed. The carcass had been dragged approximately ten feet from its original location and the pig had been turned from the supine position to the prone position. A bite, 8 inches by 10 inches, had been inflicted on the right superior portion of the pig's back (Figure 7.). Prior to the infliction of the bite, the flesh around the bite did not appear to have been affected by either fly or beetle activity. New eggs were observed on the surface of the bite.

Figure 7. Site One: Bite on Right Superior Portion of Pig One's Back

The area where the pig had been moved was surrounded by dense vegetation with a shrub covering the front half of the pig. Three trail cameras were relocated to observe the pig in its new location as the original placement of the cameras would not allow for any further observation of animal scavenging. All cameras with the exception of one recorded a large quantity of photos, some being blurred and others just showing vegetation. This indicates that movement was likely evident around the carcass, but the cameras were unable to catch footage of any animals. One camera, however, produced evidence of coyote activity (Figure 8.). The pictures taken show the presence of the animal around the carcass but did not capture the animal interacting with the carcass. Nevertheless, I infer that a coyote or multiple coyotes moved Pig One to a location ten feet away, turned the body 180 degrees and inflicted bite on the animals back.

Figure 8. Site One: Picture Taken from Wildlife Camera Depicting a Coyote.

On May 22nd (Day Eight) at 2:35 P.M., evidence of scavenging was again observed. The initial bite mark was approximately 50% larger than its initial size. Few flies were found in the bite mark, and the bite mark still remained above the level of the ribs. Nevertheless, no footage of animals was observed and again numerous photos were taken, either exhibiting white images or vegetation, thus showing that enough motion was present to set off the motion sensors.

On May 23rd (Day Nine) at 1:12 P.M., Pig One had again been moved, approximately one foot in the initial direction of movement. The pig was now covered by denser vegetation. Fly activity was minimal and mature maggots were found in the neck area, around the rectum and near both hind-limbs. The odor of Pig One had significantly lessoned, and some skin around the upper back and forelimbs appeared to be drying. No footage was captured from trail cameras to evidence an animal feeding on the carcass. Trail cameras were not relocated as the pig was still in view of the cameras.

On May 24th (Day Ten) at 2:00 P.M., no additional signs of animal scavenging were noted. Fly activity had increased at the location of the bite mark. The left posterior limb was now fully skeletonized, and the skin on the pig's back was notably dry.

On May 25th (Day Eleven) at 11:42 A.M., almost no fly or maggot activity remained around carcass, while beetle activity was moderate. Skin on the posterior portion of the carcass was notably dry. Analysis was prohibited on May 26th (Day Twelve) due to an archery competition taking place at the WWR.

On May 27th (Day Thirteen) at 12:34 P.M., Pig One had again been moved, approximately eight feet in the initial direction of movement. Four bones were found approximately four and a half feet away from the cadaver. One of these bones appeared to have been gnawed. Beetle activity had increased, while fly activity was minimal. Trail cameras captured many photos of vegetation; however, no pictures of wildlife were taken. Due to the distance the pig was moved and evidence of a large carnivorous species at the site previously – the coyote – I infer that a coyote or multiple coyotes moved the pig the additional eight feet.

From May 28th (Day Fourteen) through June 1st (Day Eighteen), Pig One's skin became increasingly dry and there was no evidence of scavenging. On June 2nd (Day Nineteen) at 12:24 P.M., sections of the skin were torn and segments of the flesh appeared to have been eaten. Footage of opossums was captured from trail cameras (Figure 9.). The pictures show the presence of the animals around the carcass but do not capture the opossums interacting with the carcass. Nevertheless, I infer that opossums consumed some of the pig's flesh.

Figure 9. Opossum near Pig One on May 29th.

No further evidence of scavenging occurred during the initial trial. The bones were mapped and recovered on June 7th (Day Twenty-four) between 11:34 A.M. and

3:52 P.M (Figure 10.). A noticeable pattern can be discerned from the distribution of Pig One's skeletal remains. The cranium was found at the original location of the body, while the mandible was found six feet away from the cranium in the direction of movement. A group of forelimb bones and vertebrae was found three and a half feet away from the mandible in the direction of movement, while the majority of the skeletal remains were found three feet away from the previous group of bones at the final location of the body in their respective anatomical positions. A linear pattern, therefore, exists in the distribution of Pig One's skeletal remains. As animal scavengers, likely coyotes, moved the carcass in one direction, bones separated from the body and created a linear pattern.

The only discernable gnaw markings were discovered on a bone found outside of this linear pattern. A group of five long bones was found four and a half feet away from the closest skeletal elements. These bones were separated from the body on May 27th (Day Thirteen). One of these bones had both epiphyses chewed off and had several gnaw markings on the diaphysis (Figure 11.). According to Binford's (1981) classification system of carnivore gnaw markings, the bone contains six punctures, which appear to be inflicted by canine teeth, several pits surrounding the ends of the diaphysis where the ephiphysis have been removed and undulations at both ends of the daphysis. The bone appears to have been chewed in order to obtain bone marrow. The size of the punctures and gnaw markings indicate that the bone was gnawed by a carnivore.

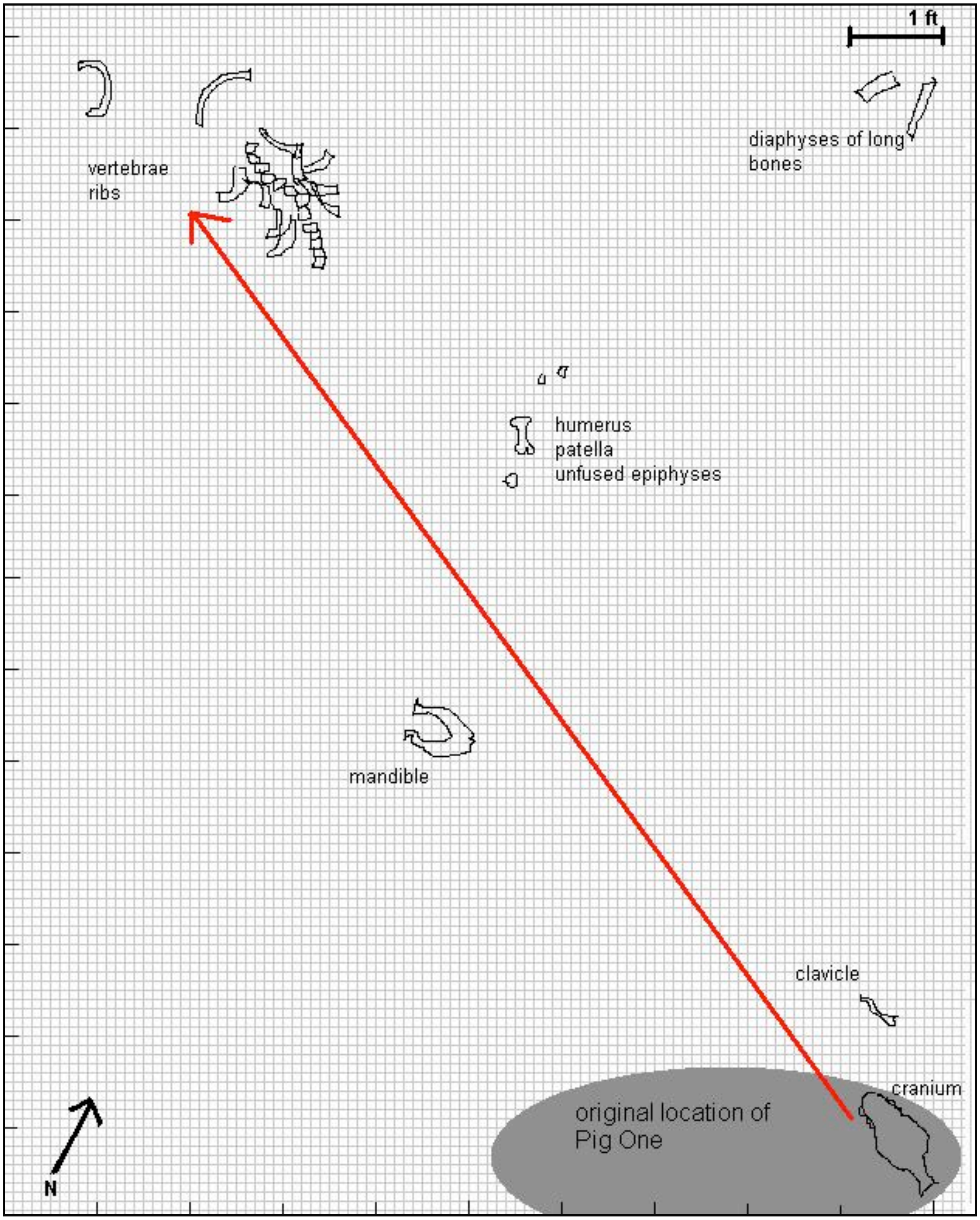

Figure 10. Site One: Final Distribution of Pig One's Skeletal Remains.

Figure 11. Site One: Long Bone with Evidence of Carnivore Gnawing.

Trial Two

Originally each pig was supposed to be taken out of freezing sequentially in order to observe each trial separately, however due to a freezer malfunction at the LSUSVM, Pigs Two through Four were removed from freezing on July 26th, 2010 and removed from refrigeration on July 31st, 2010. The second, third and fourth trials of this experiment therefore began on July 31st and lasted until August 17th, 2010, totaling 18 days. Between these dates, maximum temperatures ranged from 82º F to 100º F with a mean maximum temperature of 93º F. The minimum temperature recorded on-site ranged from 72º F to 82º F with a mean minimum temperature of 77º F. Humidity ranged from 74% to 100% with a mean of 90% (Figure 12.). Precipitation varied considerably over the study period with 11 out of the 18 days having some rain (Figure 13.). The presence of rain seems to have had some effect on scavenging activity, as, with one possible exception on August 15th, evidence of animal scavenging appeared after a day when it did not rain and on a day when it did not rain.

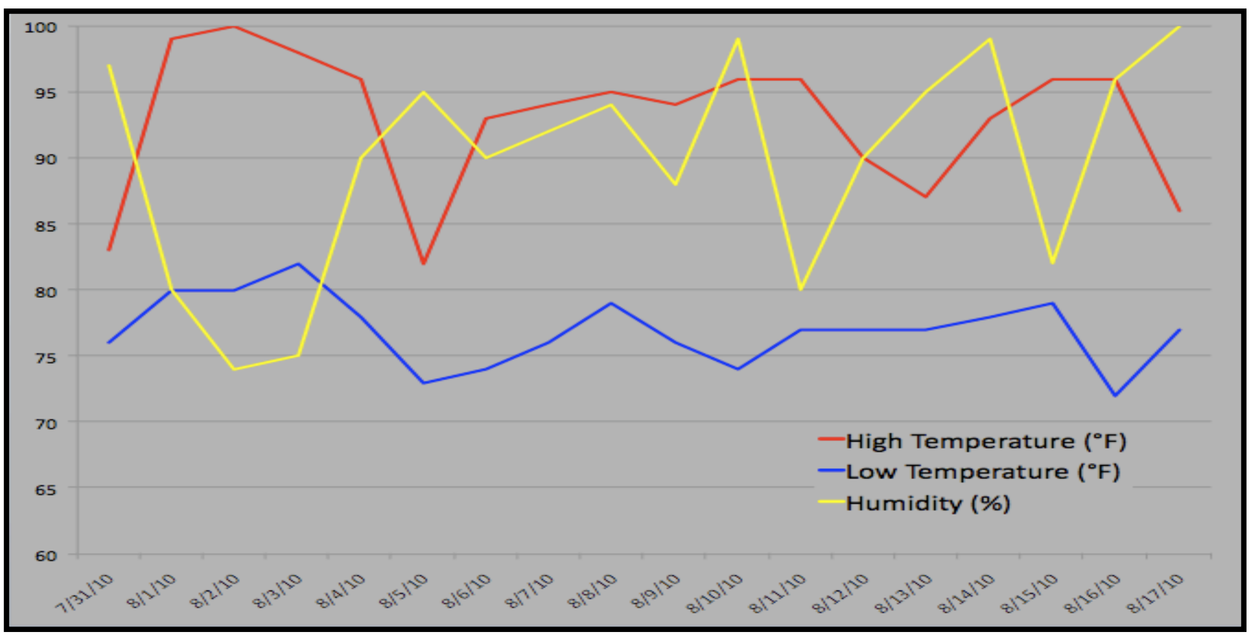

Figure 12. Sites Two, Three and Four: Humidity and Temperatures.

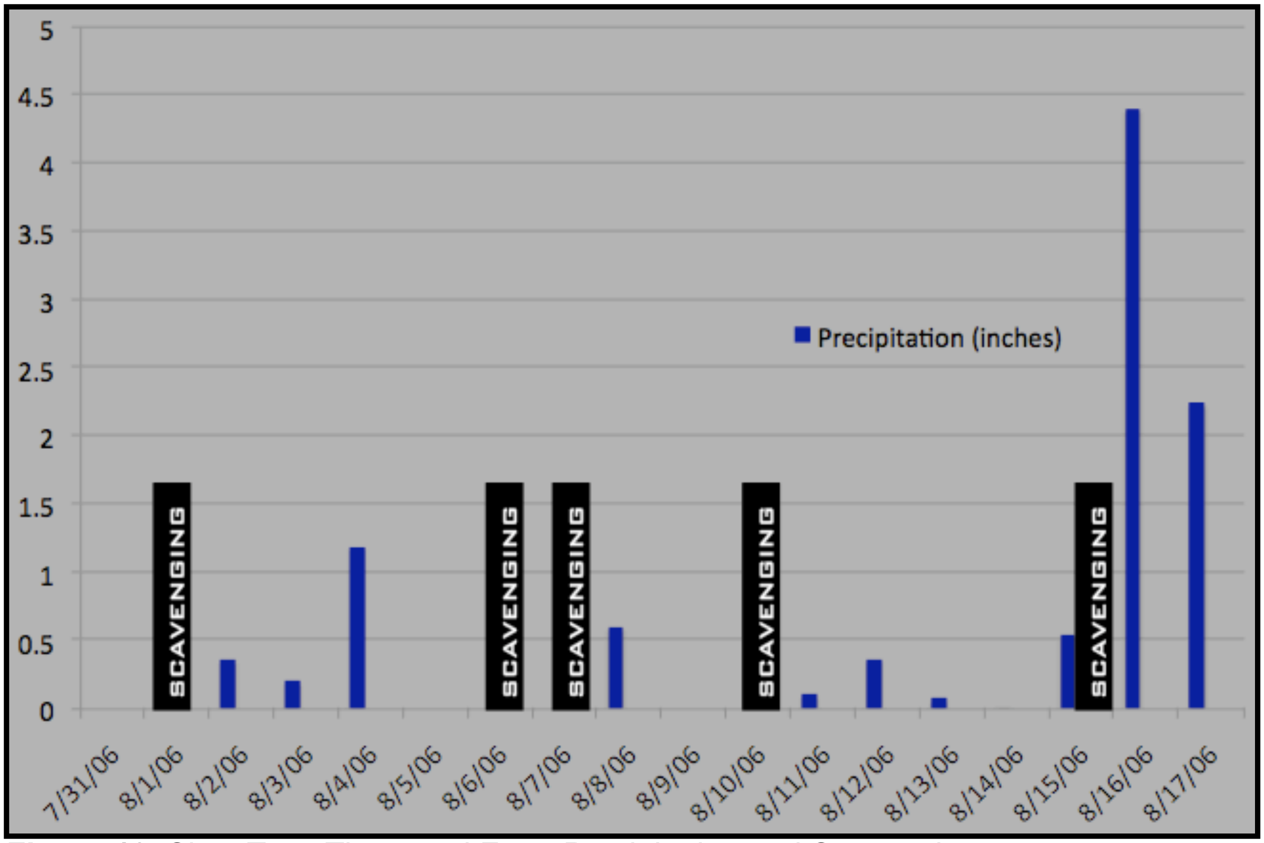

Figure 13. Sites Two, Three and Four: Precipitation and Scavenging.

Pig Two had a mass of 132 pounds, as determined by the LSUSVM. Pig Two was transported to the WWR and placed at site B on August 1st, 2010, at 11:46 A.M.. Pig Two was placed on its left side on a dirt surface with no vegetation underneath it. Each pig was placed in a different anatomical position in order to observe if animal scavengers chose to move cadavers into the same position to facilitate consumption. Three trail cameras were placed around the pig: one was placed at ground level, approximately three feet away from the pig's dorsal side, with a five second time interval setting; another placed approximately four feet off of the ground, at approximately ten feet away from the ventral side, with a 20 second time interval setting; and another at approximately one foot off the ground, at approximately six feet away from the pig's head, with a 35 second time interval setting (Figure 14.).

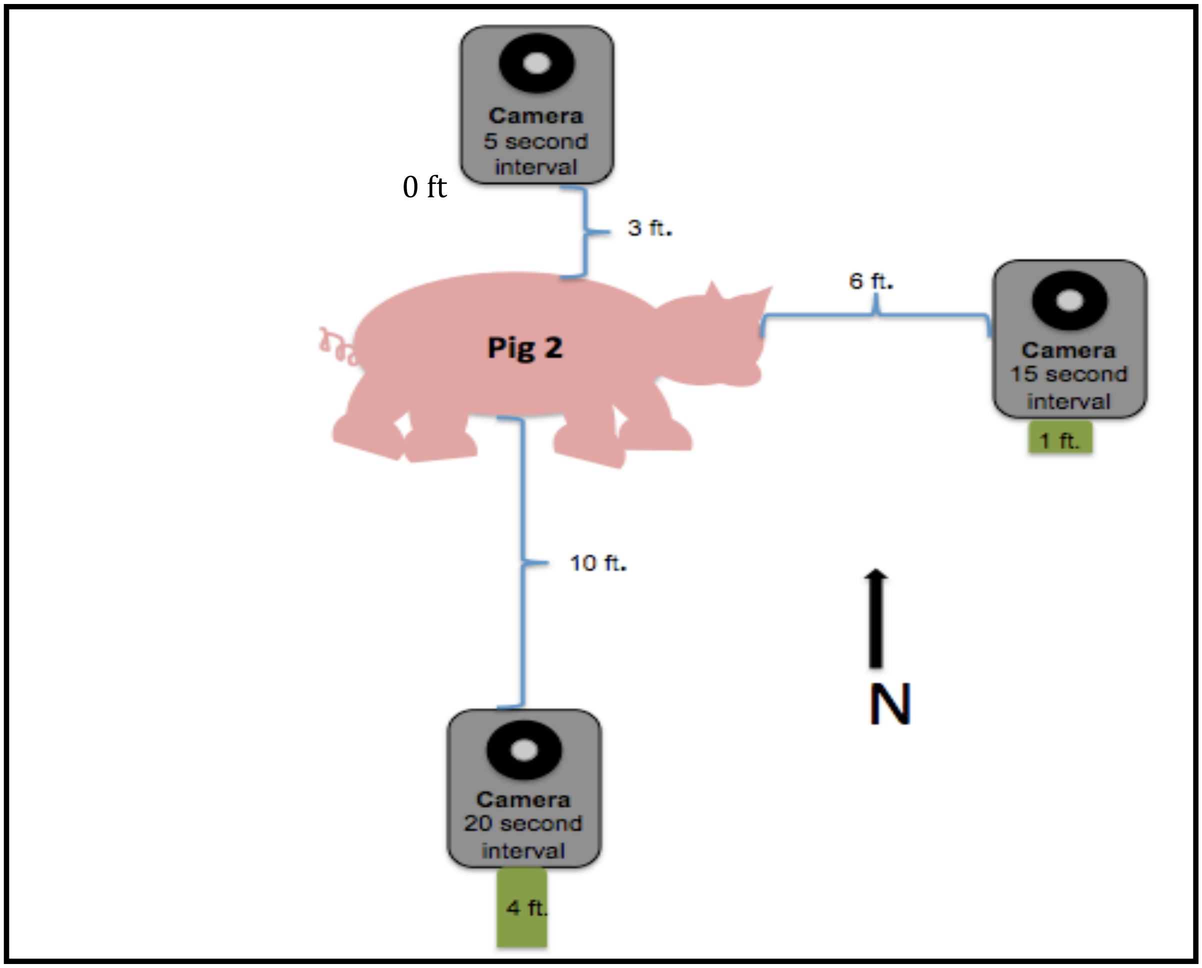

Figure 14. Site Two: Distances and Elevations of Wildlife Cameras.

On July 31st, 2010 (Day One) within minutes of Pig Two's placement at site B, flies began to arrive on the carcass. Flies settled around mouth, eyes and the surgical incision.

On August 1st, 2010 (Day Two) at 11:42 A.M., egg masses were recorded inside the oral cavity, around the eyes, in the ears and on the surgical incision. No evidence of animal scavenging was observed.

On August 2nd, 2010 (Day Three), evidence of animal scavenging was observed. The carcass remained in its original location and position. However, the left inferior limb had been removed, the flesh from the right inferior limb had been removed and a majority of the buttocks had been eaten. The skin around the buttocks was serrated, showing that the flesh had been bitten off (Figure 15.). Prior to the infliction of the bite, the flesh around the bite was not affected by either fly or beetle activity. Maggot activity was high around the front half of Pig Two, surrounding the face, torso, back, sides and upper limbs.

Figure 15. Site Two: Pig Two's Left Inferior Limb Removed.

All cameras with the exception of one recorded a large quantity of photos showing only vegetation. In addition to detecting movement created by animals, trail cameras may also detect movement of vegetation caused by wind or may start recording when sunlight hits the motion sensor. These factors could have contributed to the frequency of photographs taken. Another possibility is that cameras may have detected animal movement but were unable to take photographs of animals because they were placed too close to the cadaver. One camera, however, documented a coyote (Figure 16.). The picture depicts the animal around the carcass, but does not capture the animal consuming the carcass. Coyotes tend to be wary of cameras and areas where they detect a human presence. As such they are often able to "avoid photo-capture" (Sequin et al. 2003:2016). Harris and Knowlton found that coyotes responded with "avoidance and neophobic reactions" to novel stimuli found within familiar environments (2001:2009). Nevertheless, despite the lack of photographic evidence, I infer that a coyote or multiple coyotes removed Pig Two's left inferior limb, ate the flesh from the pig's right inferior limb and consumed flesh from the pig's buttocks.

Figure 16. Coyote near Pig Two, August 2nd.

On August 3rd (Day Four) at 11:50 A.M., Pig Two entered the bloat stage of decomposition. Minimal fly activity was observed and maggot migration had commenced as maggots were found between three and six feet away from the carcass. Beetle activity was moderate. Skin on the posterior portion of the carcass was dry. No evidence of animal scavenging was observed. Analysis was prohibited on August 4th (Day Five) due to rain. On August 5th (Day Six) at 11:20 A.M., Pig Two's face was fully skeletonized. Fly, maggot and beetle activity was high and the carcass had a strong odor of decay. Maggots were present on the inferior portion of Pig Two where animal scavenging had previously occurred. On August 6th (Day Seven) at 2:37 P.M., both the mandible and cranium were separated from the pig's body. Both bones remained in their relative anatomical position as their removal resulted from invertebrate scavenging.

On August 7th (Day Eight) at 2:42 P.M., evidence of animal scavenging was again observed. The carcass had been dragged approximately five feet from its original location. Both superior limbs were removed, and bite marks were observed on the flesh of one limb, found two feet away from Pig Two's right superior side (Figure 17.). The other limb was not recovered. Trail cameras captured dozens of white images, a few of which showed opossums (Figure 18.). Due to the distance the pig was moved, opossums are unlikely the primary animal scavengers that moved the body on the night of August 6th. Coyotes may have again disarticulated elements from the pig and moved the body, however no evidence exits to support this claim.

Figure 17. Site Two: Pig Two's Superior Limb Removed from Body

Figure 18. Site Two: Opossum near Pig Two, August 7th.

On August 8th (Day Nine), trail cameras again captured several pictures of opossums. Pig Two was not moved from the location it was found in the previous day and no evidence of animal gnawing was observed on the body. Due to the presence of opossums around the corpse without making an impact on the body, I infer that these animals were feeding on invertebrates around the corpse. Maggot and fly activity were minimal; beetle activity was moderate, especially on the underside of the corpse.

On August 9th (Day Ten) at 1:12 P.M., no evidence of animal scavenging was observed. Mummification of the carcass continued with the skin becoming darkened and hardened. Maggot masses were noted on the abdomen, in the neck and around the posterior portion of Pig Two, where both limbs had been removed. On August 10th (Day Eleven), maggots were only found on the ground surface and were observed 15 feet from the carcass. Fly activity was minimal, while a large number of ants were observed feeding on maggots.

On August 11th (Day Twelve), the skin was drier and fewer maggots were observed around the carcass. Most of the ribs were visible and the body was almost fully skeletonized. Trail cameras again recorded the presence of opossums; yet, no evidence of animal scavenging was noted to the body. I infer that opossums were feeding on invertebrates and not the pig.

Between August 12th (Day Thirteen) and August 15th (Day Sixteen), the corpse continued to skeletonize. On August 15th at 12:30 P.M., Pig Two was fully skeletonized, with some dried skin remaining around the vertebrae and ribs. Trail cameras captured the presence of a raccoon, yet no changes were noted to the corpse. I infer that the raccoon did not engage in scavenging.

The bones were mapped and recovered on August 18th (Day Nineteen) between 9:30 A.M. and 11:12 A.M (Figure 19.). A noticeable pattern can be discerned from the distribution of Pig Two's skeletal remains. The cranium and mandible were found at the original location of the body, while a majority of the skeletal remains were found five feet away from the cranium and mandible at the final location of the body in their respective anatomical positions. One bone was found two feet away from the axial skeleton. A linear pattern therefore exists in the distribution of Pig Two's skeletal remains. As animal scavengers, likely coyotes, moved the carcass in one direction, bones separated from the body and created this pattern.

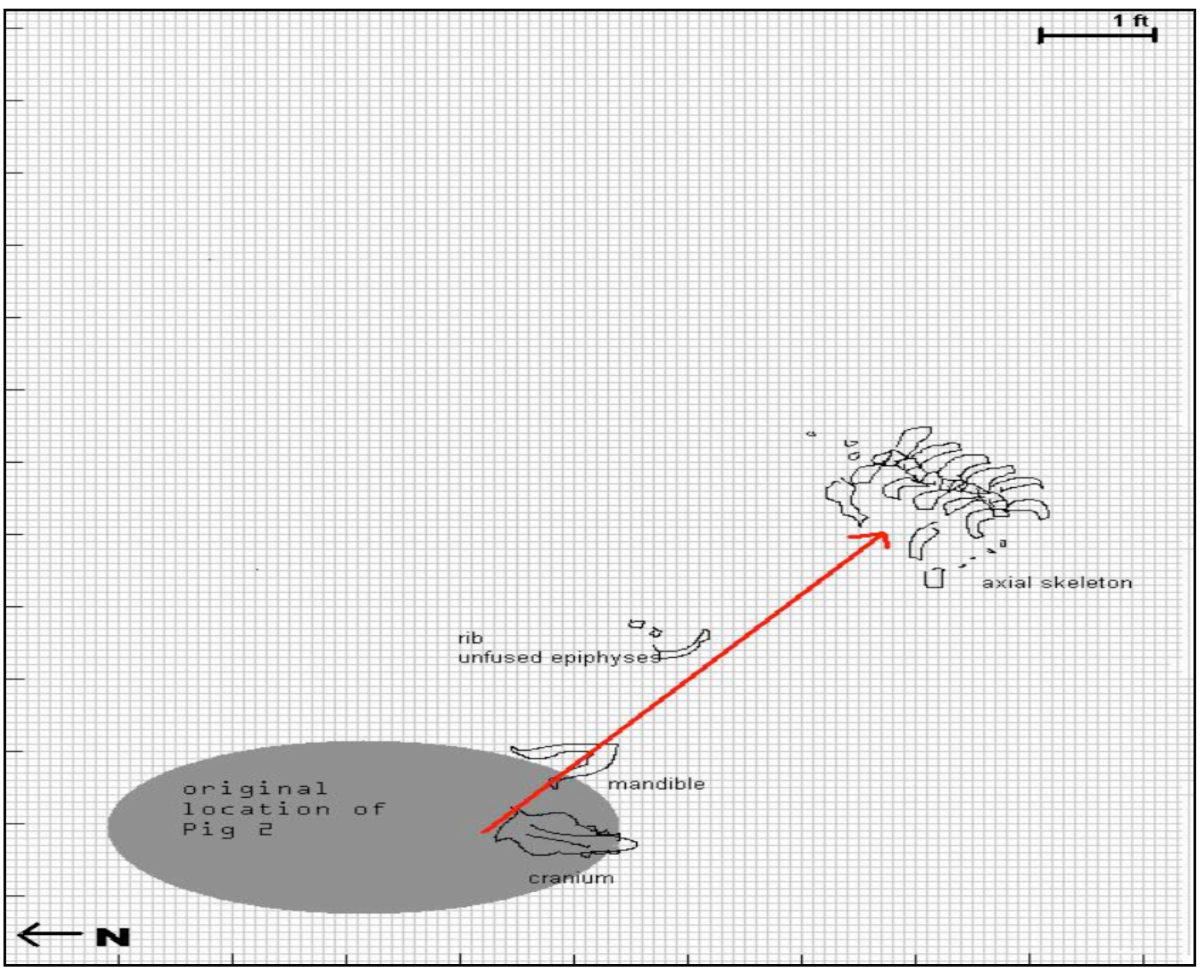

Figure 19. Site Two: Distribution of Pig Two's Skeletal Elements

Trial Three

Pig Three had a mass of 120 pounds, as determined by the LSUSVM. Pig Three was transported to the WWR and placed at site C on August 1st, 2010, at 12:20 P.M.. Pig Three was placed on its right side on a dirt surface with no vegetation underneath it. Two trail cameras were placed around the pig: one was placed approximately four feet off of the ground, approximately 10 feet away from the pig's head, with a 20 second time interval setting; and the other was placed approximately two feet off of the ground, at approximately five feet away from the dorsal, with a five second time interval setting (Figure 20.).

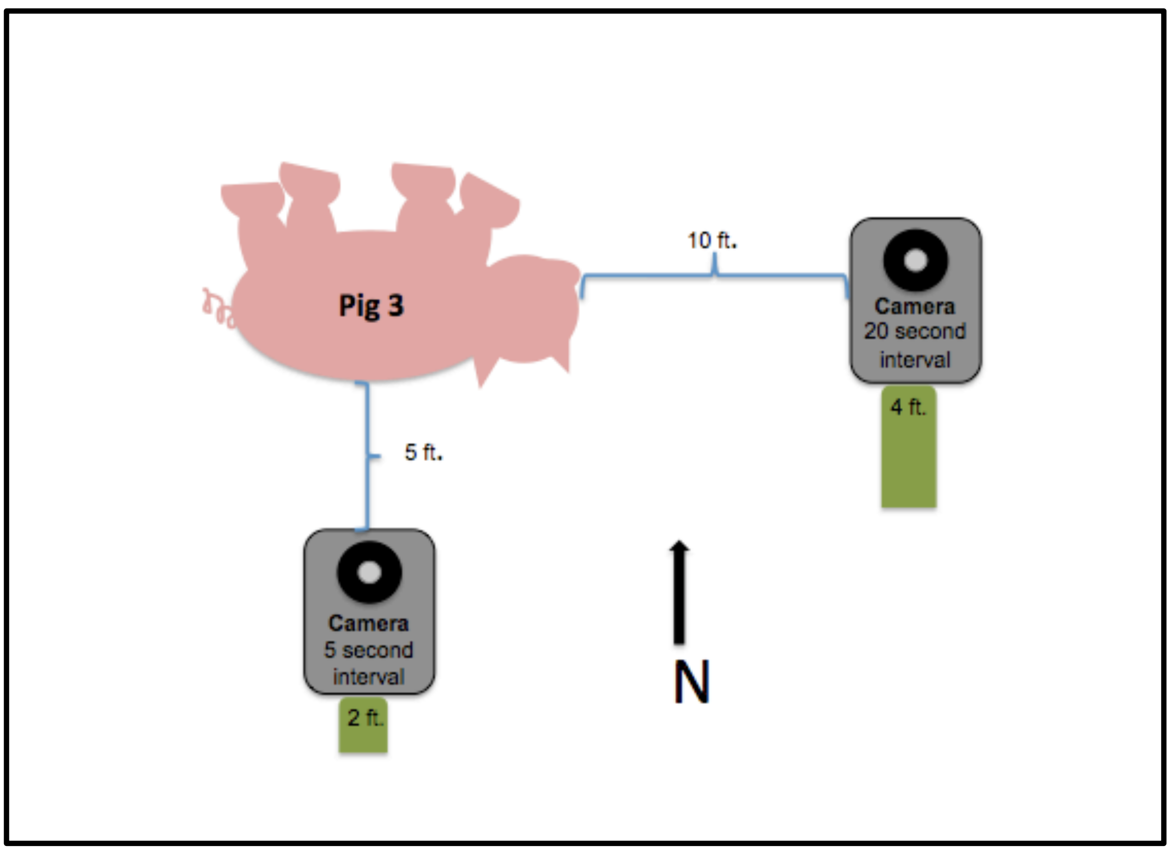

Figure 20. Site Three: Distances and Elevations of Wildlife Cameras

On July 31st, 2010 (Day One) within minutes of Pig Three's placement at site C, flies began to arrive on the carcass. Flies settled around mouth, eyes and ears.

On August 1st, 2010 (Day Two) at 12:22 P.M., Pig Three had been removed from site C. The dirt around the original location of the pig was darkened and a trail, over 15 feet in length, was created by dragging the body over the soil (Figure 21.). Multiple bones were found along the this trail with several large groupings of bones. Most of the axial skeletal was not recovered, yet the appendicular skeletal remains were recovered in a noticeable linear pattern (Figure 22.). The cranium was found in the original location of the body, with the mandible found two feet away in the direction of movement. A scapula and some long bones were found approximately eight feet away from the mandible in the direction of movement, while another group of long bones was found five feet away from the previous group. Attempts to locate the rest of the corpse were made, but ultimately the appendicular skeleton of Pig Three was not found.

Figure 21. Site Three: Trail Created by One or More Animals Dragging Pig.

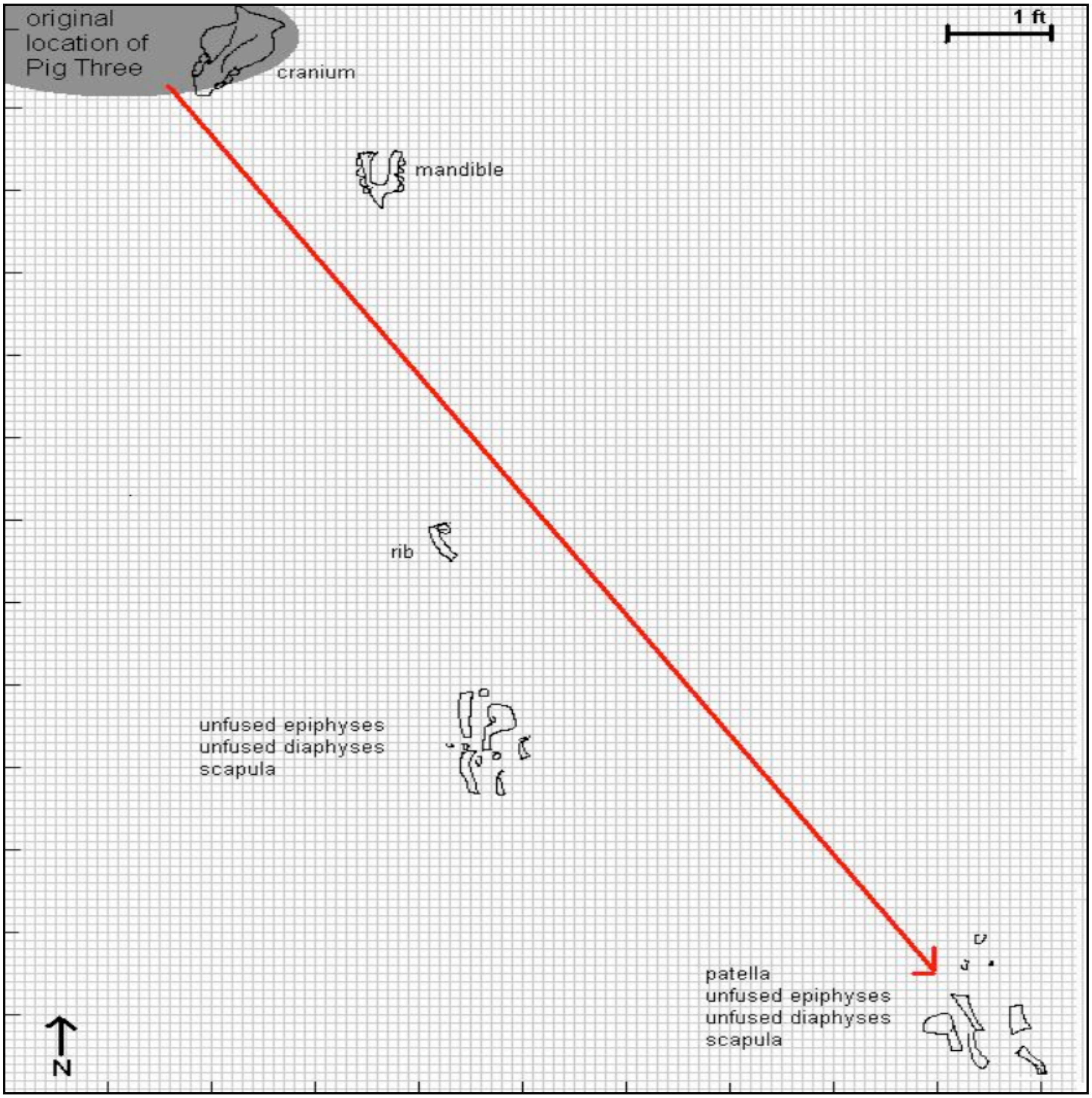

Figure 22. Site Three: Distribution of Pig Three's Skeletal Elements.

Based on the previous two trials in which I inferred that coyotes dragged carrion away from their original location in order to facilitate consumption, I infer that coyotes removed Pig Three.

Trial Four

Pig Four had a mass of 142 pounds, as determined by the LSUSVM. Pig Four was transported to the WWR and placed at site D on August 1st, 2010, at 12:45 P.M. Pig Four was placed on its ventral side on a dirt surface with no vegetation underneath it. Two trail cameras were placed around the pig: one was placed on the ground approximately three feet away from the pig's left side, with a five second time interval setting; and the other was placed approximately four feet off of the ground, at approximately eight feet away from the right side, with a 15 second time interval setting (Figure 23.).

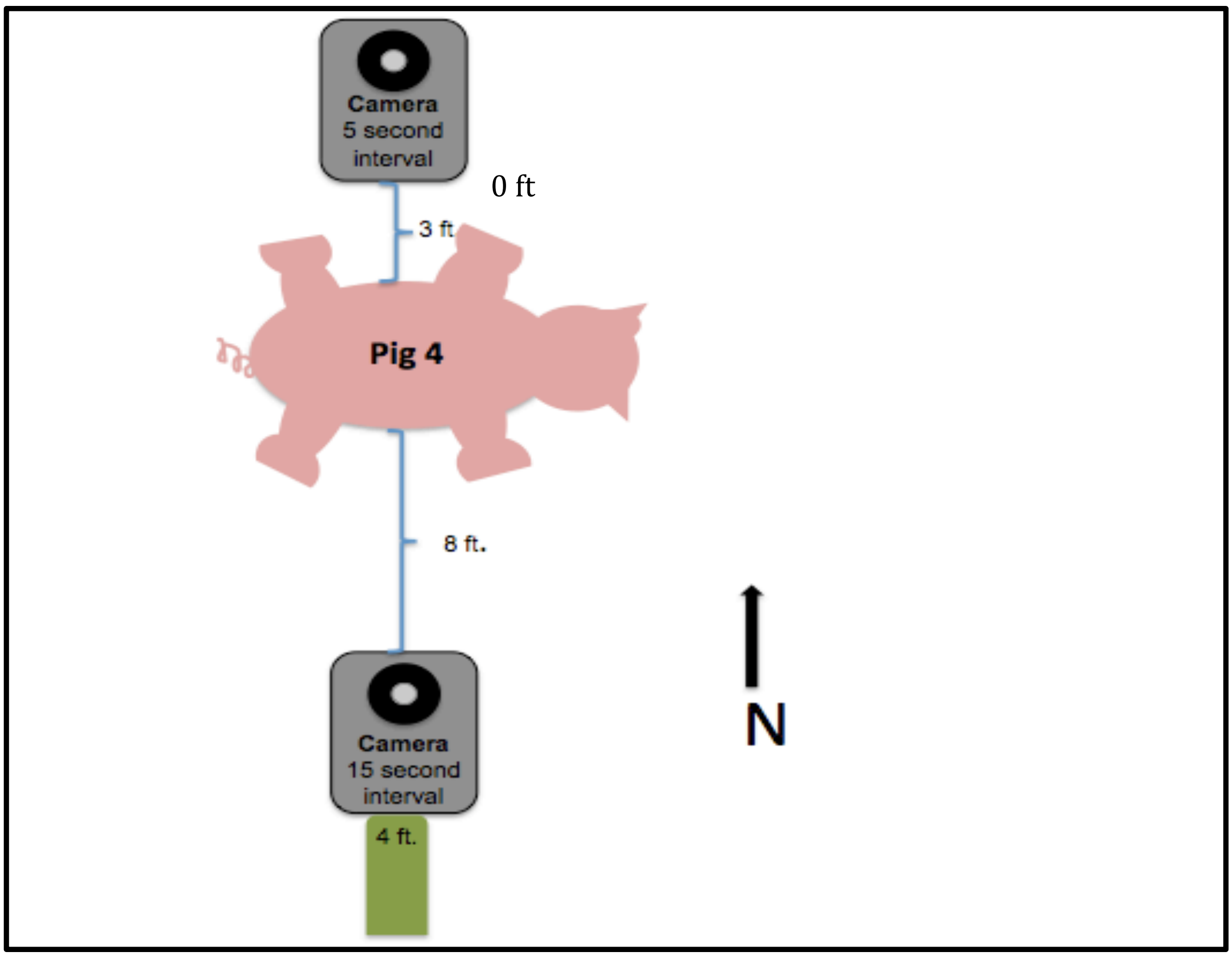

Figure 23. Site Four: Distances and Elevations of Wildlife Cameras

On July 31st, 2010 (Day One) within minutes of Pig Four's placement at site D, flies began to arrive on the carcass. Flies settled around the mouth, eyes, ears and on the pig's dorsal side.

On August 1st, 2010 (Day Two) at 1:20 P.M., Pig Four was completely skeletonized. The pig remained in relative anatomical position with no noticeable gnaw markings. Trail cameras were reviewed for evidence of animal scavenging and one camera revealed a picture of a turkey vulture, taken at 4:32 P.M. on July 31st (Day One) (Figure 24.). This was the only picture taken by either camera. No marks were observed on the skeletal remains of the pig and the bones were not scattered.

Figure 24. Site Four: Turkey Vulture near Pig Four, July 31st.

CONCLUSION

I have inferred from the current study on the succession of animal scavengers interacting with pig cadavers in South Louisiana, that coyotes start to consume carrion early after death followed by opossums. The study illustrates that some terrestrial animal species interact with carrion before others.

Trail cameras were used to identify the species of animals that interacted with the carrion but were not able to record feeding behaviors. The cameras used in these experiments were all placed within ten feet of the cadavers. In some cases cameras may have been too close to wildlife to capture discernable images. Also, cameras that were placed on the ground were more susceptible to being set off by sunlight and therefore took numerous pictures that did not depict animal scavengers (Cutler and Swann 1999). In two out of the four cases, trail cameras exhibited evidence of coyotes and then opposums interacting with carrion, while in a third coyotes are assumed to have consumed the cadaver based on similar patterns of feeding. In the fourth trial, a turkey vulture was shown to be the first and sole animal scavenger of the body. This cadaver was fully skeletonized in less than 24 hours. The site that had evidence of turkey vulture scavenging had less tree covering than the remaining three sites. Turkey vultures are thus likely to be an animal scavenger when there is less tree cover around the carrion.

Rain seems to affect animal scavenging as most evidence of animal scavenging coincided after a day when it did not rain and on a day when it did not rain. One possible exception of this exists, as an image of a raccoon was captured on a day when it did rain. No evidence of animal scavenging was noted on this day and I infer that the raccoon was merely passing by the camera and did not engage in scavenging activity. More research is needed to determine whether this pattern is due to chance or to animal behavior.

A pattern of destruction was not determined for the animals that interacted with the cadavers. One bone was recovered with gnaw markings. This bone exhibited punctures, pits and undulations typical of carnivorous scavenging. Due to the limited timeframe of the study and the fact that skeletal remains were recovered as soon as all soft tissue was no longer present, no additional bones with gnaw markings were found.

I infer that carnivorous animals are more likely to gnaw on bones near or after full skeletonization of a body. This information may aid in the determination of PMI as gnaw markings are more likely to be present when a body has had enough time to become fully skeletonized through invertebrate and vertebrate scavenging. In the case of this study, skeletonization was completed between 18 and 25 days and gnaw markings were found on day 13 when the cadaver was almost fully skeletonized with some dried tissue.

In addition to coyotes feeding on carrion soon after its disposal, these animals also have a pattern of dragging carrion and flipping it to access flesh unexposed to invertebrate colonization. Coyotes also remove elements from the body to be consumed at other locations. Unlike coyotes, opossums do not appear to move carrion as they feed. I infer that these animals pick flesh from the body that is easily accessible and also feed on the invertebrates in and around the body. According to Hopkins and Forbes slugs and snails are “the most important” food item for opossums during the summer months (1980:26). Due to the anatomical similarities between these invertebrates and maggots it is feasible that opossums primarily utilize carrion in order to find and consume invertebrate decomposers. Once any flesh left on the carcass starts to dry out and invertebrate activity becomes minimal, animal scavenging appears to cease.

As a result of the moving of carcasses by coyotes, the skeletal remains of bodies that have been scavenged by carnivores may be rearranged in a somewhat linear pattern with the cranium located at the original position of the body, the mandible closest to the cranium and the remaining skeletal remains located farther from the cranium and mandible but in line with the first two elements. This information can provide useful in scene analysis, as when recovering a scene that has been scavenged by animals it can be inferred that the original site of body deposit is located at or near the place where the cranium is found.

Insect and animal scavenges appear to affect each other's feeding patterns. For instance, opossums consume some of the invertebrate scavengers that have started decomposing carrion. This likely affects the natural succession of insects. Also, coyotes likely flip carrion to access segments of flesh that have not yet been colonized by insects. I infer that the movement of the body alters the location of eggs, larva and insects, and changes the location of orfices and colonized areas. This may also affect the natural succession of insects.

Summary

This study served to observe, document and evaluate the impact of wildlife on cadavers in an unprotected, outdoor environment. The data generated from this experiment aided to understand the behaviors of animal scavengers. The results of this experiment suggest a pattern in the succession of animal species feeding on carrion. With future replicate studies such a pattern may prove useful in taphonomic analysis.

This study provides information on the effects of animals on rates of decomposition in the summer months in Southeastern Louisiana. This study found that animal scavenging has an association with PMI. Utilized in conjunction with other dating methods, the observations of animal scavenging may prove beneficial in estimating a PMI.

Precipitation was the principal determining factor that influenced the presence of animal scavenging, as, with the exception of one case, animals did not scavenge on days when it rained or on a day after it had rained. Amount of tree cover was a determining factor in the species of animal that scavenged the cadaver, as the site with less tree cover was utilized by avian scavengers while the other sites that were well covered were utilized by terrestrial scavengers.

Further research is needed to give a more complete picture of the relationship between animal scavenging and PMI. Studies consisting of longer PMIs, conducted in different seasons and in different geographic regions, would be useful. Given the significance of animal scavenging on PMI estimates, the results of this study suggest that forensic investigators make every effort to identify the presence of animal scavenging so as not to confuse the results of this postdepositional process with body disposal or perimortem trauma. The results of this study also have implications for archaeological research, namely in how animal scavengers may affect the distribution of skeletal remains.

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