Estimation of time since death in humans using mature pigs

Tiffany T. Terneny

The University of Montana

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ESTIMATION OF TIME SINCE DEATH IN HUMANS USING MATURE PIGS

by

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B.S., University of Houston, 1995
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for the degree of
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Estimation of time since death in forensic investigations is difficult. In cases involving accidental death or homicides, it is useful to have at least a rough estimate of when the victim died in order to narrow down the person’s identity.

Studies conducted on the processes of decomposition can in some cases, aid in constructing a time frame within which death probably occurred. The stages of decomposition that a mammal goes through are clear cut and easily identifiable. Each stage is characterized by specific changes in tissue morphology and insect activity. Environmental conditions play an important role in decomposition. In warmer environments, decomposition occurs rapidly, while in colder climates the process takes longer. This thesis investigates the processes of decomposition that occur in the environment of Northwestern Montana. This is the first study of its kind conducted in this state.

The ability to accurately estimate time since death depends on knowing and understanding the stages involved in the decompositional process. The fresh stage, the bloat stage, the active decay stage, the advanced decay stage, the dry stage, and the remains stage all present specific visual clues, and these can be looked for in deciding what stage of decomposition the remains are in. Color of the skin, areas of damage, insect activity, and skeletalization are all important factors in making this determination. This thesis shows it is possible to estimate time since death in Northwestern Montana.
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INTRODUCTION - CHAPTER 1

The goal and purpose of this thesis is to measure the rate of decay of mature pigs to serve as a baseline from which the rate of decay of humans can be estimated. Determining time since death in forensic cases is an area of criminal investigation in which physical anthropologists and law enforcement officials have differing expectations. Physical anthropologists believe that it is difficult to estimate time since death and that such estimates are not precise. They believe that in cases where severe skeletalization of remains has occurred, it is impossible to determine the exact time since death. These reservations apply less to remains that still have significant amounts of tissue. In cases such as this, it is the job of a pathologist or medical examiner to conduct time since death studies.

Physical anthropologists occasionally handle cases in which a small amount of tissue may still be present, but the amount of tissue is too small to be informative to a pathologist. In these cases, a great deal of importance is placed on the degree of decomposition of the body. For physical anthropologists, it is important to recognize the stages of skeletalization, whether they are partial or complete. The methods most commonly used in this process look at such things as the presence of skin or muscle, the persistence of cartilage and/or ligaments, and the odor of the bones if there is any (Payne 1965).

Complete skeletalization is defined by physical anthropologists as no soft tissue left (including cartilage and ligaments), and no discernible odor coming from the bones. Other important factors that have aided in time since death estimations for physical anthropologists are insect activity, animal activity, temperature, and how much skeletalization has taken place (Payne 1965). For
example, the flesh from a body can be removed by a flock of black vultures in a few hours. It takes a little more time for the same result to be achieved by a pack of dogs or other animals (Bass 1987). In cases where carnivores and scavengers do not modify the cadaver, skeletalization may take months rather than hours. In situations such as these, insects and microorganisms play a major role in decomposition. High temperatures will hasten destruction by insects and microorganisms, while low temperatures will slow the process down (Bass 1987).

In an acidic environment, the mineral in bone called hydroxyapatite will break down into soluble salts of calcium and phosphorous. With a buried body, the more acid in the soil, the more rapid the breakdown. If the soil is basic or neutral, a buried skeleton can last centuries in good condition (Micozzi 1991). One feature that can alert physical anthropologists to signs of great antiquity in remains, is the presence of fine grains of sand or dirt in the marrow space of an unbroken buried long bone (Bass 1987). The dirt or sand enters through the nutrient foramina, which are very small. This is a common occurrence in buried prehistoric Native American skeletons.

What is important to note is that all of these methods of estimating time since death are highly dependent on the type of environment in which the remains are found. Not all environments have no seasonal change, or the presence of black vultures. From studies conducted in Florida, it is estimated that in climates similar to those of that state, defleshing of remains on the surface of the ground may occur in a minimum of two weeks, and a maximum of eight months. A buried body in the Florida type of environment will skeletonize in a minimum of one year, and possibly two years (Bass 1987). Extensive studies of decomposition have been conducted all over the south, at such
Universities as Florida and Tennessee. However, the weather and environment of Northwestern Montana is very unlike the environment of the southern states. Temperature, seasonal differences, and insect activity are all very different in Northwestern Montana. The goal of this study is to investigate whether or not it is possible to estimate time since death in Northwestern Montana using the method of decompositional stages developed in other areas of the United States, such as the south. I hypothesize that it is possible to estimate time since death using these methods. The data collected and analyzed will either support or disprove this hypothesis.

It is difficult for law enforcement agents and physical anthropologists to estimate how long human remains have been exposed to the environment of Northwestern Montana and its elements, because there are such great temperature changes in the state, especially seasonal changes. The information generated from this thesis may be valuable in assisting both law enforcement officials and physical anthropologists in Northwestern Montana and states that have similar environments, in determining time since death in homicide, missing persons, and accidental death cases, if the methods described herein can be shown to be valid.

Much research has been done using the decomposition of animals to estimate decomposition rates in humans. The work done by Payne (1965) is most applicable. In part of his research, Payne conducted a summer carrion study of the baby pig, *Sus scrofa* during the summers of 1963 and 1964 in South Carolina. Although the environment of South Carolina is decidedly different from the environment of Northwestern Montana in terms of flora and fauna, weather, and insect activity, the guidelines, materials, and methodology that Payne used seemed applicable to this project.
Several other researchers have discussed the various stages of decomposition of faunal remains. Reed (1958), in his study of dog carcasses in Tennessee, outlines four stages of decomposition, while others such as Johnson (1975) chose to have only two or three stages associated with decomposition. Johnson (1975) thoroughly discusses insect populations in terms of during which stages of decay they tend to be present, along with briefly outlining some stages and stating the impact of certain insect populations on those stages. For the purpose of my thesis, I have chosen to use Payne's (1965) stages, because they consisted of a greater number of categories. Payne's stages are: fresh, bloated, active decay, advanced decay, dry, and remains (1965).

In terms of information on insect activity, I used information from a number of sources. Catts and Haskell (1990), not only discuss the function of insect families in terms of decomposition, but also provide detailed sketches of the insects, which helped in identifying the samples of insects that were collected during this project. The research presented by Catts and Haskell (1990), was geared toward aiding law enforcement officials in the estimation of time since death using entomological samples. Another work which aided in the clarification of the presence and function of certain insect families, was Borror, Triplehorn, and Johnson (1989). Although this text was more general than specific, it served as a cross check for the identification of certain insect species that were encountered in my research.

In order to understand the processes of decomposition, changes in tissue morphology must be documented in order to understand the importance of the processes that redistribute matter back into the environment. Each aspect of the decompositional stages discussed is important in accumulating knowledge of
the process as a whole. Color of the remains, their condition, and their putrefaction are all important to this understanding. It is also imperative to discuss the insect activity associated with these stages of decomposition.
I initially considered using euthanized dogs for the purpose of this experiment, but I soon found out that it is difficult to obtain dogs for experimental purposes in the Missoula area. Not only would I not have known the time of death of the dogs, but I also faced the problem of variability in size and amount of hair. I could not be sure that the dogs I would receive would be all the same size, or have the same amount of hair on their bodies. In order to make my results as applicable as possible to humans, I wanted to find a species that has a weight comparable to that of humans, and whose body hair was roughly similar to humans as well. These criteria are fulfilled acceptably by Sus scrofa, the common pig. Upon choosing the species to use in this project, Phil Bowman, the Director of Lab Animal Resources, was notified. When I was notified that my choice was acceptable, I procured my choice of specimens.

Only two pigs were used in this study. I am aware that using a larger sample size would have been preferable, but a lack of funding prevented me from obtaining more research specimens. I could afford only two pigs, but I feel that the thoroughness with which the project was conducted makes up for the small sample size.

STUDY AREA

Northwestern Montana’s topography is characterized by a series of forested mountain ranges which run roughly northwest to southeast throughout the area. These ranges are the direct result of processes of erosion and glacial action. The glaciers affecting northwestern Montana roughly 10,000 to 100,000 years ago formed u-shaped valleys, sharp pinnacles and glacial moraines (McRae and Jewell 1990). Glacial ice dams stopped the flow of water in the Clark Fork River of northern Idaho around 15,000 years ago. This caused the
valleys of western Montana to become filled with water, creating Glacial Lake Missoula. This lake was drained and filled at least 41 times during a period of time lasting roughly 1,000 years. The evidence of draining and refilling of the lake can be seen clearly in the form of faint horizontal lines visible on Mount Jumbo and Mount Sentinel, which overlook Missoula (ibid). Missoula, Montana has an elevation of 3,205 feet, and is located at the mouth of Hellgate Canyon which is the path of the Clark Fork River between Mount Jumbo and Mount Sentinel. This narrow canyon broadens and joins five river valleys. The Flathead Jocko Valley from the north, Hellgate and Blackfoot valleys from the east, Bitterroot valley from the south, and the Missoula valley from the west. This creates a bowl shaped setting featuring both temperate weather and winter temperature inversion where warm, moist air is trapped and held in the valley by high pressure (ibid). The whole area is affected considerably by influence from the Pacific Ocean. The Rocky Mountains help protect this area from frigid continental winds, but Northwestern Montana still experiences snow accumulation. January tends to be the coldest month, with daily minimum temperatures of roughly 10 - 12 degrees Fahrenheit, to highs of 28 degrees Fahrenheit. July is usually the hottest month with an average temperature of 80 degrees. Thunderstorms occur in the summer, May and June are the rainiest months, wherein Missoula receives an average of about 13 inches a year (ibid).

The area in which this study was conducted, is on private property owned by Mr. Harvey Clouse. It is located near the corner of Reserve Street and Mullan Road in Missoula, Montana. To get to the site, it is necessary to go through cow fields, past power conductors, and into an area that is frequently used for disposal of deer and elk remains. The area contains a deer run,
Map 2

(McRae and Jewell, 1990:302)
through which ungulates are occasionally seen, and contains a variety of conifers such as Douglas fir, western red cedar, western hemlock, ponderosa pine, lodgepole pine, and western white pine. There is a rocky embankment that leads up to a gravel road, with ditches located in the area below the embankment. Chipmunks live in the rocks, and insects are present and visible, especially ants, wasps, bees, and flies. The environment has sparse brush cover in the spring months, but considerable grass and brush cover through the summer months. The specimens were put in an area just above what used to be a river, and river rocks are still present and visible. Skeletal remains of butchered deer and elk from hunting, can be found throughout the region, because it has long been used as a dumping ground for hunters. There are also a few dessicated carcasses of bovines which presumably died of natural causes.

The two pigs used for this research project were mature. The two pigs, one on the surface of the ground and the other buried, served as the subjects for the research project.

Pig #1 was designated as the pig to be buried. It was 125 cm long, 38 cm wide and weighed 160 pounds. It was buried in a hole 80 cm wide, 180 cm long and 60 cm deep by 1:30 PM on April 5, 1996, the day it was killed. A plywood board was placed over the grave in order to prevent animals from exhuming the carcass, and also to prevent the domesticated animals of the area from becoming injured.

Pig #2 was designated as the pig to leave exposed on the surface. It was 135 cm long, 43 cm wide, and weighed 180 pounds. It was also placed in its position by 1:30 PM on April 5, 1996, the day it was killed. It was placed on the surface of the ground uncovered. A 2 m by 1 m perimeter was set up around
the carcass of pig #2 using stakes and string. This perimeter served not only as a reference to determine disturbance of the carcass by scavenging, but it also served as the boundary of the study area and any disturbance within it was noted.

Insect activity, and the condition of the remains as they deteriorated, served as the two main variables of my research. To ensure consistency throughout this project, photographs were taken daily until the pig on the surface of the ground, Pig #2, became skeletonized. This was done in order to facilitate answering the question of how long it takes a human sized mammal to decompose in the spring/summer months when exposed to the environment of Northwestern Montana. The pig buried, Pig #1, was checked twice during the year. Pig #1 was examined infrequently to ensure that the subsurface decomposition was interrupted as little as possible. The first exhumation of the buried pig took place on September 1, 1996 beginning at 2:00 PM. The second and final exhumation took place on April 5, 1997. Through this project, standards useful for estimating time since death were developed which utilized tissue color, tissue decomposition, outside temperature, and insect activity as parameters.

The following information was recorded each day until pig #2 was skeletonized, and each time pig #1 was exhumed:

1. color associated with decomposition
2. areas where decomposition occurred, and when it occurred
3. insect activity, such as what insects were present, and where they were found on the carcass
4. scavenging that has taken place by birds or other animals
5. temperature and weather for the day
 Samples of all insects in and around the carcass were taken in order to be identified. After identification took place, each insect species was evaluated in order to estimate its importance and impact on the processes associated with decomposition.

 Many of the distinct physical changes a carcass undergoes during decomposition are the result of insect activity. Those insects which are known to feed on both dead and decaying organic materials are called saprophagous insects (Catts and Haskell 1990). This group includes not only those insects that consume the decaying materials, but those that may feed on other insects associated with carrion and/or those insects feeding on the microorganisms of a carrion environment. Although saprophagous insects are found in many orders of the insect world, only a few were encountered here.

 STAGES OF DECOMPOSITION

 Fresh Stage - The fresh stage of decomposition begins when the specimen is killed, and continues until the first signs of bloating occur, which usually takes around two days. The only odor associated with this stage is attributed to the natural smell of the specimen, and that which it might have been consuming prior to its death. Calliphoridae (blow flies), Muscidae (house flies), and Sarcophagidae (flesh flies) were among the first insects to arrive on the scene during the fresh stage of decomposition (Payne 1965). These types of flies generally deposit their eggs or larvae in the natural openings of a carcass, and also in any area where the skin is broken (Catts and Haskell p.50).

 Bloated Stage - The bloated stage begins at the first visible signs of bloating, and ends when the bloating process is no longer evident. This stage of
decomposition is the result of a build up of gases trapped inside of the carcass. The production of these gases is the result of the anaerobic breakdown of proteins, and is called putrefication. The first visible signs of bloating usually occurs in the region of the abdomen. One noticeable result of this is that small amounts of blood are forced from the nose and anus. This stage of decomposition can be affected directly by the weather of the region. If the ambient air temperature is warm, bloating will occur more rapidly and last 2 to 5 days. If it is colder, the carcass will go through a series of inflations and deflations, over a period of several weeks. This often happens winter months when processes of freezing and thawing occur (Johnson 1975).

At this stage, the insects Calliphoridae (blow flies), Muscidae (house flies), Sarcophagidae (flesh flies) are still present and actively depositing their larvae. Also present and depositing larvae at this time, are Piophilidae (cheese skipper flies), and Lonchaeidae (small blackish flies). Histeridae (hister beetles), ants, Staphlinidae (rove beetles), Drosophilidae (small fruit flies), Coreidae (leaf-footed bugs), and Stratiomyidae (soldier flies) all visited and had an active role in speeding up decomposition at night (Payne 1965).

**Active Decay Stage** - The active decay stage begins roughly when bloating has ceased, and ends when the majority of flesh has been removed from the specimen. This stage of decomposition is characterized by intense insect activity. The skin of the carcass is ruptured in many areas at this stage of decomposition. This rupturing of the skin aids the internal processes of putrefication. This stage is marked by the presence of larvae that have penetrated the skin of the research specimen, and are consuming the carcass. As the burrowing of the maggots takes place, two important processes occur.
First, the air that enters the carcass through the burrowing action of the maggots aids in the decay of the interior. Second, the tissue of the carcass reaches a liquid state as a result of certain enzymes secreted by the maggots (Johnson 1975). The larvae usually begin consumption at those points on the carcass that offer the least amount of resistance, such as eyes, ears, nose mouth and anus. This stage is characterized by the greatest amount of insect activity with many different species being involved. Areas of skin experiencing the most maggot activity are marked by the loss of hair. Those areas of skin with the least amount of maggot activity, retain the hair for a longer period of time. Also during this stage, the carcass takes on a wet appearance, where the liquefication and disintegration of tissue begins and continues to be noticeable (Payne 1965). On rainy days, the products of this liquefication of tissue turn into a thick tan colored foam, a result of both maggot movement in the area where the foam is seen, and maggot excrement. Color of the tissue is also a factor here, and is seen in various combinations, such as black, dark brown, light brown, orange, tan and green. The odor of decay is at its strongest during this stage of decomposition as well, the strong putrid smells being associated with the breakdown of tissue. Staphylinidae (rove beetles), Histeridae (hister beetles), Calliphoridae (blow flies), Muscidae (house flies), Sarcophagidae (flesh flies), Sepsidae (Black scavenger flies), Otitidae (picture - winged flies) are present on the carcass for the first time during this stage. Silphidae (carrion beetles), Phalangidae (daddy - long legs), Tachinidae (a type of fly that predates on other flies larvae), Syrphidae (syrphid flies or flower flies), Sphaeroceridae (small dung flies), Apoidea (bees), Geotrupinae (earth - boring dung beetles), and Carabidae (ground beetles) were also noted to be present for the first time during this stage of decomposition (Payne 1965).
**Advanced Decay Stage** - In this stage of decomposition, the soil around the carcass up to 50 centimeters away, and down to 3.0 centimeters, is disturbed. The disturbance manifests itself as minute tunnels in the dirt surrounding the carcass that are the result of the burrowing action of arthropods, such as maggots (Reed 1958). There is still dessicated tissue present around some areas, such as the rib cage and cranium. Most of the tissue has already been removed, and color of the flesh that remains in scattered places on the carcass can be described as golden brown (Reed 1958). At this stage of decomposition, most of the odors associated with decay have faded significantly. Also, the insect activity changes greatly with respect to the quantity and variety of species. The numbers of Calliphoridae (blow flies), and Muscidae (house flies) drop off significantly, while the numbers of Sphaeroceridae (small dung beetles), Drosophilidae (small fruit flies), and Otitidae (picture-winged flies) increase substantially (Payne 1965). Staphylinidae (rove beetles) and Histeridae (hister beetles) are still present at this stage in medium numbers (Payne 1965). Trogiidae (small winged psocids) are also present at this stage (Payne 1965). The beetles and smaller insects burrow through the soil around the carcass during the day, and seem to be most active during the night (Borror et al 1989).

**Dry Stage** - It is sometimes difficult to determine exactly when the advanced decay stage ends, and this stage begins. Many researchers have combined these two stages into one (Reed 1958). For the purpose of this thesis however, the two are distinguished from each other. This stage can most easily be defined as the stage in which insect activity and tissue disintegration have slowed considerably or stopped altogether. Mummified or dissecated skin,
cartilage, and bone are all that remain. The bones associated with the carcass begin to bleach out at this stage, and the arthropods present are species that consume what little is left, such as the dry skin. Some examples of these insects and other arthropods are the centipedes, millipedes, isopods (tweedle bugs), snails, Leptoceridae (long-horned caddisflies), dermistidae (skin beetles), Nitidulidae (sap beetles), Cleridae (checkered beetles), ants, and mites (Payne 1965). Many of these smaller insects still found around the carcass during the dry stage are soil-inhabiters. Soil-inhabiters feed on the excess carrion that became mixed with the soil surrounding the carcass (Catts and Haskell 1990). At the latter end of the dry stage, Dermistidae (skin beetles) and others begin to leave the partially dissecated and slightly bleached bones. Other insect families such as Sphaeroceridae (small dung flies), Drosophilidae (small fruit flies), Psocidae, and Nitidulidae (sap beetles) are still in the vicinity (Payne 1965).

Remains Stage - This is the final stage of decomposition to be discussed in association with this research project. It is very difficult to determine exactly when the dry stage ends and the remains stage begins. There are a few clues to help. At this stage there are typically no insects affecting the carcass, except for those normally present in the surrounding area. The only odor present is that of the surrounding area, and all that remains of the carcass is bone and small bits of dried flesh (Payne 1965).

Studies done in association with buried pigs have outlined many of the same stages that are used with carcasses decomposing above ground. For the purpose of this thesis, these stages used in reference to Pig #2, (the surface pig) will also be applied to Pig #1, (the buried pig). Although this pig was not
checked as often in relation to this research project, the information gleaned from the buried pig is still important.
RESULTS - CHAPTER 3

The stages associated with decomposition outlined in the previous chapter help in understanding the changes that the carcasses of Pig #1 and Pig #2 underwent over the span in which this research was conducted.

RESULTS FROM PIG #2 (EXPOSED)

The changes that occurred with Pig #2 will be discussed first, because of the more extensive data collected for this specimen.

FRESH STAGE

The fresh stage of decomposition in relation to Pig #2, began on April 5, 1996 the day the pig was killed, and lasted until, April 7, 1996, when the pig began to bloat. On day one, the day the pig was first laid out, the temperature was seventy degrees. Flies were already beginning to show attention to the carcass (Fig.1). On the second day, fly activity was especially apparent in the area associated with the death of the pig: behind the ear where it was put down by being shot with a firearm. The skin color of the carcass began to change from its natural pink color, to a deep purple in the areas of the neck and head (Fig. 2). Red ants were visibly congregating around the area of the snout, where a minute amount of blood was visible. This was the result of pressure building up inside the carcass, and forcing out the blood as bloating began.

BLOATED STAGE

Day three, April 7, 1996, marked the end of the fresh stage, and the beginning of the bloated stage of decomposition. The bloated stage lasted from April 7 to April 13. On day three, a large amount of blood had drained out of the pig's snout. This was probably due to the extreme bloating of the carcasses' head and neck, which had taken on a very dark purple hue (Fig.3). No maggots
were visible yet, but fly activity had greatly increased. Samples were taken, and
the fly activity was determined to be associated with Muscidae (house flies),
Calliphoridae (blow flies), Sarcophagidae (flesh flies) and Drosophilidae (fruit
flies), all of which were extremely active around the area of the gunshot wound.
Ants were observed beginning to work on consuming the tips of both ears of the
pig. As the bloated stage ran its course, many changes began to happen.

On day four of the decompositional process, the skin color of the
abdominal region had continued to change from its natural pink color to hues of
green and purple (Fig. 4). Flies were still concentrated around the region of the
head, and by the fifth day, the Calliphoridae (Blow flies) were visibly laying eggs
in the mouth and snout of the carcass. The size of the gunshot wound behind
the pig’s ear began to enlarge, as ants and flies consumed the exposed flesh,
and the skin color of the underside had turned to a splotchy green and blue
(Fig. 5). The carcass was so bloated, that the legs of the pig were no longer
touching each other, but spread apart a considerable distance. At this time as
well, ants were consuming the nipples of the carcass.

By the sixth day, the skin color of the underside of the carcass had turned
entirely green. At this time the outside temperature had turned colder, it was fifty
degrees on the 10th of April.

There was little change on days seven and eight; the pig was still
extremely bloated, and the underside skin color of the carcass remained a deep
green.

On the ninth day, the last day of the bloated stage, the bloating of the
carcass had ceased. The legs of the carcass were once more touching each
other, even though the green color of the underside remained. The damaged
area behind the ear continued to extend, and by April 13 (day 9), it had reached
into the region of the neck (Fig. 6). The fly activity at this time was still concentrated around the head, but now was most intense in the area of extensive damage behind the ear.

**ACTIVE DECAY STAGE**

The active decay stage began on April 14, 1996 and lasted until June 20, 1996. During this stage, the carcass experienced the most change in terms of insect activity and decomposition. It would be extremely difficult to explain the changes that occurred during this stage on a day by day basis, because the stage spanned roughly two months. Instead, it seems more reasonable to give an overview of the changes that occurred, paying attention only to certain dates in which significant change took place.

The underside of the carcass turned from a deep green to a deep blue during the first days of the advanced decay stage (Fig. 7). As time went on, this deep blue color turned to black and began to spread to other regions of the carcass such as the leg (April 19), and neck regions.

In areas that were particularly concentrated with maggot activity, the skin became very thin, due to consumption by the maggots. This was first visible on day 23 of the decompositional process, April 27, when an area extending from the back legs to the rump became a distinct pea green color.

By day 24, the black areas of skin in the abdominal region had become even more prominent (Fig. 8).

By day 33, the black area of skin located on the underside of the carcass, was in the process of sloughing off. It contained small holes, and had a lattice-like appearance due to the action of maggots eating through it.

A brown colored region appeared on the abdomen of the carcass on day 35. By day 38, this brown colored spot had turned an orange color and become
depressed into the body of the carcass. Later it became an area of exposed
tissue that continued to spread to the dorsal side of the specimen, where
maggot activity was obvious. Areas of skin on the carcass that had turned black
were exhibiting a wrinkled texture, and then sloughed off (Fig. 9). After this loss
of skin occurred, the carcass began to take on a wet, waxy appearance in those
areas where skin loss occurred.

By the end of the active decay stage (day 77) most of the flesh on the
carcass had disappeared. The little tissue left took on a golden brown,
mummified look, marking the beginning of the advanced decay stage.

In terms of insect activity during the active decay stage of decomposition,
maggots became apparent by day 11, and were visible in the snout and mouth
of the carcass. On this day as well, beetles made their first appearance, and
were visibly feeding on maggots in the mouth and snout of the carcass.
Throughout this stage of decomposition, beetles were a good indicator of where
the most maggot activity was taking place. Members of the family Silphidae, or
black and white carrion beetles, were consuming the maggots and other larvae
found on and in the carcass. Ants continued consuming areas such as the
nipples of the abdominal region. Members of fly families such as Calliphoridae
(blow fly), Muscidae (house fly), Sarcophagidae (flesh fly), Piophilidae (cheese-
skipper flies) and Drosophilidae (fruit flies) were all present, busily laying eggs
and consuming the carcass.

On day 18, the flies were not only concentrated in the region of the head,
but began to focus around the anal region of the carcass (Fig. 10). Maggots
then began to concentrate in the shadiest areas of the carcass such as the
cranium and the folds of skin between the legs. The carcass was partially lifted
to inspect underneath, and maggots were active and visible there as well.
Maggot activity in the area of damage in the cranial region was very high (Fig. 11).

By day 29, maggot activity was visibly going on inside the carcass; the skin had become so thin that they were visible in areas such as the abdomen. Also on day 29, the larvae of the carrion beetle, (Silphidae), were visible on the carcass for the first time consuming maggots. As the maggots consumed the carcass, a green - gray liquid appeared accompanied by a vanilla colored foam in all the areas in which they concentrated. This was most visible in the region of the head, neck, and shoulder, especially after it had rained on May 12, day 38, and it was also seen in the areas between the carcass' legs, the posterior region, and the region of the abdomen. This ooze and foam continued to be generated even when it was not raining (Fig. 12). By day 45, this foam and ooze encompassed the entire carcass. The surface of the carcass was visibly rising and falling due to maggot activity inside, and by day 51 fly larvae was being laid in the dirt in the areas that the foam and ooze had penetrated.

Since there was so much maggot activity during the active decay stage, temperature of the maggot masses in different areas of the carcass was taken. The outside temperature on May 25, 1996, day 51 of the decompositional process, was 70 degrees. Temperature reading #1 was taken on a maggot mass located in the area of the back right leg which registered at 92 degrees Fahrenheit. Temperature reading #2 was taken in the area of the right front leg where the bones of the carcass were visible, this reading registered 100 degrees Fahrenheit. Temperature reading #3 was taken of the cranial region inside the head of the carcass which read 96 degrees Fahrenheit. The last temperature reading was that of the maggot mass occupying the ooze outside of the body on the ground soil. This last reading registered 93 degrees
Fahrenheit. Readings #2 and 3# appeared to be the ones of highest maggot density, and also had the highest temperature readings, so it follows that the higher the apparent density of the maggot mass, the more heat that mass generates. Maggot activity continued and was consistent throughout the active decay stage of decomposition. Evidence of maggot activity was observed by the presence of foam (Fig. 13).

On day 63, or June 5, Histeridae (hister beetles) and Dermestidae (skin beetles) were visibly consuming tissue in areas where only a small amount of tissue and ligaments remained. By the beginning of June, many of the maggots had pupated, although maggot activity was still occurring. Evidence of this was seen in the amount of pupal casings around the carcass. The two days before June 18, day 75 of the process, Missoula experienced thunderstorm and rain activity. After this intense rain, maggot activity became intensified due to the newly introduced moisture, but by day 77 the activity came near to completion as the carcass dried out. The insects present at the end of the active decay stage were mostly made up of members of the families Histeridae (hister beetles), Dermestidae (skin beetles), Silphidae (carrion beetles) and their respective larvae.

At the beginning of this stage, the region of damage that had radiated out from the area of the gunshot now extended into the shoulder region, and by day 12 (April 16) it had become deeper (Fig. 14). Distinct contrasts between red and white tissue of muscle and fat was discernible in the depth of the damaged region. After day 12, or April 16, 1996 this area continued to experience insect activity in the form of maggot and ant consumption throughout this stage. Upon looking at the carcass, it was obvious that the majority of damage occurring during the first weeks of this stage was the result of a concentration of insects in
the region of the head, spanning down into the shoulder region. By April 21, or
day 17, portions of the cranium and upper vertebrae began to become visible
and by day 24 the damage encompassed the throat region of the carcass. On
day 30, an indentation appeared right above the region of the pig’s tail. The
skin was not missing or broken in this area, it was simply a deep depression.
By day 42, the head and shoulder region of the carcass was entirely caved in,
and the interior abdominal region had begun to be exposed due to insect
consumption of the covering flesh.

On day 46, another area of penetration was present in the region of the
abdomen, under the nipples toward the back legs. At this time as well, the skull
of the carcass became distinctly visible, and the bones of the front right leg were
visible as well (Fig. 15). A blue organ, possibly part of the pig’s stomach,
became visible in the exposed interior of the abdominal region. The area
where the interior was exposed was shredded on the edges and tissue was
visible on the ground nearby (Fig. 16). It appeared as if something had been
consuming the flesh by tearing off pieces of tissue. Another area of skin above
the back legs had visibly been consumed.

On May 31, 1996, day 57 of the decompositional process, the carcass
had visibly changed position. The carcass had been dragged out of the study
perimeter (Fig. 17). The carcass was now on its back, and the underside, such as
the abdominal region, now faced up. The chest cavity had been shredded
in some places, and no skin or fur was present on the underside region. There
was a portion of intestine nearby that was filled with grain, and the scapula,
humerus, vertebrae, and pieces of the skull were now visible. A few days later,
the right humerus, left tibia and fibula, sternum, upper vertebrae (cervical and
thoracic), scapula, radii, ulnae, and skull were all plainly visible (Fig. 18). On
day 64, the region of the ribs still had a wet, slick, black appearance, although a large portion of the flesh was removed. Parts of the pelvis and the entire sternum were visible. By the 17th of June, day 74, all the ribs were visible, and by the 18th all the bones associated with the legs, the femur, tibia, fibula, and the metatarsals were recognizable. At the end of the active decay stage, no blackish tar residue was present at all. The specimen was very dry and mummified looking, with little tissue left on the carcass.

ADVANCED DECAY STAGE

The advanced decay stage started on June 21, 1996 and lasted until July 16, 1996. On the first day of the advanced decay stage of decomposition, or day 78 of the decompositional process, it had rained all day, so the remaining tissue lost its golden brown color because of the moisture and took on a white hue (Fig. 19). This condition continued until the weather cleared up on the 23rd of June, day 80 of the decompositional process, when the carcass resumed the characteristic golden-brown color associated with this stage of decomposition. Paw prints and burrowing activity were visible in the soil around the carcass, and there was still a small amount of insect activity by Drosophilidae (small fruit flies), beetles and maggots. The areas of skin that had been eaten or torn at recently were white, in contrast to the golden-brown color of the tissue that had not been disturbed. What was left of the carcass was lying in a pool of pungent, foul-smelling ooze, the result of rain experienced in the previous days. On day 81, what was left of the carcass was a golden conglomerate of damp ligaments and bone containing a small amount of flesh sitting in a pool of liquefied matter. The right femur, the left femur, both tibiae and fibulae, sternum, upper ribs, humeri, ulnae, the left scapula, vertebrae, skull, and coxal bones were all visible. There was still a good amount of hair
and skin on certain areas such as part of the skull, and it was very easy to see how, at this stage of decomposition, an animal carcass could be mistaken for human remains by the untrained eye.

On day 82, paw prints were once again visible in the soil surrounding the carcass. The position of the right femur had been altered, and skin had been removed by tearing from the area where the right metatarsals were located. Mites and beetles were visibly burrowing in the soil under and around the carcass, two or three Calliphoridae (blow flies), many Drosophilidae (small fruit flies), and ants were present at this stage of decomposition. Also present were the dry pupal casings of many insects (Fig. 20). It was 78 degrees that day and the carcass was visibly being affected by the heat, as the skin that was left on the back legs and rib cage had taken on a sweating appearance, which made the golden-brown color of the carcass appear slightly darker. By day 90, the second of July, there was still a very small amount of tissue left on the carcass, such as in the area of the chest cavity where maggots were still visibly working. Most of the exposed bones seemed to begin to change color, from a dark brown to a lighter shade of brown, and Drosophilidae (small fruit flies), a few maggots, and beetles were still present. By day 99 of the decompositional process, or July 11, 1996 skin still covered a small area of the skull and areas of moist tissue could still be found adhering to the rib cage (Fig. 21). On day 104, or July 16, 1996, the last day of the advanced decay stage of decomposition, the skull of the carcass still had a small amount of skin left on it, but the exposed areas were dry and beginning to bleach out, along with the aforementioned exposed bones. The little tissue left on the carcass was totally dried out, taking on a deeper shade of the golden-brown color.
DRY STAGE

The dry stage in the decompositional process began on July 17, 1996, and lasted until October 30, 1996. At this stage of decomposition, there was no visible insect activity. A small amount of skin was still covering the cranium, and a small area of the chest. There were small areas of moisture between both the front and back legs, around the bones of the upper body (scapulae, radii, femora, ulnae and upper vertebrae), and around the lower ribs and spinal column which were likely associated with rain experienced in the previous days. On day 142, or August 24th, the bones associated with the left hoof of the carcass were disarticulated and lying on the ground inside the research perimeter (Fig. 22). Small amounts of hardened skin were still present on the skull, a small area of the chest cavity, the right hoof, and the left leg in the region of the patella (Fig. 23). The lumbar vertebrae had tooth marks from being chewed upon by some scavenger. This was especially evident on spinous processes (Fig. 24). Also affected by scavenging activity were the right tibia and right scapula, which now had visible tooth marks. By day 173, or September 24, 1996, scavenging activity on the carcass had continued. The ribs, sternum and chest cavity area of the specimen had been greatly disturbed. Carnivore chew marks were visible on the ends of the ribs, the edges of the sternum, and the edges of the scapulae. Both the right and left hind legs were now entirely disarticulated; the left hind leg was six feet away outside the research perimeter, and the right hoof had been scavenged so that only a few bones remained. There was no insect activity, except for a few beetles around small pieces of dried, mummified tissue. It was also obvious, that the epiphyses of the long bones were becoming disjointed.

On day 209, or October 30, 1996 (the last day of the dry stage), massive
scavenging had obviously occurred, because the carcass was strewn outside the perimeter of the research area (Fig. 25). The left scapula was located 3 degrees from magnetic north in relation to the northwest corner of the study area, 3.84 meters away. The tibia, and some associated tarsals were located at 236 degrees, approximately 1.4 meters away. Some of the lower ribs were removed from the carcass, and were approximately 2.9 meters away from their previous position. Most of the rib cage and chest cavity were now in the upper right hand corner of the research perimeter unit. What was left of the rest of the rib cage was still in its previous position, except that it had settled somewhat into the ground (Fig. 26).

REMAINS STAGE

The remains stage began on October 31, 1996 and lasted until April 5, 1997 the day the bones were collected. There was no odor associated with the remains, and no insect activity was going on. The carcass was only a scatter of bleached out and dried bones (Fig.27). These bleached out bones could be found both inside and outside of the research perimeter (Fig. 28).

The research conducted in this thesis produced the following data on the process of decomposition:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Duration</th>
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<tr>
<td>Fresh Stage</td>
<td>3 days</td>
</tr>
<tr>
<td>Bloat Stage</td>
<td>7 days</td>
</tr>
<tr>
<td>Active Decay Stage</td>
<td>68 days</td>
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<tr>
<td>Advanced Decay Stage</td>
<td>27 days</td>
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<tr>
<td>Dry Stage</td>
<td>105 days</td>
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<tr>
<td>Remains Stage</td>
<td>157 days</td>
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### Tissue Color Associated With Decomposition

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<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
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<td>7</td>
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## Insects Associated With Decomposition

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<tr>
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<td>Advanced Decay Stage</td>
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### J K

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<th></th>
<th>J</th>
<th>K</th>
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<td>Mites</td>
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<tr>
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<td>5</td>
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</tr>
<tr>
<td>6</td>
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<td>yes</td>
</tr>
<tr>
<td>7</td>
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</table>
RESULTS FROM PIG #1 (BURIED)

Pig #1 was exhumed only twice during this research project, in order to disturb the processes of decay as little as possible. The first time the pig was exhumed was September 1, 1996, and the second time was April 5, 1997, a year from the time the research project first began. On September 1, 1996 at 1:52 PM, the plywood that covered the grave site was removed. Underneath the plywood were ants, spiders, crickets, and dry pupal casings. Something had visibly been digging in the southwest corner of the grave, and the entire area of the ground underneath the plywood was moist and wet. The entire area that made up the grave of the specimen was now depressed into the ground, whereas when the pig was initially buried the soil was level with the surrounding soil of the area. There were very few plants under the plywood, only two or three weeds. The grave was excavated with shovels and trowels using standard archaeological techniques.

At 27 centimeters down, odor was first detected. As digging continued, the soil became darker, and more moist. At 32 centimeters, the foul odor had dissipated slightly, the soil becoming more moist. At 35 centimeters the odor came back stronger than before, and the carcass had become visible.

The carcass was reached at 2:45 PM and began attracting flies. Upon fully exposing the carcass, Drosophilidae (small fruit flies) began to pour out of all orifices on the carcass, and also began to rise out of the surrounding soil. Maggots were found on a rock located underneath the chin area of the carcass. The entire body appeared deflated. The carcass was still covered in tissue and skin, hair was still present all over the body, and strong odor of decomposition accompanied it. The buried carcass was moist in the head and abdominal regions. A depression was visible where the back legs join into the abdominal
region, and the right eye of the carcass was missing. Although the skin and tissue of the carcass was intact, there was a dark green area on the jowl region of the specimen.

In comparison to pig #2, pig #1 was not very far along in terms of decomposition the first time it was unearthed. Pig #1 appeared to still be in the bloated stage of decomposition, or at least making the transition out of it into the active decay stage. This determination was reached due to the color of the skin of the carcass which was the dark green normally associated with the end of the bloated stage and beginning of the active decay stage.

On April 5, 1997, 366 days after it was first buried, the buried pig was unearthed for the last time. A large amount of white tissue was still present on the carcass, especially on the underside. Hair was still present as well. The pig was in the active decay stage of decomposition, although the mouth area of the cranium and the legs were skeletonized. Dead maggots were visible on the carcass and still in the early stage of larval development. The maggots probably died because they were underground and had less of an oxygen supply. They were in particularly high volume in the region of the cranium associated with the mouth, and ears. The side of the carcass closest to the ground had less loss of white tissue, than the side of the carcass toward the surface. Very little change had taken place since the last time the carcass was checked, the most change being restricted to the skeletonized legs.
DISCUSSION - CHAPTER 4

In doing this research it was found, that temperature plays an important role in the decompositional process. The ambient temperature recorded for pig #2 and its various stages of decomposition, ranged from a low of 40 degrees on April 27, 1996, to a high of 92 degrees on August 24, 1996. The average temperature for the fresh stage of decomposition lasting from April 5 - April 6 1996 was 69.5 degrees, with a low of 69 degrees, and a high of 70 degrees. The average temperature for the bloated stage of decomposition lasting from April 7 - April 13, 1996 was 57.8 degrees, with a low of 47 degrees and a high of 70 degrees. This stage was affected by the cold temperatures it experienced. Deflation of the carcass occurred on colder days, however the following day the carcass was found to be bloated once more with an increase in temperature. The average temperature for the active decay stage of decomposition lasting from April 14 - June 20 1996 was 63.3 degrees, with a low of 40 degrees and a high of 90 degrees. Insect activity during this stage was greatly increased on days after it had rained. Insect activity was also very high on days that were sunny and hot, slowing down considerably on days that were colder. On the cooler days, maggot activity was taking place at a slower rate, and fly activity was either very low, or simply stopped altogether. The average temperature for the advanced decay stage of decomposition lasting from June 21 - July 6 1996 was 75.9 degrees with a low of 55 degrees and a high of 92 degrees. Since this stage took place in the summer months, the temperature was more consistent than in previous stages. There was no affect on slowing down the decompositional processes in terms of insect activity and skeletalization. At the point of the dry stage and remains stage, temperature was no longer a key factor because the carcass was so decomposed.
The critical differences in terms of effecting decomposition are the insect families present and the mean temperature. The importance of ambient temperature can be demonstrated by analyzing the similarities and differences between the results discussed in this research and those of Payne (1965) and Johnson (1975). In Payne's study using fetal pigs, the data accumulated in association with the length of decompositional stages is as follows:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Month of August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Stage</td>
<td>1 day</td>
</tr>
<tr>
<td>Bloated Stage</td>
<td>3 days</td>
</tr>
<tr>
<td>Active Decay Stage</td>
<td>3 days</td>
</tr>
<tr>
<td>Advanced Decay Stage</td>
<td>3 days</td>
</tr>
<tr>
<td>Dry Stage</td>
<td>13 days</td>
</tr>
<tr>
<td>Remains Stage</td>
<td>Impossible to determine in this study</td>
</tr>
</tbody>
</table>

Payne's study took place in the summer of 1965, in the state of South Carolina. The entire decompositional study lasted 23 days (Payne 1965). One of the reasons Payne arrived at the data that he did, is due to the size of the specimens that were used in his study. The fetal pigs used in Payne's study weighed between 1,000 and 1,400 grams. Another, perhaps more critical reason leading to his conclusions is the environment and weather of South Carolina. This particular environment is teeming with insect species, Payne collected 522 species in all through the duration of his study. The average daily high temperature for Charleston, South Carolina in the month of April is 74 degrees (National Geographic Society 1995). The average daily temperature for the month of April in Missoula, Montana when this research project was started is 55.26 degrees. The difference in temperature between South Carolina and Montana for the month of April is important, because higher temperatures help decomposition occur more rapidly. The decompositional process takes less time for completion in South Carolina, whereas it takes more
time for completion in Montana due to lower temperatures.

In Johnson’s study on the decompositional process, the data accumulated is as follows:

<table>
<thead>
<tr>
<th>Stage</th>
<th>(March-May)</th>
<th>(June-August)</th>
<th>(Sept.-Nov.)</th>
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<tbody>
<tr>
<td>Fresh Stage</td>
<td>2</td>
<td>0.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Bloat Stage</td>
<td>19</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Decay Stage</td>
<td>23</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>Dry Stage</td>
<td>60</td>
<td>30</td>
<td>52 (Johnson 1975 p.82)</td>
</tr>
</tbody>
</table>

Johnson combined the active decay and advanced decay stages of decomposition, and disregarded the remains stage in his study. Depending on the months in which the study was conducted, Johnson’s stages of decomposition lasted from 35 days to 8 months. The animals used in this study were not all the same species. Squirrels, rabbits, a cat and an opossum were used as the research specimens. The study was conducted in Des Plains, Illinois. The average temperature for April in Illinois is 55 degrees, which is closer to the average temperature in Montana for that month. Although the temperatures are similar, the length of the stages is not. This possibly has to do with differences in environments and other factors that can be addressed by further research.

In comparison to the surface pig, the buried pig was still undergoing the processes of the active decay stage 366 days after it was buried. The surface pig entered the active decay stage 10 days after it was put out, and its active decay stage lasted 69 days. The reason the active decay stage was in the condition it was found to be in, was because the buried pig was protected from intense insect activity, moisture, and temperature change. The surface pig was exposed, so it was affected by insect activity, temperature and moisture.

It is important to clarify why this master’s thesis on decompositional rates
is different from work that was previously done in this field. The data compiled in this thesis was done in the time frame of one year giving a guideline to estimate time since death. Payne's study was done in the month of August in 1965, and Johnson's study was conducted from June 30, 1968 to November 1, 1969. This study is unique not only in terms of the time frame used. The weather of Northwest Montana had a direct impact on the data compiled, because of the variation in temperatures discussed earlier. In order to fully appreciate the differences in these studies, further research should be conducted in the same months for different parts of the United States. More research is necessary in this area associated with decompositional studies.
CONCLUSION - CHAPTER 5

It is possible to estimate time since death using the method of decompositional stages outlined in this thesis. The carcass decomposition stages were found to be consistent with studies done on decomposition in other areas of the United States, which have been used to estimate time since death. However decompositional changes did not occur at the same rate in this study as was found to be true in warmer areas of the country. In general, decomposition occurred more slowly in my study area than has been reported elsewhere. I suspect that the relative slowness of the decompositional process in Montana is due to a colder and more seasonal climate.

I therefore, conclude that my initial hypothesis, that methods of estimating time since death from decompositional stages is tentatively supported. Although many studies have been conducted in other states with environments very different than that of Northwestern Montana, the same principles apply when using stages of decomposition as the method of estimating time since death. The stages used in this thesis that pertain to the area of Northwestern Montana, are very clear cut and well defined in terms of what changes a carcass undergoes from stage to stage. This is important, because it will facilitate in the use of the method in field situations. The information compiled in this Master's thesis can be used in assisting both Law Enforcement Officials and Forensic Anthropologists in making more accurate time since death estimations. Familiarity with local insect populations, will also aid in the use of this method of time since death estimation. This method involves the deterioration of the carcass back into the environment, however it is an easier estimate than other methods, because there are certain hallmarks to look for in relation to each stage discussed. Tissue color, inflation of the carcass, deflation of the carcass,
insect activity, and condition of the remains are all important factors in this study. Part of the most important information generated from this thesis, is that information providing guidelines for the estimation of time since death. From the data generated in this thesis, is is safe to say that if a skeleton is found on the surface of the ground, it has been in its place for the period of at least one year. If a skeleton is found in a buried situation, it has to be over a year old, because the pig in this project did not become skeletonized in that period of time. Estimating time since death is extremely important in forensic cases, because it can led up to other information involving the individual in question. From the first estimate can come the identity of the individual, and may eventually aid in the arrest of persons responsible as in a case of murder. It is an important step in the forensic processing of a crime or accidental death scene.
Fig. 1. Fresh Stage of Decomposition.
Flies already beginning to show attention to the carcass.
Fig. 2. Fresh Stage of Decomposition.
Surface pig bloating, and changing from pink to deep purple in area of head and neck.

Fig. 3. Bloat Stage of Decomposition.
Head bloated and almost entirely purple.
Fig. 4. Bloat Stage of Decomposition.
More bloating occurring, note the flies on the underside, and its color change.

Fig. 5. Bloat Stage of Decomposition.
Damage to ear greatly increasing.
Fig. 6. Bloat Stage of Decomposition.
Damage to ear now extending behind the ear, into the neck region.
Fig. 7. Active Decay Stage of Decomposition.
Underside of carcass is now green.

Fig. 8. Active Decay Stage of Decomposition.
Black areas of underside are becoming more prominent.
Fig. 9. Active Decay Stage of Decomposition. 
Underside of carcass is black, and appears wrinkled.
Fig. 10. Active Decay Stage of Decomposition.
Massive damage to the neck, large flap of skin is hanging over area where carcass is hollowed out.

Fig. 11. Active Decay Stage of Decomposition.
Area of damage to the head is now filled with both large and small maggots.
Fig. 12. Active Decay Stage of Decomposition. Area of maggot activity in head is generating the characteristic foam associated with maggot refuse.
Fig. 13. Active Decay Stage of Decomposition.
Entire perimeter around carcass, to about half a foot away is the ooze generated by the foam.

Fig. 14. Active Decay Stage of Decomposition.
Damage to neck, ear, and shoulder region has slowed in spreading, but is now becoming deep.
Fig. 15. Active Decay Stage of Decomposition.
Bones of front right leg are visible, but still contain generous amounts of tissue.
Fig. 16. Active Decay Stage of Decomposition.  
Shredded underside region of the carcass.

Fig. 17. Active Decay Stage of Decomposition.  
Change of position of the carcass, it is now dragged outside research perimeter and the underside has been altered.
Fig. 18. Active Decay Stage of Decomposition. The right humerus, left tibia, and left fibula are now visible.
Fig. 19. Advanced Decay Stage of Decomposition. The carcass is very wet due to the rain of the day, giving the tissue a white color instead of a golden-brown color.

Fig. 20. Advanced Decay Stage of Decomposition. Pupal casings are visible in the region of the femur.
Fig. 21. Advanced Decay Stage of Decomposition. Skin still covers areas of the cranium, and moist tissue can still be found in some regions such as the rib cage.
Fig. 22. Dry Stage of Decomposition.
Mostly skeletal remains of carcass. Note the disarticulated hoof in the middle left of photo.

Fig. 23. Dry Stage of Decomposition.
Small amounts of tissue still present on cranium and rib cage.
Fig. 24. Dry Stage of Decomposition.
Spinous process of vertebrae affected by scavenging. Note the chewing marks on the ends.
Fig. 25. Dry Stage of Decomposition.
Massive scavenging has occurred. Portion of the carcass is strewn outside the research perimeter.
Fig. 26. Dry Stage of Decomposition.
Carcass is strewn outside the research perimeter.
Fig. 27. Remains Stage of Decomposition.
Scatter of bleached out, dry bones.
Fig. 28. Remains Stage of Decomposition. 
Scatter of bleached out, dry bones.
References


Micozzi, Marc S. 1991. Postmortem Change in Human and Animal


